

2017 DSM EVALUATION REPORTS

EFFICIENCY NOVA SCOTIA

Final Report

March 21, 2018



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2017 DSM PROGRAMS EVALUATION

EXECUTIVE SUMMARY

EFFICIENCY NOVA SCOTIA

Final Report

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ABBREVIATIONS

ASHP	Air-source heat pump
BDM	Business Development Manager
BNI	Business, non-profit and institutional
CRA	Corporate Research Associates
DA	Delivery agent
DIY	Do-it yourself
DSM	Demand-side management
EA	Energy advisor
ENS	Efficiency Nova Scotia
EUL	Effective useful life
GHG	Greenhouse gas
LED	Light-emitting diode
MEPS	Minimum energy performance standards
MSHP	Mini-split heat pump
M&V	Measurement and Verification
NRCan	Natural Resources Canada
NTGR	Net-to-gross ratio
PCF	Peak coincidence factor

DEFINITIONS

Accuracy	Reflects the proximity of measurements to the true value.
Adjustment ratio	The ratio of evaluated results to tracked results. This ratio expresses the adjustment made to tracked savings or other tracked values such as effective useful life.
Base case	To determine gross savings, a base case is established providing detailed information about the reference (e.g. pre-existing or standard) measure or equipment chosen to be compared with the efficient measure or equipment. For the reference measure or equipment, the base case may include such information as the hours of operation, wattage and the base consumption.
Bias	Systematic deviations of measurements from the true value.
Billing calibration	An activity that consists of adjusting the expected energy savings based on the relative difference between the results of the energy simulations and the actual energy consumption of the building or system.
Confidence interval	The estimated range of values which is likely to include the unknown population parameters.
Displaced wattage	The displaced wattage is defined as the difference between the wattage values of the baseline equipment or product and the efficient equipment or product.
EnerGuide rating	An EnerGuide (official brand of Natural Resources Canada) rating is a standard measure of the home's energy performance. It is a measure of the efficiency of the building only and does not take into account occupant behaviour. It shows how energy efficient the home is through modelled heat losses of the home, based on several factors including building envelope characteristics, heated volume, heating systems and air leakage.
Effective useful life	The period a measure is expected to be in service and provide both energy and peak demand savings. This value combines the equipment life and the measure persistence, which includes factors such as business turnover or early retirement.
Equipment life	The number of years installed equipment will operate before it fails.
Equivalent CO ₂	A unit of measurement indicating the amount of carbon dioxide to which various kinds of emitted greenhouse gases are equivalent in terms of warming effects. In this report, the gases' global-warming potential is estimated over a timescale of 100 years.
Equivalent effective useful life	The number of years by which the first-year savings estimate is multiplied to obtain lifetime energy savings. This value takes into account variations in annual energy savings throughout the effective useful life due to increased baselines.
Evaluated savings	Gross and net savings calculated by the Evaluator using the parameters (unitary savings values, installation rates, interactive effects, net-to-gross ratio, etc.) validated or measured during the evaluation process. Unless otherwise specified, the evaluated savings are the first-year savings.

Evaluation plan	The evaluation plan summarizes the program description, objectives, base cases, documentation, evaluation methodology, budget and schedule.
First-year savings	The first full year of energy savings generated by an energy efficiency measure.
Free-ridership	Percentage of gross savings attributable to participants who would have implemented the same or similar energy efficiency measures, with no change in timing, in the absence of the program.
Gross energy savings	Energy savings generated by energy efficiency measures, before applying the net-to-gross ratio.
Induced consumption	Energy consumption of appliances that would have been unplugged and not replaced by participants in the absence of the program.
Interactive effects	Effects on the energy consumption of other systems in the building (such as heating and cooling) due to the installation of an energy efficiency measure.
Internal spillover	Savings attributable to participants who continue to implement the energy efficiency measure introduced by a program after participating in it once, without participating in the program a second time.
In-service rate	The proportion of incentivized products that are installed and operating. This rate is usually applied to programs through which rebates are offered in-store and products are likely to be stored for a certain period before being installed, such as LED bulbs.
Lifetime energy savings	The energy savings that occur over the lifetime of an energy efficiency measure. Lifetime energy savings account for a measure's effective useful life and any increase in the baseline efficiency level (which reduces attributable annual savings) over its lifetime.
Line loss factor	The multiplier to convert savings at the customer meter to savings at the utility generator. It accounts for the electrical losses of the transmission and distribution system.
Margin of error	The amount of random sampling error.
Market effects	The impact of the program on the market (such as increased product availability, practices, and prices) that extends beyond changing the program participants' behaviour. This includes spillover among non-participants.
Net energy savings	Energy savings that can be reliably attributed to a program. This includes effects, such as free-ridership and spillover, that negatively or positively affect the energy savings attributable to a program.
Net-to-gross ratio	The ratio of net energy savings to gross energy savings.
Non-sampling error	Errors arising during the course of all survey activities other than sampling. Non-sampling errors tend to lead to bias in measurements and are very difficult to quantify.
Peak coincidence factor	The percentage of measure demand savings that coincide in time with the annual peak demand of the entire electricity system.

Peak demand savings	The demand savings that coincide in time with the expected annual peak demand period of the entire electricity system.
Precision	The extent to which repeated measurements agree with one another.
Random sampling error	The error in measurement due to the fact that measurements are taken from a subset of the population and not the entire population.
Sample size	The number of observations or replicates included in a statistical sample.
Secondary market impacts	Energy consumption of appliances that would have been transferred to the secondary market if said appliances had not been retired.
Tracked savings	Gross and net savings calculated by ENS in the tracking system, based on various parameters such as number of participants, unitary savings values, installation rates, interactive effects, and the net-to-gross ratio.
Unitary savings	Energy or peak demand savings established on a unitary basis. This unit can either be a product (e.g., an 8 W LED lamp), a capacity (e.g., one-ton capacity of an air-source heat pump) or a participant (e.g., one participant taking part in a behaviour-based program).

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INTRODUCTION

Efficiency Nova Scotia (ENS) is a franchise held by EfficiencyOne and is responsible for helping Nova Scotians improve the energy efficiency of their homes and workplaces. ENS designs, markets and delivers energy efficiency and conservation programs for various segments of the population. ENS receives funding for its activities from Nova Scotia Power and the Province of Nova Scotia. The funds received from Nova Scotia Power cover the costs of activities designed to help reduce electricity consumption, whereas funds from the Province of Nova Scotia are primarily earmarked for activities designed to help reduce the use of other fuels by low-income households.

Econoler was commissioned to: i) evaluate the 2017 ENS demand-side management (DSM) program portfolio comprised of six electricity efficiency programs; and ii) assess the impacts of energy efficiency codes and standards introduced in Nova Scotia. To carry out this assignment, Econoler collaborated with Research Into Action, Equilibrium Engineering, Corporate Research Associates (CRA) and Technosim.

Econoler served as team leader in the 2017 evaluation and was involved in every aspect thereof. Specifically, Econoler was in charge of coordinating and supervising all activities, conducting final reviews of all data collection instruments, performing impact evaluation calculations, as well as preparing and reviewing the evaluation reports. Research Into Action carried out the process evaluations, while Equilibrium Engineering conducted the on-site visits and contributed to some impact evaluation analyses. CRA conducted the interviews and surveys with participants and partners, as well as analyzed and reported on data collected through these activities. Technosim (Michel Parent) carried out site visits, project reviews and simulation model reviews for Custom Incentives New Construction as well as site visits and project reviews for Custom Incentives Building Optimization. Throughout this report, this team is referred to as the Evaluator.

For each program, the Evaluator prepared a DSM evaluation report presenting general findings, electrical first-year energy savings results, lifetime energy savings, peak demand savings and avoided greenhouse gas (GHG) emissions.¹

The evaluation revealed that the ENS DSM program portfolio achieved a total of 130.749 GWh in net energy savings and 23.679 MW in net peak demand savings at the generator in 2017. These savings represent 85,393 tonnes of CO₂ eq in terms of annual avoided GHG emissions. The total net lifetime energy savings amount to 1,620.838 GWh. In addition to the savings generated by ENS DSM programs, Codes and Standards were found to have achieved energy savings of 21.914 GWh and peak demand savings of 4.028 MW at the generator².

¹ Throughout this report, energy savings always refer to first-year energy savings rather than lifetime energy savings, unless specified otherwise.

² Energy and peak demand savings generated through Codes & Standards are not claimed since they are not the result of activities directly conducted by ENS.

The purpose of this report is to present the evaluation results of the overall ENS DSM program portfolio, along with the results of each program and their components. The following sections summarize evaluation objectives and scope, evaluation methodology, impact evaluation results, overall DSM portfolio performance, market evolution and recommendations to enhance the program component portfolio. An in-depth analysis of individual program component performance is also outlined herein.

1 EVALUATION OBJECTIVES AND SCOPE

The objectives of the 2017 evaluation of ENS DSM program components were to:

- › Assess the effectiveness of program component design and delivery
- › Determine the extent to which program component implementation is proceeding as planned (i.e. ensuring that equipment has been installed and is working as expected)
- › Determine the gross energy and peak demand savings at the generator
- › Determine the net-to-gross ratio (NTGR)
- › Determine the net energy and peak demand savings at the generator
- › Determine the lifetime energy savings
- › Quantify avoided greenhouse gases emissions linked to electricity savings

The Evaluator has introduced the last two items on this list for the first time for the 2017 evaluation.

Table 1 below outlines the various programs assessed as part of the 2016 and 2017 evaluations, along with their respective components and the types of evaluations conducted. It should be noted that some program components are further divided into services, which are discussed throughout this report. That is the case for the Custom program component which includes the Retrofit, New Construction and Building Optimization services, as well as for Business Energy Rebates that is comprised of two services, Mail-in and Instant Rebates.

In Table 1, “C” represents a complete evaluation, and “R” indicates that reduced evaluation activities were performed compared to 2016.

Table 1: Types of Evaluations Conducted for Each Program Component

Program	Program Component	2016			2017		
		Process	Market	Impact	Process	Market	Impact
Residential Efficient Product Rebates Program	Appliance Retirement		C	C			R
	Instant Savings		C	C		R	R
Existing Residential Program	Home Energy Assessment		C	C		C	C
	Green Heat		C	C	C	C	C
	Efficient Product Installation		C	C		C	C
New Residential Program	New Home Construction		C	C		C	C
Efficient Product Rebates Program	Business Energy Rebates		C	C		C	R
Custom Incentives Program	Custom		C	C	C*	C	R
	Energy Management Information Systems	C	C	C		C	C
	Strategic Energy Management**	C	C	C			
Direct Installation Program	Small Business Energy Solutions	C	C	C		C	C
*The process evaluation specifically targets the Retrofit service of the Custom program component. ** Due to the start date of the latest Strategic Energy Management (SEM) cohort, SEM did not have any participants who achieved savings in 2017; therefore, no evaluation was conducted for 2017.							

The types of evaluations conducted were chosen based on an analysis of 2017 evaluation objectives, key results of the previous evaluations and recent changes made to each program component. Based on this analysis and as outlined in Table 1, the Evaluator, in collaboration with ENS, decided to partially reduce the scope of market and impact evaluations for four program components, namely Appliance Retirement, Instant Savings, Business Energy Rebates, and Custom. The rationale for selecting the evaluation type conducted for each program component is discussed below.

Process Evaluations

The Evaluator recommended that the Green Heat program component and Retrofit service of the Custom program component would benefit the most from a process evaluation in 2017.

Green Heat was selected because of the major changes resulting from the introduction of mini-split heat pumps (MSHPs) in October 2015. The Green Heat participation level increased from approximately 250 participants in previous years to over 1,000 in 2016. The 2016 impact evaluation demonstrated that the free-ridership level was quite high for MSHP participants, in part because a large proportion of participants had already made the decision to install an MSHP before hearing about the program component. ENS redesigned the participant process in 2017 and was interested in learning more about the effectiveness of the program changes. Conducting an in-depth process evaluation and market evaluation helped identify ways to improve the program component design and marketing strategy.

Retrofit, under the Custom program component, is one of the greatest contributors to the Business, Non-Profit and Institutional (BNI) portion of the ENS portfolio, traditionally representing nearly 30 percent of BNI net savings. Program participants have various reasons for participating and different levels of energy efficiency proficiency. Given that many of the simpler lighting projects have been transferred to Business Energy Rebates, ENS must find new and innovative ways to maintain high Custom participation levels. The process evaluation yielded findings that can inform improvements to be made to this program component to ensure it remains relevant and attractive to the BNI market.

Market and Impact Evaluations

In choosing the market and impact evaluation activities to be conducted in 2017, the Evaluator considered the research themes that required deeper analysis and those that have been fully addressed by previous evaluations.

For instance, the 2016 evaluation revealed that more attention should be paid to the metering activity in Appliance Retirement because the margins of error for metered energy consumption remained high. Therefore, the Evaluator and ENS worked more closely together on metering data collection and analysis in 2017. However, the NTGRs obtained through participant surveys have remained quite stable in the previous two years for Appliance Retirement and no major new findings were made in the 2016 market evaluation of this mature program component. Consequently, conducting a market evaluation would have been of little value, and the participant survey was removed from the 2017 scope of work to free up and allocate additional resources to metering. Since the NTGR, a key impact parameter, was not reassessed in 2017, the impact evaluation scope was indicated as “reduced” in Table 1, although more effort was allocated to the metering activities.

For Instant Savings, the Evaluator focused on the impact evaluation of LED lamps and fixtures (these products generating by far the most savings for the program component), as well as clothes washers and refrigerators for which the baseline changed as a result of new federal regulations. For other products whose unitary savings values have generally remained stable for several years, the 2016 unitary savings values were used for the 2017 impact evaluation. The in-store survey was limited to only the fall campaign in 2017 because no major changes were expected to occur since the last in-store survey conducted in the 2016 fall campaign.

More resources were allocated to the 2017 market and impact evaluations of Green Heat. The Evaluator conducted a billing analysis of both air-source heat pumps (ASHPs) and MSHPs to implement the 2016 recommendation of continuing to refine savings assumptions for heat pumps. Also, because a new participant path had been added to Green Heat (a mail-in rebate), an additional participant survey and a unitary savings review were performed in 2017.

A complete market and impact evaluation was conducted for the Mail-in service of Business Energy Rebates. As for the Instant Rebates service of Business Energy Rebates, the Evaluator chose to conduct an end-user survey to better understand the service's influence on the market. By contrast, instead of a full unitary savings review, which had been performed every year to date, the Evaluator validated whether the values recommended in 2016 still applied to 2017. The Evaluator determined that the unitary savings values recommended in 2016 remain valid since they were based on regulations still in effect and a thorough review of hours of use.

The full process evaluation conducted for the Custom Retrofit service involved conducting in-depth interviews with participants and conducting on-site visits at some interviewee facilities. Participants tend to experience fatigue if they are repeatedly contacted and when surveys are long, so, to reduce survey length and ensure data quality, the Evaluator did not perform free-ridership and spillover surveys with Retrofit participants, thus reducing the impact evaluation scope. This decision is justifiable because the NTGRs, which are developed from free-ridership and spillover values, have remained stable between 0.90 and 0.92 over the past five years. The Evaluator therefore used an NTGR value based on the free-ridership and spillover levels of the past five years to calculate net savings. Since questions about the market were included in the process evaluation, the scope of the market evaluation is indicated as "complete" in Table 1.

The other program components each underwent a complete market and impact evaluation.

2 EVALUATION METHODOLOGY

This section presents the methodology used and the activities carried out to evaluate ENS DSM program components and services.

The Evaluator first reviewed all relevant documentation, particularly focusing on the modifications that ENS made to implement the recommendations from previous evaluations. Subsequently, a series of data-collection activities were undertaken by the Evaluator to complete the process, market and impact evaluations where applicable. These activities are described below.

For evaluation activities that yield quantitative results based on a sample, the Evaluator aimed to achieve a maximum margin of error of 10 percent at a confidence level of 90 percent. Margins of error are presented and discussed in individual program reports where applicable. As part of this evaluation, the Evaluator calculated the margins of error for survey samples, installation rates, savings adjustment ratios, measured energy consumption values and free-ridership levels. Examples of calculations used to establish margins of error are presented in Appendix II. In a few cases, results with a margin of error superior to 10 percent were used by the Evaluator; the reasons for these choices are explained in each report where such a situation occurs.

2.1 Interviews

The 2017 evaluation methodology included interviews with ENS program managers, partners, participants and industry associations. Between August 2017 and January 2018, the Evaluator conducted 112 interviews with various stakeholders. Summaries of completed interviews for each program component are presented in Table 2.

Table 2: 2017 Interviews Completed

Program Component or Initiative	Interviews Completed in 2017					
	Program Manager	Distributors/ Contractors	Participants	Retailers	Energy Advisors	Associations
Appliance Retirement	1	-	1	-	-	-
Instant Savings	1	-	-	8	-	-
Home Energy Assessment	1	-	-	-	4	-
Green Heat	1	20	-	-	-	-
Efficient Product Installation	1	-	-	-	-	-
New Home Construction	1	-	4	-	-	-
Business Energy Rebates	1	8	-	-	-	-
Custom	1	10	15	-	-	-
Energy Management Information Systems	1	-	4	-	-	-
Small Business Energy Solutions	1	-	-	-	-	-
Codes and Standards	-	-	-	-	-	28
Total	10	38	24	8	4	28

2.2 Surveys

Using contact information provided by ENS, CRA conducted phone surveys with participants and builders, as well as an intercept survey with light-emitting diode (LED) lamp buyers at retail stores.

Surveys

Between September and December 2017, CRA conducted telephone surveys with participants for most program components. For the New Home Construction program component, CRA also conducted a telephone survey with builders.

The content of the surveys varied from one program component to another. The surveys were used to collect information on the following major aspects:

- › Internal spillover and free-ridership
- › Cross-influence from ENS promotion and other programs
- › Participation motivations
- › Barriers to the installation of products, measures or upgrades
- › Satisfaction with the program component and ENS
- › Recommendations for improvement
- › Demographics and firmographics

Intercept Survey

As part of the Instant Savings evaluation, an in-store intercept survey was conducted with participants who purchased eligible LED lamps during the fall campaign. The in-store interviews were conducted at five of the participating retailers in September and October 2017.

The intercept survey was meant to generate feedback on the following aspects of Instant Savings:

- › LED lamp purchases and expected uses
- › Awareness of Instant Savings
- › Awareness of ENS
- › Free-ridership
- › Awareness about rebated products
- › Demographics

Table 3 presents a summary of the surveys completed for each program component as well as the number of respondents in each survey.

Table 3: 2017 Surveys

Program Component	Surveys Completed in 2017		
	Participants	Intercept	Builders
Instant Savings	-	100	-
Home Energy Assessment	70	-	-
Green Heat	141*	-	-
Efficient Product Installation	100	-	-
New Home Construction	13	-	59
Business Energy Rebates	130**	-	-
Small Business Energy Solutions	70	-	-
Total	524	100	59
*91 participants from the old path and 50 participants from the new path.			
** 70 Mail-in participants and 60 Instant Rebates participants.			

2.3 On-site Visits

For the 2017 evaluation, the Evaluator visited a total of 309 participant sites. These visits were primarily conducted in the summer and fall of 2017, with the exception of Efficient Product Installation site visits, which also occurred in the spring of 2017. The objective of the on-site visits was to collect data to establish or validate some of the parameters used in the savings calculations, namely installation rates, interactive effects, internal spillover and the technical characteristics of implemented measures. For Small Business Energy Solutions, some of these visits were conducted while the small business energy auditors were performing their audits to observe and evaluate the audit process. For Appliance Retirement, the Evaluator also conducted three visits to the recycling facility where the retired appliances were dismantled and recycled to ensure that the metering process was conducted properly once appliances reached the recycling facility.

Table 4 indicates the number of on-site visits conducted for each program component. The complete results of the on-site work are provided in the individual program component evaluation reports.

Table 4: 2017 On-site Visits

Program Component	On-site Visits Completed in 2017
Appliance Retirement	3
Green Heat	25
Efficient Product Installation	110
Business Energy Rebates	82
Custom	34
Small Business Energy Solutions	55
Total	309

2.4 Unitary Savings Review

For the evaluated program components where savings were established on a unitary basis, the Evaluator reviewed the savings presented in the tracking system. First, their consistency with the results of the previous evaluation was validated. The Evaluator then updated those savings if necessary. In some cases, the Evaluator relied on calculations presented in the technical reference manuals of other jurisdictions, while, in others, product specifications were used to obtain customized savings based on engineering calculations. For program components that offered a large variety of products, the most popular products were sampled to establish the average properties of each product category (e.g. lamp wattage). The unitary savings for Efficient Product Installation, as well as some of the measure categories under Appliance Retirement, Green Heat and Instant Savings, were reviewed using this methodology. For the Instant Rebates service and some measures in Instant Savings, the unitary savings from the 2016 evaluation, which had been determined using this methodology, were applied again in 2017.

2.5 Project Files Review

For those program components whose savings were established based on custom calculations for each measure installed, the Evaluator reviewed the savings calculations of a sample of projects. These calculations consist of either simple engineering calculations based on the specification of the baseline and efficient measures, or the outcomes of a measurement and verification procedure based on metered data. To ensure the accuracy of the calculations used, this activity included a review of the project documentation (specification sheets, modelling reports, ENS's CIRx Screening Tool, etc.) generally accompanied by an on-site visit to better understand the context in which measures were operating. Where appropriate, the Evaluator made modifications to the equations used or to parameter values.

The resulting adjustments were sometimes extrapolated to all program component tracked savings or the savings of non-sampled projects of the same category (e.g. lighting projects). This methodology was applied to Custom and Small Business Energy Solutions, the Mail-in Rebates service of Business Energy Rebates and some measure categories under Green Heat.

2.6 Billing Analysis

For Green Heat, a billing analysis was conducted with participants who had an MSHP installed in previous years to establish the average energy savings achieved. The billing analysis compared those participants' energy consumption as a function of heating degree days for a one-year period prior to the installation of their heat pumps and for one heating season immediately following installation.

2.7 Metering Analysis

For Appliance Retirement, the Evaluator ensured that the appliances retired in 2017 were adequately metered by developing a sampling plan and conducting three site visits to the appliance recycling facility to observe the metering process. The Evaluator also analyzed the raw data obtained from the metering activities to calculate average energy consumption. These activities were in response to the 2016 recommendations regarding new metering equipment and procedures.

With participants of Efficient Product Installation, the Evaluator conducted a residential lighting metering study from September 2016 to August 2017. Data collection devices were installed in 75 homes, each for an average duration of three months. The main objective of the study was to estimate the average daily hours of use of LED lamps and their coincidence with the peak demand period of the electricity grid in Nova Scotia. The Evaluator applied the results to the Instant Savings, Efficient Product Installation and Codes & Standards savings calculations.

2.8 Simulation Model Review

A simulation model review was performed for five of the New Construction service projects to thoroughly verify the accuracy of the energy models. This activity involved reviewing the simulation model against as-built drawings, project documentation and results of the on-site verification.

2.9 Effective Useful Life Review

To establish the persistence of energy savings over time, the Evaluator reviewed the effective useful life (EUL) values used in all program components. This included conducting a literature review of EUL values presented in the most recent technical reference manuals in other jurisdictions and other types of studies for each measure in the ENS portfolio.

Furthermore, the Evaluator took into account multiple baselines for LED products in Business Energy Rebates, Small Business Energy Solutions, Efficient Product Installation, and Instant Savings. The Evaluator determined when existing products will no longer constitute an adequate baseline in the EUL of LED products and calculated an equivalent EUL that accurately yields lifetime energy savings when multiplying by first-year savings.

2.10 Avoided GHG Emissions Quantification

The impact of ENS activities on avoided GHG emissions was estimated for all program components by using a Nova Scotia-specific factor for GHG emissions generated by electricity production.³ Since data for 2017 was not available at the time of writing, the Evaluator relied on 2016 data from Nova Scotia Power. The factor was obtained by dividing Nova Scotia Power's total system emissions in 2016, which were 7,079,268 CO₂ eq tonnes, by its total electricity generation of 10,839 GWh. This yielded a factor of 0.6531 kg of avoided CO₂ eq per net annual kWh saved at the generator.

³ The quantification of avoided GHG emissions only considers avoided electricity generation. Additional fuel consumed as a result of fuel-switching measures, such as those found in the New Construction service (of the Custom Incentives program), are not considered in this methodology.

3 IMPACT EVALUATION RESULTS

This section presents an analysis of the impact evaluation results for all program components by comparing the 2017 tracked energy and peak demand savings with those evaluated. The evaluated net-to-gross ratios, lifetime energy savings and greenhouse gas emission reductions are also presented in subsections below.

3.1 Individual Impact Evaluation Results

Table 5 and Table 6 summarize the evaluated energy and peak demand savings as well as the corresponding savings tracked by ENS for each program component offered in 2017. For evaluated energy and peak demand savings, initial gross savings correspond to savings before the Evaluator applied installation rates, in-service rates, interactive effects factors or savings adjustment ratios. The adjusted gross savings correspond to savings once these parameters were applied. Net savings were calculated by multiplying adjusted gross savings by the NTGR. Lifetime energy savings are equal to the savings generated by the efficient measure over its EUL. The Evaluator reviewed the EUL value for each efficient measure.

Table 5: 2017 Evaluated Results and Tracked Energy Savings at the Generator

DSM Program	DSM Program Component	2017 Energy Savings (GWh)						
		Evaluated					ENS	
		Annual Initial Gross Savings	Annual Adjusted Gross Savings	NTGR	Annual Net Savings	Lifetime Net Energy Savings	Annual Tracked Gross Savings	Annual Tracked Net Savings
Residential Efficient Product Rebates	Appliance Retirement	5.266	5.266	0.59	3.094	23.050	4.852	2.761
	Instant Savings	22.343	22.343	0.87	19.543	179.116	23.562	26.162
Existing Residential	Home Energy Assessment	8.959	8.306	0.76	7.007	140.139	8.945	7.145
	Green Heat	8.510	5.026	0.59	2.980	53.925	8.510	5.170
	Efficient Product Installation	21.308	19.439	0.92	17.877	157.288	21.257	18.082
New Residential	New Home Construction	3.838	3.212	1.45	3.371	101.242	3.845	2.993
Residential Subtotal		70.224	63.592	0.85	53.872	654.760	70.971	62.313
Efficient Product Rebates	Business Energy Rebates	64.637	60.465	0.77	46.583	547.135	64.637	50.670
Custom Incentives*	Custom	24.437	22.421	0.937	21.005	313.977	24.437	22.836
	Energy Management Information Systems	1.752	1.402	1.00	1.402	4.112	1.752	1.752
Direct Installation	Small Business Energy Solutions	10.036	8.920	0.88	7.887	100.854	10.036	8.757
BNI Subtotal		100.862	93.208	0.82	76.877	966.078	100.862	84.015
Portfolio Total		171.086	156.800	0.83	130.749	1620.838	171.833	146.328
Codes & Standards		21.914	21.914	-	21.914	-	-	-
Total (Portfolio and C&S)		193.000	178.714	0.85	152.663	1620.838	171.833	146.328

*Due to the start date of the latest Strategic Energy Management (SEM) cohort, SEM did not have any participants who achieved savings in 2017; therefore, no evaluation was conducted for 2017.

Table 6: 2017 Evaluated Results and Tracked Peak Demand Savings at the Generator

DSM Program	DSM Program Component	2017 Peak Demand Savings (MW)				
		Evaluated				ENS
		Annual Initial Gross Savings	Annual Adjusted Gross Savings	NTGR	Annual Net Savings	Annual Tracked Net Savings
Residential Efficient Product Rebates	Appliance Retirement	0.740	0.740	0.60	0.443	0.368
	Instant Savings	2.993	2.993	0.85	2.558	5.186
Existing Residential	Home Energy Assessment	2.535	2.348	0.76	1.981	2.029
	Green Heat	4.271	5.114	0.60	3.073	2.604
	Efficient Product Installation	2.401	2.317	0.92	2.129	3.012
New Residential	New Home Construction	1.086	0.909	1.45	0.954	0.847
Residential Subtotal		14.026	14.421	0.77	11.138	14.046
Efficient Product Rebates	Business Energy Rebates	13.833	9.295	0.78	7.286	11.000
Custom Incentives*	Custom	2.757	3.739	0.97	3.637	2.635
	Energy Management Information Systems	0.137	0.255	1.00	0.255	0.137
Direct Installation	Small Business Energy Solutions	2.068	1.538	0.89	1.363	1.804
BNI Subtotal		18.795	14.827	0.85	12.541	15.576
Portfolio Total		32.821	29.248	0.81	23.679	29.622
Codes & Standards		4.028	4.028	-	4.028	-
Total (Portfolio and C&S)		36.849	33.276	0.83	27.707	29.622

*Due to the start date of the latest Strategic Energy Management (SEM) cohort, SEM did not have any participants who achieved savings in 2017; therefore, no evaluation was conducted for 2017.

The following subsections discuss how evaluated savings compare to ENS tracked savings for each program and component.

3.1.1 Residential DSM Programs

Residential Efficient Product Rebates

The Residential Efficient Product Rebates program achieved net energy and peak demand savings of 22.637 GWh and 3.001MW respectively at the generator in 2017. The two program components under Residential Efficient Product Rebates are Appliance Retirement and Instant Savings. Their savings results are described below.

Appliance Retirement

In 2017, a total of 6,138 inefficient appliances were retired or replaced through Appliance Retirement and HomeWarming, including appliances retired through a pilot conducted with the Halifax Regional School Board. The program component achieved 3.094 GWh in net energy savings and 0.443 MW in net peak demand savings at the generator in 2017, which are respectively 12 percent higher than tracked energy savings and 20 percent higher than tracked demand savings. Evaluated savings were higher than tracked savings primarily due to an increase in the average energy consumption of retired freezers, as measured by 2017 metering activities. This increase resulted in higher unitary savings values for freezers for both Appliance Retirement and HomeWarming.

The evaluated net peak demand savings were higher than the tracked net peak demand savings due to the higher revised energy savings as well as an increase in the peak-demand-to-energy ratio for dehumidifiers (from 0.000 to 0.335).

Instant Savings

In 2017, a total of 710,540 eligible products were sold in participating stores across Nova Scotia. Among these products, 651,968 were LED lamps, which represents a decrease compared to 2016 participation levels. This lower number of LED lamps sold is mainly due to the introduction of a price floor to prevent retailers from selling LEDs at very low prices, a situation that had resulted in high sales in 2016. However, 2017 sales are still much higher than any other previous year.

The Evaluator found that Instant Savings achieved 19.543 GWh in net energy savings and 2.588 MW in net peak demand savings at the generator, thus respectively 25 percent lower than tracked energy savings and 51 percent lower than tracked demand savings. Evaluated savings were lower than tracked savings for two reasons. Firstly, LED A-type lamps represent more than 60 percent of Instant Savings and their gross unitary savings decreased by 6 percent due to the unitary savings review. Secondly, market effects established for 2017 were lower compared to 2016 levels given the new availability of sales data in 2017, which allowed for a more accurate estimate of the quantity of LEDs sold outside the Instant Savings campaigns that were influenced by the program component.

The evaluated net peak demand savings are 49 percent lower than the tracked net peak demand savings. This difference is largely due to the same reasons as the lower energy savings, but is further explained by the lower evaluated peak demand-to-energy ratios used for lighting products based on the findings of the 2017 Residential Lighting Metering Study.

Existing Residential

In 2017, the net energy savings of Existing Residential reached 27.864 GWh while the net peak demand savings amounted to 7.183 MW at the generator. Existing Residential is comprised of Home Energy Assessment, Green Heat, and Efficient Product Installation. The results of the three program components are discussed below.

Home Energy Assessment

The Evaluator determined that Home Energy Assessment achieved 7.007 GWh in net energy savings and 1.981 MW in net peak demand savings at the generator with 931 participants, aligning closely with tracked energy savings and demand savings. The evaluated net energy and peak demand savings values are both 2 percent lower than those tracked by ENS. This difference is explained by a decrease in the NTGR value due to a reduction in 2017 spillover level compared to 2016.

Green Heat

The 2017 participation level for Green Heat was much higher than in previous years. Non-electrically heated participants were eligible to install an MSHP under Green Heat beginning in August 2017, which was not the case in previous years and partially explains the increase in participation. Eighty-seven percent of the measures installed through Green Heat in 2017 were MSHPs. In total, 1,288 MSHPs were installed in electrically heated homes, while 303 MSHPs were installed in non-electrically heated homes. Moreover, the removal of the pre-approval process as of August 2017 likely contributed to higher participation.

The Evaluator found that, with 1,829 measures installed, Green Heat achieved 2.980 GWh in net energy savings and 3.073 MW in net peak demand savings at the generator. These values are respectively 42 percent below tracked energy savings and 18 percent higher than tracked peak demand savings. The lower than expected energy savings is largely due to the decrease in the unitary savings for MSHPs and ASHPs, as well as a slight decrease in the NTGR resulting from the higher free-ridership level established for new path participants with electric heating who installed MSHPs. In fact, those new participants had a free-ridership level of 51 percent, while free-ridership was established at 35 percent for the old path. Since ENS's tracked savings assumed the free-ridership level of the old path for both new and old path participants, this resulted in underestimated overall free-ridership.

The evaluated net peak demand savings were higher than those tracked by ENS due to the adjustment made for participants who installed an MSHP or ASHP in non-electrically heated households, for which ENS had tracked 0.0 MW in peak demand savings.

Efficient Product Installation

A total of 13,672 households participated in Efficient Product Installation in 2017, which was 18 percent lower than the total number of participants in Residential Direct Install and Rental Properties & Condos combined for 2016.⁴ A total of 377,875 efficient products were installed in 2017, which was 10 percent fewer than in 2016. The Evaluator found that Efficient Product Installation achieved 17.877 GWh in net energy savings and 2.129 MW in net peak demand savings at the generator in 2017.

Evaluated net energy savings were less than 1 percent lower than the tracked net energy savings. The overall installation rate (the proportion of measures found to be installed during on-site visits) decreased from 96 percent (tracked) to 91 percent (evaluated), but was offset by an increase in the NTGR value from 0.88 (tracked) to 0.92 (evaluated). The decrease in the overall installation rate between tracked and evaluated results is mainly attributable to the decrease in the smart power controller installation rate (from 78% in ENS tracked results to 57% in evaluated results). The adjustments made to the unitary savings and the interactive effects had only a small impact on the difference between tracked and evaluated savings.

The evaluated net peak demand savings were 29 percent lower than the tracked net peak demand savings. This difference was mainly associated with the lower evaluated peak demand-to-energy ratios based on the findings of the 2017 Residential Lighting Metering Study than those used by ENS for lighting products.

New Residential

The New Residential program, comprised of New Home Construction and the Passive House pilot, achieved net energy savings of 3.371 GWh and net peak demand savings of 0.954 MW at the generator in 2017.

New Home Construction

A total of 420 participants completed projects under New Home Construction in 2017 and generated electrical savings. Six participants completed one or more projects through the Passive House pilot. The Evaluator found that New Home Construction generated net energy savings of 3.351 GWh and net demand savings of 0.948 MW, and the Passive House pilot generated net energy and demand savings of 0.020 GWh and 0.006 MW respectively. The evaluated savings are 13 percent higher than those tracked by ENS. This difference is due to an increase in the market effects established for 2017 (35% in 2017 compared to 20% in 2016), which in turn increased the 2017 NTGR value.

⁴ Efficient Product Installation was introduced in 2017 pursuant to a merger of the Residential Direct Install and Rental Properties & Condos program components.

For the Passive House pilot, both the net evaluated energy and peak demand savings are 57 percent lower than those tracked by ENS because of the high free-ridership rate (61%) established for this component, which in turn lowered the NTGR value.

3.1.2 Business, Non-Profit and Institutional DSM Programs

Efficient Product Rebates

Efficient Product Rebates has one component, Business Energy Rebates. In 2017, Business Energy Rebates achieved 46.583 MWh in energy savings and 7.286 MW in peak demand savings at the generator.

Business Energy Rebates

Business Energy Rebates delivers incentives through the Mail-in or Instant Rebates services. In 2017, a total of 288 Mail-in projects were implemented by 213 unique participants. For Instant Rebates, a total of 315,867 rebated products were sold by distributors in 2017 (compared to 294,942 products in 2016 and 215,121 products in 2015), constituting a 7 percent increase over 2016 levels.

Overall, the evaluated net energy savings are 8 percent lower than the tracked values due to downward adjustments to both Mail-in and Instant Rebates savings (3% and 11% respectively).

For Mail-in, due to efforts made by ENS to apply the savings calculations recommended by the Evaluator in the 2016 evaluation, minor adjustments were made to gross savings, resulting in a negative adjustment of 3 percent between tracked and evaluated savings. For Instant Rebates, the decrease in tracked savings was mostly due to the lower NTGR established for 2017 and a greater proportion of products being affected by free-ridership levels (from 66% of products in 2016 to 75% in 2017). Furthermore, some downward adjustments were made to gross savings, which affected some of the most popular products in Instant Rebates, namely LED linear lamps and LED downlight fixtures.

Net peak demand savings are 34 percent lower than their corresponding tracked values. For Mail-in, the downward adjustment to net peak demand savings was 16 percent, due to a large adjustment to a single heating, ventilation and air conditioning project. As for Instant Rebates, the downward adjustment to peak demand savings was 40 percent, mainly as a consequence of the peak coincidence factor (PCF) being reduced by 14 percent compared to 2016 for indoor lighting products. The PCF corresponds to the likelihood of the measure being in use during Nova Scotia's peak demand period, i.e. between 5 pm and 7 pm.

Custom Incentives

In 2017, the Custom and Energy Management Information Systems components, which are part of the Custom Incentives program, achieved 22.407 GWh in net energy savings and 3.892 MW in net peak demand savings at the generator.

Custom

For 2017, the suite of services offered through Custom is broken down as follows: Retrofit; New Construction; and Building Optimization. A total of 64 projects achieved savings under Retrofit, 46 of which were completed projects and 18 claimed partial savings. In both New Construction and Building Optimization, seven projects reported savings, six of which were completed projects and one reported partial savings.

The evaluated net savings for Custom are 8 percent below the tracked value. This reduction was mostly due to New Construction, which had its gross energy savings reduced by 27 percent this year. Retrofit, which accounted for 70 percent of Custom gross savings, had only small adjustments made to its savings (about 1%). A reduction of 12 percent on Building Optimization savings had minimal impact on the overall difference between the tracked and the evaluated net savings.

There is a 38 percent difference between the evaluated and tracked net peak demand savings for Custom. The adjustments made to New Construction's peak demand savings explain most of this variation; those adjustments increased the evaluated savings by 1.012 MW for both the gross and net peak demand savings.

Energy Management Information Systems

Four participants reported savings in 2017, in addition to three projects that were at different stages of EMIS and had not yet generated savings by the end of 2017. The Evaluator concluded that EMIS achieved 1.402 GWh in net energy savings and 0.255 MW in net peak demand savings at the generator.

In 2017, the Evaluator adjusted the incremental savings for two projects for which the approach used by the service provider to estimate energy savings was not based on an appropriate incremental baseline approach. This change resulted in a 20 percent reduction between evaluated and tracked energy savings. The other two projects, which used valid baseline approaches, were not adjusted.

The large increase in peak demand savings (86%) is attributable to the addition of peak demand savings to two projects that had not reported any. The NTGR used by ENS remained unchanged.

Direct Installation

Direct Installation has one program component, Small Business Energy Solutions. In 2017, Small Business Energy Solutions achieved 7.887 GWh in net energy savings and 1.363 MW in net peak demand savings at the generator.

Small Business Energy Solutions

In 2017, among the 417 projects completed through Small Business Energy Solutions, 367 were implemented by following the do it yourself (DIY) path and 50 were implemented through the audit path. The evaluated net energy savings are 10 percent below the corresponding tracked figure. This is mainly due to the adjustment made to the gross savings of some lighting measures to correct for discrepancies detected during the site visits in hours of use values as well as baseline and efficient wattages.

The evaluated net peak demand savings are 24 percent lower than the tracked value. Again, this downward adjustment is mainly due to the adjustments made to the peak demand savings of lighting measures, for which the PCFs had to be revised to zero to reflect the fact that certain lamps did not operate during system peak hours.

3.1.3 Codes and Standards

The Evaluator focused on the impacts on the Nova Scotia market of federal and provincial regulations such as the Natural Resources Canada (NRCan) Amendment 13 regarding the introduction of minimum energy performance standards (MEPS) for some products and increased MEPS for others.

The overall energy and peak demand savings for Codes and Standards were established at 21.914 GWh and 4.028 MW respectively at the generator. Savings were not tracked for Codes and Standards. The savings attributable to Codes and Standards resulted from increasing the mandatory minimum efficiency levels applicable to the target products and building codes in the market. Although similar products and buildings are targeted by ENS programs, program savings are distinct from those generated by Codes and Standards. Savings associated with programs result from an increase in building and product efficiency above the efficiency requirement of the respective code or standard, whereas the savings associated with Codes and Standards result from an increase in said minimal efficiency standard

3.2 Net-to-gross Ratio

The NTGRs, outlined in Table 5 and Table 6 above, were applied to the gross savings impacts to estimate net savings impacts. NTGRs were established based on the levels of free-ridership and, in some cases, internal spillover. The estimation of NTGRs for the evaluation of ENS program components was based on a self-reporting approach. Appendix III presents examples of the calculations used to establish the free-ridership, internal spillover and NTGR values in the 2017 evaluation.

The level of free-ridership was established for most program components by conducting surveys or in-depth interviews. These surveys or interviews included a set of questions that were used to establish program component attribution for the free-ridership calculation. Subsequently, a weighted average based on each respondent's savings was used to estimate the program component overall free-ridership level. As was the case in 2016, the free-ridership calculation methodology took into account the impact of cross-influence of previous participation in other ENS program components. For a few program components or services, the Evaluator did not establish a free-ridership level. In Building Optimization and Energy Management Information Systems, the limited market penetration of these components and the limited knowledge of participants on recommissioning, or energy management information systems prior to participation explain why the level of free-ridership was considered to be nil.

The impact evaluation included an assessment of internal spillover level for program components where spillover is a factor. This assessment included telephone surveys or interviews conducted during on-site visits. In all cases, participants were asked if they had implemented additional energy efficiency measures without receiving funding or assistance from ENS. If so, participants were asked a set of questions designed to identify the additional energy efficiency measures implemented and their associated savings. Subsequently, another question was asked to quantify the level of influence the program had on their decision to implement these additional measures. The value established on the level of program influence was used to determine the portion of the additional savings attributable to the program. Finally, the level of internal spillover was established by dividing the total quantity of additional savings attributable to the program by the total quantity of savings achieved by the program for all the survey respondents.

Based on the free-ridership and spillover levels established, the NTGR was calculated using the following equation:

$$NTGR = (1 - \% \text{ free-ridership} + \% \text{ internal spillover})$$

Table 7 below summarizes the free-ridership and spillover levels established in the 2017 evaluation as well as the resulting NTGR for each program component. For all programs, with the exception of Instant Savings and New Home Construction, the spillover levels correspond to internal spillover. For Instant Savings and New Home Construction, this value corresponds to market effects (including external spillover).

Table 7: 2017 Free-ridership, Spillover and NTGRs

Program Component or Service and Measures		Free-ridership Levels	Spillover Levels	NTGR
Appliance Retirement ^{a, b}	Refrigerators	-	1%	0.55
	Freezers	-		0.55
	Air Conditioners	-		0.32
	Small Refrigerators	-		0.50
	Small Freezers	-		0.50
	HomeWarming Appliances	-	-	1
Instant Savings	LED Lamps	32%	16%	0.83
	All Other Products	-	-	1
Home Energy Assessment	N/A	25%	1%	0.76
Green Heat	MSHP in Fully Electrically Heated Homes	42%	-	0.58
	MSHP in Mainly Electrically Heated Homes	40%	-	0.61
	MSHP in Non-electrically Heated Homes	33%	-	0.67
	Central Heat Pumps	44%	-	0.56
	Solar and Biomass Measures	36%	-	0.64
	Heat Pump Water Heater	-	-	1
New Home Construction	New Home Construction	29%	35%	1.06
	Passive House Pilot	61%	-	0.39
Efficient Product Installation	LED Lamps Non-low Income Tenants	14%	1%	0.87
	LED Lamps Non-low Income Owners	26%	6%	0.80
	LED Lamps Low-income Participants	-	-	1
	Other Products Non-low Income Tenants	-	1%	1.01
	Other Products Non-low Income Owners	-	6%	1.06
	Other Products Low-income Participants	-	-	1
Business Energy Rebates – Mail-in Rebate	N/A	14%	0%	0.86
Business Energy Rebates – Instant Rebates	LED Linear Fixtures	32%	-	0.69
	LED Downlight Fixtures	36%		0.64
	LED Linear Lamps	38%		0.62
	LED General-use and Decorative Lamps	38%		0.62
	All Other Products	-	-	1
Custom	Custom Retrofit ^b	9%	0%	0.91

Program Component or Service and Measures		Free-ridership Levels	Spillover Levels	NTGR
	New Construction	-	-	1
	Building Optimization	-	-	1
Energy Management Information Systems	N/A	-	-	1
Small Business Energy Solutions	Audit Path	7%	-	0.93
	DIY Path	13%		0.87
^a For Appliance Retirement, the Evaluator complied with Uniform Methods Project guidelines and no free-ridership level was calculated.				
^b Net-to-gross ratios were determined with the results of past evaluations.				

The free-ridership levels for LED products, which are offered across several program components and represent most of the 2017 energy savings, remained quite high in 2017. This result is discussed in the Market Evolution Section (section 5) below.

3.3 Lifetime Energy Savings

The Evaluator reviewed the effective useful life values for measures offered by ENS and their associated lifetime energy savings for the first time in 2017. The Evaluator found that the DSM portfolio generated 1,620.838 GWh in lifetime energy savings. As presented in Table 8 below, the weighted average EUL of measures offered in the ENS portfolio is 12.4 years. Program components with measures affecting the building envelope, such as insulation, generate large lifetime savings due the persistence of these types of measures. For example, Home Energy Assessment has an average EUL of 20.0 years, and while this program component accounts for 5 percent of annual net energy savings, it generates 9 percent of the portfolio lifetime energy savings. Similarly, New Home Construction has an average EUL of 30.0 years, and while it contributes to 3 percent of annual energy savings, it generates 6 percent of lifetime energy savings. Programs composed of mainly lighting measures, such as Instant Savings and Efficient Product Installation, generate lower lifetime energy savings compared to their annual savings due to the shorter equivalent EUL of these types of products.

Table 8: 2017 Evaluated Net Lifetime Energy Savings at the Generator

DSM Program	DSM Program Component	Annual Net Energy Savings (GWh)	Lifetime Net Energy Savings (GWh)	Weighted Average EUL (years)
Residential				
Residential Efficient Product Rebates	Appliance Retirement	3.094	23.050	7.4
	Instant Savings	19.543	179.116	9.2
Existing Residential	Home Energy Assessment	7.007	140.139	20.0
	Green Heat	2.980	53.925	18.1
	Efficient Product Installation	17.877	157.288	8.8
New Residential	New Home Construction	3.371	101.242	30.0
Residential Subtotal		53.872	654.760	12.2
BNI				
Efficient Product Rebates	Business Energy Rebates	46.583	547.135	11.7
Custom Incentives*	Custom	21.005	313.977	14.9
	Energy Management Information Systems	1.402	4.112	2.9
Direct Installation	Small Business Energy Solutions	7.887	100.854	12.8
BNI Subtotal		76.877	966.078	12.6
Portfolio Total		130.749	1620.838	12.4
*Due to the start date of the latest Strategic Energy Management (SEM) cohort, SEM did not have any participants who achieved savings in 2017; therefore, no evaluation was conducted for 2017.				

3.4 Greenhouse Gas Emission Reductions

The Evaluator also established the avoided GHG emissions due to the DSM portfolio for the first time in 2017. Table 9 presents the greenhouse gas emission reductions from each program component in 2017.

Table 9: Evaluated Avoided GHG Emissions in 2017

DSM Program	Program Component	Avoided GHG Emissions CO ₂ eq Tonnes
Residential		
Residential Efficient Product Rebates	Appliance Retirement	2,021
	Instant Savings	12,764
Existing Residential	Home Energy Assessment	4,576
	Green Heat	1,946
	Efficient Product Installation	11,675
New Residential	New Home Construction	2,202
Residential Subtotal		35,184
BNI		
Efficient Product Rebates	Business Energy Rebates	30,423
Custom Incentives* ⁵	Custom	13,719
	Energy Management Information Systems	916
Direct Installation	Small Business Energy Solutions	5,151
BNI Subtotal		50,209
Portfolio Total		85,393
Codes & Standards		14,312
Total (Portfolio and C&S)		99,705
* Due to the start date of the latest Strategic Energy Management (SEM) cohort, SEM did not have any participants who achieved savings in 2017; therefore, no evaluation was conducted for 2017.		

⁵ The quantification of avoided GHG emissions only considers avoided electricity generation. Additional fuel consumed as a result of fuel-switching measures, such as those found in the New Construction service (of the Custom Incentives program), are not considered in this methodology.

4 DSM PORTFOLIO PERFORMANCE

This section presents an analysis of how evaluated savings compare to ENS's planned savings at both the portfolio and program component levels. Satisfaction results, historical performance and contribution of individual program components to portfolio savings are also outlined in this section.

4.1 Savings Performance

Table 10 presents ENS's planned savings,⁶ the evaluated results and the variance for the 2017 evaluation.

⁶ Mid-course planned savings adjusted by ENS.

Table 10: 2017 Planned Savings and Evaluated Results

DSM Program	Program Component	Mid-course Planned Savings		Evaluated Results*		Variance*	
		GWh	MW	GWh	MW	GWh (%)	MW (%)
Residential							
Residential Efficient Product Rebates	Appliance Retirement	2.6	0.3	3.094	0.443	18%	50%
	Instant Savings	20.0	3.3	19.543	2.558	-2%	-22%
Existing Residential	Home Energy Assessment	5.4	1.3	7.007	1.981	29%	54%
	Green Heat	3.5	1.7	2.980	3.073	-16%	81%
	Efficient Product Installation	24.4	3.6	17.877	2.129	-27%	-40%
New Residential	New Home Construction	4.0	0.9	3.371	0.954	-16%	1%
Residential Subtotal		60.0	11.1	53.872	11.138	-10%	1%
BNI							
Efficient Product Rebates	Business Energy Rebates	37.2	5.9	46.583	7.286	25%	24%
Custom Incentives	Custom	24.8	1.9	21.005	3.637	-15%	95%
	Energy Management Information Systems	4.0	0.1	1.402	0.255	-65%	88%
	Strategic Energy Management**	1.7	0.2	0.000	0.000	-100%	-100%
Direct Installation	Small Business Energy Solutions	8.8	1.9	7.887	1.363	-10%	-29%
BNI Subtotal		76.5	10.0	76.877	12.541	0%	26%
Portfolio Total		136.5	21.0	130.749	23.679	-4%	13%
* Numbers may not add up due to rounding.							
**Due to the start date of the latest Strategic Energy Management (SEM) cohort, SEM did not have any participants who achieved savings in 2017; therefore, no evaluation was conducted for 2017.							

The ENS portfolio of DSM program components achieved 130.749 GWh in total net energy savings at the generator, 4 percent lower than the planned energy savings. The total portfolio net peak demand savings of 23.679 MW exceeded the planned demand savings by 13 percent.

Residential programs achieved 53.872 GWh in net energy savings and 11.138 MW in net peak demand savings at the generator. Energy savings were 10 percent lower than planned due to lower than expected savings from the Existing Residential and New Residential programs, which were both 16 percent below the planned energy savings.

The underperformance of those two programs was due to lower than expected participation. In addition, the number of A-type lamp replacements in Efficient Product Installation decreased significantly in 2017. The Evaluator believes that this is most likely due to the decreasing number of incandescent lamps in

participating households as program participants purchase other lighting technologies than incandescents to replace burned-out lamps. However, two other residential program components achieved higher-than-planned energy savings: (1) Appliance Retirement (18% above planned mainly due to upward revisions in unitary savings); and (2) Home Energy Assessment (29% above planned mostly due to lower free-ridership than in previous years).

Residential demand savings were higher than planned due to higher demand savings in Home Energy Assessment and Green Heat. For the latter, no peak demand savings had been anticipated for heat pumps installed in non-electrically heated households. Therefore, the planned demand savings were lower than actual results.

The ENS BNI programs achieved 76.877 GWh in net energy savings at the generator, thus achieving the planned energy savings. While most program components did not achieve their energy savings goals, the higher than expected savings of Business Energy Rebates mitigated these shortfalls. The Business Energy Rebates energy savings were 25 percent above its planned energy savings.

Both Custom Incentives and Direct Installation had lower than planned energy savings. Custom Incentives did not achieve its planned energy savings by 27 percent due to lower-than-anticipated participation levels in the Custom and Energy Management Information Systems program components and the absence of participants generating savings in Strategic Energy Management.

BNI programs achieved 12.541 MW in net peak demand savings at the generator, exceeding the mid-course planned demand savings by 26 percent. Both Efficient Product Rebates and Custom Incentives had higher than planned demand savings. For the former, high energy savings were achieved mostly because of high participation, while for the latter, it appears that planned peak demand savings were conservative.

4.2 Participant and Partner Satisfaction Performance

Once again in 2017, the evaluation revealed that a very high number of participants expressed satisfaction with ENS and its programs. Most participants were pleased with their interactions with program partners, specifically in terms of professionalism and quality of work performed. As for partners, most were satisfied with their interactions with ENS and value their involvement in the program. Table 11 below presents satisfaction scores obtained in the 2017 evaluation.

Participants gave all program components satisfaction scores over 8.0 on a 10-point scale, except New Home Construction which scored 6.6. In 2017, ENS merged the Residential Direct Install and Rental Properties & Condos program components to form Efficient Product Installation. This new component obtained the highest participant satisfaction rating, along with the Business Energy Rebates Mail-in service, indicating that the transition has been smooth and successful. Partner satisfaction with Instant Savings decreased in 2017, with an average rating of 7.0 out of 10, down from 8.5 in 2016. Frustrations among partner retailers mostly originated from the introduction of a price floor for LED products by ENS.

Table 11: 2017 Satisfaction Results

DSM Program	Program Component or Service	Participant Satisfaction	Partner Satisfaction
Residential			
Residential Efficient Product Rebates	Instant Savings	-	7.0
Existing Residential	Home Energy Assessment	8.6	8.3
	Green Heat - Old Path	9.0	6.8
	Green Heat - New Path	8.8	7.5
	Efficient Product Installation	9.0	-
New Residential	New Home Construction	6.6	7.2
BNI			
Efficient Product Rebates	Business Energy Rebates - Mail-in Rebates	9.0	-
	Business Energy Rebates - Instant Rebates	-	6.5
Custom Incentives	Custom - New Construction	8.0	-
	Custom - Building Optimization	8.3	-
	Energy Management Information Systems	8.3	-
Direct Installation	Small Business Energy Solutions	8.8	-

4.3 Historical Portfolio Analysis

This section presents in Table 12 and Table 13 year-over-year program performance and contribution of individual program components to portfolio savings, providing a historical overview between 2013 and 2017 of component performance and changes in DSM portfolio composition.

Table 12: Evaluated Net Energy Savings at the Generator, 2013-2017

DSM Program	DSM Program Component	Energy (GWh)					Energy (% of Total Portfolio)				
		2013	2014	2015	2016	2017	2013	2014	2015	2016	2017
Residential											
Residential Efficient Product Rebates	Appliance Retirement	4.059	3.941	3.002	2.722	3.094	3%	3%	2%	2%	2%
	Instant Savings	26.524	9.360	10.121	34.593	19.543	16%	6%	7%	25%	15%
Existing Residential	LED Holiday Light Exchange	0.303	0.192	0.115	--	--	0%	0%	0%	--	--
	Home Energy Assessment	2.588	5.785	4.723	4.872	7.007	2%	4%	3%	4%	5%
	Green Heat ^a	1.617	1.534	1.872	3.992	2.980	1%	1%	1%	3%	2%
	HomeWarming ^b	1.678	2.311	-	--	-	1%	2%	--	--	-
	Efficient Product Installation (Residential Direct Install ^c)	37.275	24.607	15.675	16.360	17.877	23%	16%	11%	12%	14%
	Efficient Product Installation (Rental Properties and Condos Service ^d)	2.100	2.720	3.287	2.638		1%	2%	2%	2%	
New Residential	New Home Construction	5.890	4.572	3.988	3.908	3.371	4%	3%	3%	3%	3%
Home Energy Report	Home Energy Report	-	25.437	27.183	--	--	-	17%	20%	--	--
Residential Subtotal		82.034	80.459	69.966	69.085	53.872	50%	53%	51%	51%	41%
BNI											
Efficient Product Rebates	Business Energy Rebates ^e	34.619	24.610	36.446	37.797	46.583	21%	16%	26%	28%	36%
Custom Incentives	Custom ^f	33.947	28.638	20.709	21.571	21.005	21%	19%	15%	16%	16%
	Energy Management Information Systems	-	5.006	3.786	2.018	1.402	-	3%	3%	2%	1%
	Strategic Energy Management	-	-	--	2.269	--	--	--	--	2%	--
Direct Installation	Small Business Energy Solutions	12.649	13.175	7.034	4.123	7.887	8%	9%	5%	3%	6%
BNI Subtotal		81.215	71.429	67.975	67.778	76.877	50%	47%	49%	50%	59%
Portfolio Total		163.249	151.888	137.941	136.863	130.749	100%	100%	100%	100%	100%

^a 2012, 2013 and 2014 Green Heat results include the Solar component. In early 2015, ENS incorporated the Solar program component into Green Heat.

^b HomeWarming was called Low Income Homeowner until the end of 2014.

^c 2011 Residential Direct Install results correspond to Efficient Product – Low-income Renters pilot, which offered a similar mix of products as Residential Direct Install.

^d Rental Properties and Condos and Residential Direct Install were combined in Efficient Product Installation as of 2017.

^e 2011 Business Energy Rebates includes the sum of the savings for Mail-In rebate from Business Energy Rebates and Instant Rebates from Smart Lighting Choices.

^f Custom includes Custom Retrofit, Custom New Construction and, in 2014-2015, Existing Building Commissioning.

Table 13: Evaluated Net Peak Demand Savings at the Generator, 2013-2017

DSM Program	DSM Program Component	Peak Demand (MW)					Peak Demand (% of Total Portfolio)				
		2013	2014	2015	2016	2017	2013	2014	2015	2016	2017
Residential											
Residential Efficient Product Rebates	Appliance Retirement	0.645	0.627	0.477	0.363	0.443	2%	2%	2%	1%	2%
	Instant Savings	3.793	1.479	1.599	6.77	2.558	11%	6%	7%	26%	11%
Existing Residential	LED Holiday Light Exchange	0.653	0.414	0.174	--	--	2%	2%	1%	--	--
	Home Energy Assessment	0.602	1.423	1.162	1.378	1.981	2%	5%	5%	5%	8%
	Green Heat ^a	0.665	0.594	0.587	2.282	3.073	2%	2%	3%	9%	13%
	HomeWarming ^b	0.398	0.539	-	--	--	1%	2%	--	--	--
	Efficient Product Installation (Residential Direct Install ^c)	8.499	5.734	3.652	2.73	2.129	25%	21%	16%	11%	9%
	Efficient Product Installation (Rental Properties and Condos Service ^d)	0.359	0.634	0.766	0.568		1%	2%	3%	2%	
	New Residential	New Home Construction	1.545	1.175	1.025	1.106	0.954	5%	4%	5%	4%
Home Energy Report	Home Energy Report	-	2.892	3.724	--	--	-	11%	16%	--	--
Residential Subtotal		17.159	15.511	13.166	15.197	11.138	50%	57%	58%	59%	47%
BNI											
Efficient Product Rebates	Business Energy Rebates ^e	9.367	4.88	5.903	7.094	7.286	28%	18%	26%	27%	31%
Custom Incentives	Custom ^f	4.811	4.116	2.479	2.258	3.637	14%	15%	11%	9%	15%
	Energy Management Information Systems	-	-	--	0.082	0.255	-	--	--	0%	1%
	Strategic Energy Management	-	-	--	0.269	--	--	--	--	1%	--
Direct Installation	Small Business Energy Solutions	2.759	2.57	1.125	1.07	1.363	8%	10%	5%	4%	6%
BNI Subtotal		16.937	11.566	9.507	10.773	12.541	50%	43%	42%	42%	53%
Portfolio Total		34.096	27.077	22.673	25.97	23.679	100%	100%	100%	100%	100%

^a 2012, 2013 and 2014 Green Heat results include the Solar component. In early 2015, ENS incorporated the Solar program component into Green Heat.

^b HomeWarming was called Low Income Homeowner until the end of 2014.

^c 2011 Residential Direct Install results correspond to Efficient Product – Low-income Renters pilot, which offered a similar mix of products as Residential Direct Install.

^d Rental Properties and Condos and Residential Direct Install were combined in Efficient Product Installation as of 2017.

^e 2011 Business Energy Rebates includes the sum of the savings for Mail-In rebate from Business Energy Rebates and Instant Rebates from Smart Lighting Choices.

^f Custom includes Custom Retrofit, Custom New Construction and, in 2014-2015, Existing Building Commissioning.

In 2017, ENS achieved a total of 130.749 GWh in net energy savings and 23.679 MW in net peak demand savings at the generator. These values represent a slight decrease compared to 2016 in both energy savings (4%) and peak demand savings (9%), primarily due to decreases in the residential sector. The residential components experienced a 22 percent decrease in net energy savings compared to the 2016 evaluation.

Instant Savings saw a 44 percent decrease in savings compared to 2016, which is explained by an exceptional result in 2016 when one national retailer offered an unusually low promotional price during a campaign. Efficient Product Installation had a small decrease (6%) in energy savings compared to 2016, due to lower than anticipated participation and fewer opportunities for incandescent lamp replacements. Finally, energy savings in Green Heat decreased by 25 percent compared to 2016. While participation levels in this component reached a new high, a decrease in unitary savings for MSHPs and ASHPs as well as increasing free-ridership levels impacted 2017 savings.

However, two components partially compensated for the components that had reduced savings. Home Energy Assessment had a 44 percent increase in energy savings over 2016 due mainly to lower free-ridership. In addition, Appliance Retirement had a 14 percent increase over 2016 due to mostly upward revisions in unitary savings.

The BNI components saw a 13 percent increase in net energy savings compared to the 2016 evaluation, primarily due to the positive performance of Business Energy Rebates as well as the record high participation in Small Business Energy Solutions. Since together these programs represent almost 70 percent of the BNI portfolio savings, they compensated for programs that did not meet planned energy savings. While energy savings from Custom remained fairly stable with a 3 percent decrease, energy savings from Energy Management Information Systems dropped 31 percent since 2016 because participants have been taking part in the component for many years and new savings are more difficult to achieve.

As highlighted in Table 12 above, the residential contribution decreased from 51 percent in 2016 to 41 percent in 2017, whereas this sector contributed at least 50 percent in all previous years. This is mostly due to the steady increase in savings from Business Energy Rebates, which went from 28 percent in 2016 to 36 percent in 2017.

Since ENS transitioned in 2015 toward LED products as the primary lighting technology eligible for incentives under its portfolio, the share of savings generated by these products has been increasing. Instant Savings, Efficient Product Installation, and Business Energy Rebates, which together represented 64 percent of ENS energy savings in 2017, generated most of their energy savings through lighting measures (89% for Instant Savings, 67% for Efficient Product Installation and 86% for Business Energy Rebates). These percentages are very similar to those obtained in the 2016 evaluation. The Evaluator believes that ENS will need to continue to adapt its offerings to continue maximizing generated energy savings and diversifying the types of efficient measures offered.

5 MARKET EVOLUTION

The 2016 Evaluation served to highlight three measures, among three program components, for which monitoring and analyzing market indicators were warranted in 2017 to identify when various program component offerings should be adapted or removed. These measures were:

- › Instant Savings: Residential LEDs
- › Business Energy Rebates: Commercial LEDs
- › Green Heat: MSHPs

In 2017, for each measure, the Evaluator analyzed available market data such as measured free-ridership, market share and prices to determine if trends observed in 2016 persisted over time and glean insights into the current state of market transformation for these products in Nova Scotia.

Instant Savings and Business Energy Rebates: LED Lighting

ENS has been active in the residential LED market since 2011 through Instant Savings. A socket study conducted in 2016 indicated that residential LED lamp socket saturation was 21 percent in permanent fixture lamps and 24 percent in plug-in lamps in Nova Scotia and that 59 percent of Nova Scotians had at least one LED lamp in their homes. In 2017, LED lamp shipments accounted for approximately one third of all lamps shipped in Atlantic Canada, among which A-types remained the dominant LED lamp type. Instant Savings data indicate that LED lamp prices have declined significantly, and A-types are the least expensive LED type with an average price of \$3.04 per lamp. In addition, LED lamps are available at major retailers as well as at independent stores, as indicated by the various retailer types that participate in Instant Savings. As part of the Instant Savings evaluation, the Evaluator calculated a 32 percent free-ridership level for LED lamps in 2017.

The Business Energy Rebates program component targets LEDs in the BNI sector. Following a similar trend as the residential market, the share of LED technology among lighting shipments has grown drastically for the commercial and industrial sectors in Atlantic Canada, reaching 54 percent in 2016. Furthermore, prices have declined significantly for all LED product categories. In addition, the majority of distributors in Nova Scotia carry LED products, indicating that this technology is widely available to BNI customers across the province. As part of the Business Energy Rebates evaluation, the Evaluator calculated free-ridership for four LED products and found that free-ridership ranged between 32 and 38 percent in 2017.

The increased share of LEDs in both the residential and BNI markets, price reductions, widespread availability and high free-ridership levels indicate that the barriers to LED purchases continue to decline. However, the fact that about only one lamp in four is an LED lamp in the residential market and that LEDs make up slightly more than half of new lamp shipments in the BNI market indicate that potential remains to influence consumer decisions. The Evaluator concludes that LEDs remain in a growth phase and are approaching maturity as both the residential and BNI sectors increasingly adopt LEDs. Growth

in LED sales is expected to continue in the years ahead since more efficient technology is not currently available and Canadian energy efficiency regulations will not impact LED lamps and fixtures in the near future. Also, the savings generated by LED products are expected to decline because the baseline efficiency for lighting will increase.

Green Heat: Mini-split Heat Pumps

In October 2015, Green Heat was expanded to include MSHPs. The addition of MSHPs to Green Heat considerably boosted participation as soon as the measure was introduced. In the last year, Green Heat underwent a series of changes. Starting in August 2017, Green Heat was relaunched as a mail-in rebate program, thereby eliminating the preapproval process. This modification also included new eligibility criteria for cold-climate MSHPs and a change in the incentive structure for four of the five heat pumps incented by the program, including MSHPs. Additionally, MSHPs are now offered to both electrically and non-electrically heated homes, whereas only electrically heated homes qualified for this incentive prior to August 2017.

In 2017, MSHPs constituted 87 percent of all Green Heat installations. Electrically heated homes accounted for 81 percent of the MSHPs installed through the component and 19 percent were installed in previously non-electrically heated homes.

The market share for heat pumps as primary heating systems in Nova Scotia grew considerably, from 6 percent in 2013 to 11 percent in 2015 (data on secondary sources were unavailable).⁷ However, despite the high prevalence of MSHPs on the market and in Green Heat, there has been very little change in the overall efficiency of incented units since 2015.

The market for MSHPs continues to evolve. While participating contractors reported that efficient MSHPs (i.e. Green Heat qualified) made up about 90 percent of their MSHP sales, this share is expected to shift downward because the new eligibility criteria established in August 2017 will push participants to buy even higher efficiency MSHPs. The market indicators above provide some insight on the evolution of the market for MSHPs, but further data is required to fully assess the transformation of this market in Nova Scotia.

⁷ Statistics Canada. Table 153-0145 - Households and the environment survey, primary heating system, Canada, provinces and census metropolitan areas (CMA), every 2 years (percent), CANSIM. (Accessed: January 8, 2018)

6 RECOMMENDATIONS

Once again, the Evaluator commends ENS on its ability to quickly and effectively implement the recommendations made as part of past evaluations. The 2017 evaluation revealed that most recommendations made for each program component in former evaluations had been implemented. The 2016 crosscutting recommendation about updating the methodology for calculating interactive effects associated with lighting projects for Business Energy Rebates, Small Business Energy Solutions and Custom was implemented in all three components.

As part of the 2017 evaluation, the Evaluator has one crosscutting recommendation that applies to many ENS program components, which is outlined in Table 14.

Table 14: Crosscutting Recommendations on ENS Programs

No.	Recommendation
CR-R1.	Foster the implementation of non-lighting energy efficiency measures. Among the wide variety of energy efficiency measures offered by ENS, lighting measures accounted for most savings achieved in 2017. For example, Instant Savings, Efficient Product Installation, and Business Energy Rebates, which together represent 64 percent of ENS energy savings in 2017, generated most of their energy savings through lighting measures (89% for Instant Savings, 67% for Efficient Product Installation and 86% for Business Energy Rebates). Additionally, the Evaluator analyzed the market evolution of LED lighting and concluded that market barriers are decreasing. Consequently, the Evaluator predicts that the baseline efficiency for lighting will continue to increase and thus reduce savings. ENS offers many non-lighting measures in its portfolio. The Evaluator believes there is potential for achieving more energy and peak demand savings from non-lighting measures and recommends that ENS look for new ways to encourage their implementation. This represents an opportunity for ENS to increase energy and peak demand savings while mitigating the risk of declining lighting energy and peak demand savings.

7 INDIVIDUAL PROGRAM COMPONENT PERFORMANCE

This section provides a summary of the key findings and main recommendations for each program component. Please note that the numbering of the recommendations corresponds to the numbering presented in the recommendations appendix of the individual reports.

7.1 Residential

7.1.1 Appliance Retirement

Appliance Retirement continues to achieve considerable levels of participation and savings, despite having been in the market for several years. Considering that the majority of participants would not have recycled their appliances on their own if Appliance Retirement had not been in place (as revealed by last year's participant survey), the program component is still useful in encouraging the retirement of inefficient appliances and educating people about the cost of maintaining old appliances.

A total of 5,739 appliances were retired through Appliance Retirement in 2017, including 3,847 refrigerators, 1,659 freezers, 124 air conditioning units and 109 small refrigerators/freezers. Additionally, 59 refrigerators, 203 freezers and 124 dehumidifiers were replaced through HomeWarming and 10 refrigerators, two freezers and one small refrigerator were retired through the pilot conducted with the Halifax Regional School Board. Altogether, a total of 6,138 inefficient appliances were retired or replaced through Appliance Retirement, the pilot and HomeWarming in 2017. The participant level was stable compared to the last year (6,044 units in 2016).

As part of the 2017 evaluation, three on-site visits to the appliance-recycling facility were conducted to validate the metering process. While the metering protocol was much improved, the margins of error were higher than expected since the sample size was not large enough, notably because of the quantity of unusable data that this new approach allowed for identifying. Nevertheless, the Evaluator considers that this approach has not only helped identify the reasons for energy-consumption variations among different types of appliances, but also shown that increasing the number of units metered is the key element for reducing the margins of error. The average annual consumption values of metered appliances retired were within ranges similar to those of 2016, with the exception of freezers manufactured in 1994 and earlier.

The unitary savings values of each type of appliance retired through Appliance Retirement and HomeWarming were revised based on the results of the 2017 metering study, the characteristics of the retired appliances documented in the tracking system, as well as the information obtained from the 2016 participant survey. The Evaluator established specific unitary savings for appliances retired through the Appliance Retirement pilot to account for the usage patterns of surplus appliances found in schools.

Appliance Retirement aimed to achieve 2.6 GWh in net energy savings and 0.3 MW in net peak demand savings at the generator in 2017. The Evaluator found that it achieved 3.094 GWh in net energy savings and 0.443 MW in net peak demand savings at the generator in 2017. These savings represent 2,021 tonnes of CO₂ eq in terms of annual avoided GHG emissions. By applying a weighted average equivalent EUL value of 7.4 years, the net lifetime energy savings have been established at 23.050 GWh.

Based on the evaluation results, the Evaluator makes the following recommendations, as listed in Table 15, to optimize this program component.

Table 15: Recommendations for Appliance Retirement

No.	Recommendations
ARet-R1.	Continue to perform the metering activity to increase sample sizes. This year, the Evaluator developed a new metering protocol, which greatly improved the quality of the metering data. Although the metering approach used in 2017 was improved, the sample sizes were not large enough to provide acceptable margins of error on gross energy consumption values. Therefore, the Evaluator recommends continuing the metering activity in 2018 using the same age categories and the same protocol as used in 2017 to increase the sample size of each age category. As for the metering activity to be performed next year, the Evaluator also suggests implementing some minor changes, such as using a better tool to measure the power factor of each appliance type and measuring old appliances' inside temperature at the time of pick-up, as recommended in the Metering Review section of this report.
ARet-R2.	Improve the process for tracking appliances retired through the pilot. This year, the savings of those appliances retired through the ARet pilot were tracked using the same parameters and methodology as for full-sized residential appliances. After conducting an interview with a representative of HRSB schools, the Evaluator used different unitary gross and net savings values for the pilot. Going forward, the Evaluator recommends using the unitary savings values established in this year's evaluation for appliances retired through the pilot. The Evaluator also recommends improving the tracking process by clearly identifying the appliances retired through the pilot.

7.1.2 Instant Savings

In 2017, a total of 710,540 eligible products were sold in participating stores across Nova Scotia. Among these products, 651,968 were LED lamps (512,096 A-type and 139,872 Non-A-type LED lamps), which represents a decrease compared to 2016 participation levels. This lower number of LEDs sold is mainly due to the introduction of a price floor to prevent retailers from selling LEDs at very low prices, a situation that had resulted in extraordinary sales in 2016. However, 2017 sales are still much higher than any other previous year.

Overall satisfaction with Instant Savings varied among retailers in 2017. While the majority of retailers mentioned fairly high levels of satisfaction with the program component, the remaining retailers expressed some frustration with the introduction of a product price floor in 2017. It should be noted that the price floor did not affect all eligible products, mostly the packs of one or two LED lamps. In 2017, retailers continue to have good relationships with the delivery agent (DA); they were generally pleased with DA helpfulness, responsiveness, support, reliability, and the thorough information provided about the campaigns. Similar to 2016, the intercept participant survey indicated that ENS marketing was the most common way for participants to find out about Instant Savings, primarily through in-store promotions, followed by TV ads, the ENS website and word-of-mouth.

This year, the Evaluator reviewed the unitary savings values used for LED lamps and fixtures, which generate by far the most savings, as well as clothes washers and refrigerators whose baselines changed as a result of new federal regulations. The review however did not have a major impact on the magnitude of unitary savings. The Evaluator also established the unitary savings values of the three new products tested during the fall campaign. The NTGR was measured for the best-selling product, LED lamps, and included free-ridership and spillover. The intercept survey revealed a free-ridership level of 32 percent, while retailer interviews and sales data revealed a spillover of 16 percent, which is considerably lower than the 2016 level of 47 percent. This drop is mainly explained by more accurate sales data that revealed a lower number of LED lamp sales outside the campaigns. In 2017, the NTGR for LED lamps was established at 0.84.

Instant Savings aimed to achieve 20.0 GWh in net energy savings and 3.3 MW in net peak demand savings at the generator in 2017. The Evaluator concluded that it achieved 19.543 GWh in net energy savings and 2.558 MW in net peak demand savings at the generator. These savings represent 12,764 tonnes of CO₂ eq in terms of annual avoided GHG emissions. Based on a weighted average EUL value of 9.2 years, the net lifetime energy savings are 179.116 GWh.

Based on the evaluation results, the Evaluator makes the following recommendations, as listed in Table 16, to optimize this program component.

Table 16: Recommendations for Instant Savings

No.	Recommendations
Instant-R1.	Continue providing program component support to expand the share of LED bulbs in the Nova Scotia residential lighting market while beginning to plan an exit strategy for A-type bulbs. Given the high participation level in this program component, high purchase volume of A-type bulbs and reductions in LED prices, ENS should consider decreasing incentive levels for A-type bulbs. In addition, ENS should consider possible opportunities for shifting the focus of the program component, for example to bulb types with lower market adoption, to extend Instant Savings beyond the short-term.
Instant-R2.	Continue monitoring market indicators and collect additional information to further characterize the LED market. Because the lighting market is in a period of change, the Evaluator recommends continuing to monitor market indicators such as market share of lighting technologies, socket saturation and LED prices. Also, to better characterize the current state of the lighting market, the Evaluator recommends collecting data about the following aspects: (1) Different LED and halogen bulb types installed in homes. This information could be collected during site visits in future socket studies; and (2) Customer knowledge of LEDs. This information could be collected using questions included in a periodic Omnibus survey. An Omnibus survey is a cost-effective method where data on a wide variety of subjects is collected during the same interview.

7.1.3 Home Energy Assessment

In 2017, the Home Energy Assessment participation level of 931 participants was similar to that in 2016, but was much lower than in previous years. This decrease was attributable to the discontinuation of provincial funding in April 2015, which has resulted in participation only by homes that are primarily electrically heated. Although the participation level has decreased, the net electrical energy savings per participant have increased due to this change. When provincial funding was available, those participants using a non-electrical main heat source were also considered DSM participants if they had a backup electrical heat source. However, the proportion of savings accounted for by such participants in Home Energy Assessment's total electrical savings was quite low since their electrical savings were generated only by their secondary heating systems.

Satisfaction with Home Energy Assessment was high among participants and energy advisors (EAs) who provided an average satisfaction rating of 8.6 and 8.3 on a 10-point scale respectively. The Home Energy Assessment's environmental benefits, clear instructions on program component delivery provided by ENS and the seamless integration of NRCan standards and requirements were also praised. Although EAs viewed the tiered incentive approach as an effective one for encouraging participants to implement more measures, they found the rebate calculation challenging.

The impact evaluation did not result in any major change to tracked gross savings calculations. However, compared with last year, Home Energy Assessment's gross electrical savings per participant increased significantly in 2017, which can be explained by a higher number of participants installing a space-heating appliance this year. For 2017, a free-ridership level of 25 percent was established, which was slightly lower than the levels established by the previous evaluations (28% in 2016). The results also revealed an internal spillover of 1 percent, which was lower than the levels established by the previous evaluations. This difference can be explained by the fact that participants who exhibited spillover declared during the telephone survey that they implemented air-sealing measures after their participation in Home Energy Assessment, which do not generate high savings compared to other spillover measures observed in previous years. By applying these free-ridership and internal spillover levels, the Evaluator established the NTGR at 0.76

Home Energy Assessment aimed to achieve 5.4 GWh in net energy savings and 1.3 MW in net peak demand savings at the generator for 2017. The Evaluator has determined that Home Energy Assessment achieved 7.007 GWh in net energy savings and 1.981 MW in net peak demand savings at the generator with 931 participants. These savings represent 4,576 tonnes of CO₂ eq in terms of annual avoided GHG emissions. By applying a weighted average EUL value of 20.0 years, the net lifetime energy savings have been established at 140.139 GWh.

Based on the evaluation results, the Evaluator makes the following recommendations, as listed in Table 17, to optimize this program component.

Table 17: Recommendations for Home Energy Assessment

No.	Recommendations
HEA-R1.	Review the current incentive structure to look for possible ways to simplify it. EAs and participants alike consider rebate calculations complicated. Knowing that ENS has already begun reviewing the incentive structure to make necessary changes, the Evaluator recommends continuing this effort while trying to make this structure as simple and straightforward as possible for both EAs and participants.
HEA-R2.	Conduct a billing analysis to review the overestimation ratio. The Evaluator has found that a new version of HOT2000 was used to calculate savings for 9 percent of HEA participants. The Evaluator predicts that this proportion will probably increase in 2018. The Evaluator recommends conducting a new billing analysis in the next evaluation to establish an overestimation ratio specific to the new version of HOT2000 for HEA.

7.1.4 Green Heat

In August 2017, Green Heat underwent a series of changes, including a change in process. On August 1, 2017, Green Heat was relaunched as a mail-in rebate program component, thereby eliminating the pre-approval process. The 2017 Green Heat offerings and eligibility criteria are categorized into two paths identified as the old path and new path. Homeowners who were pre-approved for Green Heat before August 1, 2017 were eligible under the old path.

The 2017 participation level was much higher than in previous years. Participants in previously non-electrically heated households were eligible to install an MSHP under Green Heat in 2017, which was not the case in previous years and partially explains the increase in participation. Eighty-seven percent of the measures installed through Green Heat in 2017 were MSHPs. In total, 1,288 MSHPs were installed in electrically heated homes, while 303 MSHPs were installed in non-electrically heated homes. ASHPs were also offered to non-electrically heated homes for a few months in 2017 and this resulted in an increase in participation for this measure. Moreover, the removal of the pre-approval process as of August 2017 likely contributed to higher participation.

Participants were largely satisfied with most elements of Green Heat, except the rebate amounts which received lower satisfaction ratings. Participants particularly appreciated the quality of the equipment installed in their home, the eligibility confirmation process, the clarity of Green Heat requirements, and Green Heat as a whole. The new Green Heat process is viewed positively by most contractors. Although about one third of interviewed contractors were unfamiliar with the new Green Heat path, the remaining contractors who knew about the new path appeared to be more satisfied with the new path compared to the old path.

Again this year, a billing analysis was conducted with participants who installed an MSHP to review energy savings. The Evaluator performed this analysis with a larger sample of participants than 2016 to establish more accurate unitary savings values. This value was lower than the one obtained in the 2016 evaluation, which explains why average savings per participant decreased significantly.

For the first time, a billing analysis was performed for the 2017 evaluation with participants who had installed an ASHP in previous years. Revised energy savings for ASHPs are also significantly lower than those tracked by ENS. This is partially because participants often have other heating systems (electrical or non-electrical) that also contribute to the home heating load.

New path participants using an electrical heating system prior to installing an MSHP exhibited a significantly higher free-ridership level than old path participants (51% compared to 35%). The Evaluator attributed this difference to the fact that participants can now submit a Green Heat application up to 90 days after purchasing their system and that less paperwork is now required, which might result in higher participation among less motivated individuals. Free-ridership values for old path participants remained similar to 2016.

Green Heat aimed to achieve 3.5 GWh in net energy savings and 1.7 MW in net peak demand savings at the generator for 2017. The Evaluator found that it achieved 2.980 GWh in net energy savings and 3.073 MW in net peak demand savings at the generator, with 1,829 measures installed. These savings represent 1,946 tonnes of CO₂ eq in terms of annual avoided GHG emissions. The net lifetime energy savings, based on a weighted average EUL value of 18.1 years, are 53.925 GWh.

Based on the evaluation results, the Evaluator makes the following recommendations, as listed in Table 18, to optimize this program component.

Table 18: Recommendations for Green Heat

No.	Recommendations
GH-R1.	Perform the ASHP billing analysis again in 2018. Similar to MSHPs, the billing analysis resulted in a major change made to the average savings values for ASHPs. As part of this analysis, participants were categorized based on their existing heating system type. Because of the small sample sizes for each category, it was difficult to establish distinct savings for each category. The Evaluator believes that the ASHP billing analysis should be conducted again in 2018 to obtain a larger sample of participants and improve the accuracy of savings.
GH-R2.	Conduct a survey with a larger sample of participants who installed MSHPs in non-electrically heated households. As part of the 2017 evaluation, a participant survey was conducted to establish the baseline scenario for MSHPs installed in previously non-electrically heated households. Unfortunately, the sample size was small because a low number of participants had installed MSHPs in non-electrically heated households at the time of the survey. The Evaluator believes that a survey with participants living in non-electrically-heated households should be conducted again in 2018 to determine the most appropriate baseline scenario to be used for such participants. This survey should ask participants about Green Heat's influence on their decision to purchase an MSHP and how this impacted the timing of their decision. Since MSHPs installed in non-electrically heated households generated lower savings, this feedback could provide more insight on whether the inclusion of this measure in Green Heat should be reconsidered.
GH-R3.	Improve the collection of technical information about ASHPs. Peak demand savings for ASHPs are based on technical information such as heating capacity and the coefficient of performance at a temperature of -15°C. In 2015, the Evaluator was able to locate technical information on 15 ASHP models and established an average unitary peak demand savings value of 3.04 kW. Although it was recommended in the 2015 evaluation report that ENS start collecting performance data about ASHPs at -15°C, such information is still not tracked by ENS. In the absence of more accurate performance data, the unitary savings value of 3.04 kW is still used. Considering the fact that the number of ASHPs installed through Green Heat has significantly increased in the past two years (from 52 in 2015 to 143 in 2017), the Evaluator reiterates the recommendation to start tracking ASHP performance data at -15°C to increase the accuracy of the peak demand savings calculations.

No.	Recommendations
GH-R4.	Gather additional information to further characterize the MSHP market. While the market indicators presented in the Market Evolution section of this report provide some indication of the evolution of the market for MSHPs, certain key data points were unavailable or rely on information from participating contractors. As a result, the Evaluator was unable to formulate a clear conclusion on the current state of the MSHP market in Nova Scotia. Additional data should be collected in 2018, such as: › Market share of efficient MSHPs in Nova Scotia from a broader data set, including market share of secondary systems › Minimum efficiency levels of units sold by contractors › Data on the incremental cost difference between standard versus high-efficiency MSHPs and Green Heat eligible MSHPs
GH-R5.	Develop a way for potential participants to better understand which ASHP equipment is eligible. Non-MSHP participants do not have a simple list of rebated equipment to choose from and therefore must rely on contractors to determine if equipment is eligible. To drive interest in non-MSHP measures, such as ASHPs, and prevent dissatisfied participants who purchased equipment thinking it was eligible for a rebate, ENS should develop a list of eligible equipment, similar to the list established for MSHPs. Contractors could be asked to develop and update this list.

7.1.5 Efficient Product Installation

A total number of 13,672 households participated in Efficient Product Installation in 2017, which was 18 percent lower than the total number of participants in Residential Direct Install and Rental Properties & Condos combined in 2016. A total of 377,875 efficient products were installed in 2017, which was 10 percent lower than in 2016.

Efficient Product Installation achieved a very high level of satisfaction among participants, who gave it an average rating of 9.0 on a 10-point scale, which was consistent with the scores obtained by Residential Direct Install and Rental Properties & Condos in past evaluations, indicating that the transition to Efficient Product Installation has been smooth and successful. As with Residential Direct Install in 2016, the main reason cited for this high level of satisfaction with Efficient Product Installation was the interaction with the installer. Other aspects of Efficient Product Installation, such as the quality of work completed, the time required to complete the work, the energy-efficient products installed, and the information provided by the installer, also received strong satisfaction ratings.

The on-site visits and unitary savings review resulted in no major changes to the values used to calculate the savings of Efficient Product Installation, with the exception of one product, the smart power controller. In 2016, smart power controllers had an installation rate of 78 percent, which was established using the participant survey results. Since the 2016 site visit results suggested that the actual installation rate might be lower, the 2017 sample of site visits including smart power controllers was increased to 76 participants to allow the Evaluator to obtain a satisfactory margin of error for establishing the installation rate. The low installation rate has thus been confirmed by the 2017 evaluation, despite the efforts made by ENS to target tech-savvy participants and limit the number of devices installed in each home. The Evaluator has no further recommendation to make on how to improve the installation rate and recommends continuing to offer this product type through Efficient Product Installation if it is still cost-effective despite its low installation rate.

The free-ridership level was established at 26 percent for owners and 14 percent for tenants, resulting in an overall free-ridership level of 25 percent for LED lamps. The Evaluator established the internal spillover level at 6 percent for owners and at 1 percent for tenants, resulting in an overall level of 6 percent. Overall, the weighted average NTGR for low-income and non-low-income participants combined was established at 0.92.

Efficient Product Installation aimed to achieve 24.4 GWh in net energy savings and 3.6 MW in net peak demand savings at the generator in 2017. The Evaluator found that it achieved 17.877 GWh in net energy savings and 2.129 MW in net peak demand savings at the generator in 2017. These savings represent 11,675 tonnes of CO₂ eq in terms of annual avoided GHG emissions. By applying a weighted average EUL value of 8.8 years, Efficient Product Installation's net lifetime energy savings have been established at 157.288 GWh.

In summary, Efficient Product Installation continues to achieve high levels of participation and savings even though its predecessors, Residential Direct Install and Rental Properties & Condos, had been in the market for several years. Furthermore, participant satisfaction remains very high. The biggest challenge for Efficient Product Installation in the coming years will be related to the diminishing potential for LED lamp installation as fewer incandescent lamps are found in participating households.

Based on the evaluation results, the Evaluator makes the following recommendations, as listed Table 19, to optimize this program component.

Table 19: Recommendations for Efficient Product Installation

No.	Recommendations
EPI-R1.	Document the energy-saving potential related to halogen incandescents and CFL lamp replacements. The tracking report indicated that the average number of A-type LED lamps installed per household significantly decreased among participating single-family homes. Although EPI achieved high savings in 2017, this trend suggests that fewer incandescents are present in homes, and will consequently provide fewer opportunities for LED replacements in the future. The Evaluator recommends that ENS start gathering information about the types of lamps installed in EPI participants' homes to analyze the savings potential that can be tapped if general-service lamp types other than incandescents are made eligible for replacement.

7.1.6 New Home Construction

The 2017 New Home Construction participation level was at its lowest since 2011. A total of 420 participants completed projects and generated electrical savings under New Home Construction in 2017. Six participants completed a project through the Passive House pilot.

The participants and builders interviewed expressed moderately high satisfaction ratings for New Home Construction, respectively averaging 6.6 and 7.2 on a 10-point scale. The main reason for dissatisfaction among both participants and builders was that the rebate was too low. Builders also highlighted that there was not enough information about New Home Construction and its process, and the long wait time it took to receive the rebate. Although half of the participants did not provide any recommendations on how to improve New Home Construction, some suggested making the participation process simpler as one of the main recommendations. Noteworthy is that all 19 surveyed non-participant builders had participated in New Home Construction in the past. The main reasons mentioned for not participating in New Home Construction in 2017 were that the rebate was not worth the effort and that the program component was too complicated.

In 2017, no savings review was performed as part of the impact evaluation, so the Evaluator only verified that energy savings were calculated and compiled adequately. The Evaluator established New Home Construction free-ridership at 29 percent, a level similar to 2016 (27%), and the market effects at 35 percent, which represents a high increase compared to 2016 (20%). The Evaluator established the Passive House pilot's free-ridership at 61 percent. Based on the free-ridership and market effects levels established, the NTGRs for New Home Construction and the Passive House pilot were established at 1.06 and 0.39 respectively.

New Home Construction and the Passive House pilot combined aimed to achieve 4.0 GWh in net energy savings and 0.9 MW in net peak demand savings at the generator for 2017. The Evaluator found that they achieved 3.371 GWh in net energy savings (3.351 GWh for NHC and 0.020 GWh for Passive House) and 0.954 MW in net peak demand savings (0.948 MW for NHC and 0.006 MW for Passive House) at the generator in 2017. Together, the savings generated by NHC and its Passive House pilot resulted in 2,202 tonnes of CO₂ eq in terms of annual avoided GHG emissions. The net lifetime energy savings amounted to 101.242 GWh, based on a weighted average EUL of 30.0 years.

Based on the evaluation results, the Evaluator makes the following recommendations, as listed in Table 20, to optimize this program component.

Table 20: Recommendations for New Home Construction

No.	Recommendations
NHC-R1.	Conduct a process evaluation for NHC in 2018. During the 2017 evaluation, participants and builders made certain criticisms about NHC, especially on incentive levels and the participation process. Also, the NHC participation level continued to decrease. In light of these findings and the substantial changes made to NHC in 2017, the Evaluator recommends conducting a process evaluation of NHC next year to determine if current program component processes, parameters and model of delivery are optimized to meet market needs. The process evaluation's scope could include a benchmarking study of other Canadian or North American jurisdictions to compare NHC to other similar programs, and an in-depth consultation with builders and other key actors involved in the residential new construction market to find the most effective ways to generate more projects through a simple and straightforward participation process. Market data should also be collected to obtain insights about market forces that may be influencing the decline in NHC participation.
NHC-R2.	Conduct a billing analysis to review the overestimation ratio. The current overestimation ratio was obtained from a billing analysis of Home Energy Assessment participant data. In past years, no billing analyses were conducted with NHC participants since only a few participants had their as-built energy consumption value available. Now that energy consumption is available for more participants and a new version of HOT2000 is being used to calculate energy savings, the Evaluator recommends conducting a new billing analysis in the next evaluation to establish an overestimation ratio specific to new houses under NHC and the new version of HOT2000.

7.2 Business, Non-Profit and Institutional

7.2.1 Business Energy Rebates

In 2017, a total of 288 Mail-in projects were implemented by 213 unique participants. As for Instant Rebates, a total of 315,867 rebated products were sold by distributors in 2017 (compared to 294,942 products in 2016 and 215,121 products in 2015), constituting a 7 percent increase from 2016.

The level of satisfaction with Mail-in remains high for 2017, with participants rating it on average 9.0 on a 10-point scale. Participants were asked about specific aspects of Mail-in, namely interactions and communications with contractors, distributors and consultants, as well as rebate amounts, the application forms, paperwork, and the time required to receive the rebate. Mail-in succeeded in maintaining high satisfaction scores with all these service aspects for a second year in a row, indicating sustained improvement in Mail-in satisfaction since 2015. Eight distributors involved in Instant Rebates were interviewed. Overall satisfaction with the service was rated an average score of 6.5 on a 10-point scale, which is consistent with the 2016 result of 6.4.

The results of the site visits and project reviews conducted for Mail-in revealed that only small adjustments were required to tracked energy savings. As was the case in previous years, adjustments to peak demand savings were slightly higher because of changes made to peak coincidence factors. Few changes were made to the Instant Rebates tracked savings.

The influence of Mail-in on participant decisions to implement energy efficiency projects remains high since the free-ridership level was established at 14 percent and no spillover was identified in 2017. This level is consistent with what was observed in 2016 (16%). The Evaluator used a new approach to measure the free-ridership level of Instant Rebates in 2017, using both the participant survey and distributor interviews. The Evaluator calculated free-ridership levels for four LED product categories. Those products have a free-ridership level between 32 and 38 percent, while the overall free-ridership level for Instant Rebates is 27 percent.

Business Energy Rebates aimed to achieve 37.2 GWh in net electricity savings and 5.9 MW in net peak demand savings at the generator for 2017. In 2017, Business Energy Rebates achieved the highest savings levels in its history, with 46.583 GWh in net energy savings and 7.286 MW in net peak demand savings at the generator. This result is due in part to the high participation in Instant Rebates which achieved 30.805 GWh in 2017 compared to 24.299 GWh in 2016, along with an increase in average unitary savings of rebated products.

These savings represent 30,423 tonnes of CO₂ eq in annual avoided GHG emissions. The net lifetime energy savings are 547.135 GWh based on a weighted average EUL value of 11.7 years.

Based on the evaluation results, the Evaluator makes the following recommendations, as listed in Table 21, to optimize this program component.

Table 21: Recommendations for Business Energy Rebates

No.	Recommendations
BER-R1.	Continue to monitor the market evolution of LED lamps and adapt the BER offer when needed. The 2017 evaluation served to confirm solid market evolution. The high number of LEDs sold during the 2017 year, their declining retail prices, as well as the increased market share and free-ridership levels for these products indicate that market barriers are decreasing. Moreover, the market analysis confirmed that while LED products are still in a growth phase, they are approaching maturity as the BNI sector increasingly adopts these technologies. The Evaluator therefore recommends that ENS continue to monitor the evolution of the LED market by examining market indicators such as those discussed in Section 7 to identify when some product categories should be removed from the service due to a high level of market transformation.
BER-R2.	Identify opportunities to diversify the portfolio of projects completed through BER Mail-In. As demonstrated in the 2017 evaluation, lighting projects account for over 60 percent of gross savings in BER Mail-in. Since Instant Rebates is designed to offer almost exclusively lighting products, Mail-in is the best option to diversify the BER portfolio which generates the most savings of all ENS program components. With LED lighting products becoming increasingly popular and transforming the lighting market, ENS is at risk of seeing its savings decline for this service. The Evaluator expects to see continued increases in both free-ridership and baselines as the technology is more widely adopted. Therefore, the Evaluator recommends that ENS identify BNI sectors that are currently underrepresented in the Mail-in service and that could potentially generate significant savings.
BER-R3.	Continue and improve the tracking of BER Instant Rebates participants. The 2017 evaluation was the first time that the Evaluator had access to a list of Instant Rebates participants and could therefore conduct a survey of participants. However, the participant list did not include all participants and information was not collected systematically. The Evaluator recommends that ENS continue tracking individuals and businesses participating in the service. ENS should document the data-collection process and, if possible, record the proportion of tracked participants among all participants as well as the savings attributable to each participant. This would allow the Evaluator to refine the quality of the impact analysis, notably with better estimations of annual hours of use as well as free-ridership and spillover levels.

7.2.2 Custom

In 2017, the three services included under Custom (Retrofit, New Construction, and Building Optimization) resulted in 78 projects generating savings and 58 projects completed. Retrofit accounted for the majority of savings achieved through Custom and accounted for 79 percent of the Custom projects completed in 2017. Participation in New Construction and Building Optimization remained low, with only six projects completed in each service in 2017. In 2017, ENS made efforts to provide more support for participants to better understand the Building Optimization process. The impact of this change on participation levels should be noticeable in 2018.

Consultants were satisfied with Retrofit requirements, their interactions with ENS, and the expansion in business that Retrofit provided their firms. Participants provided multiple examples of aspects of Retrofit that they especially appreciated other than the incentives. This list included: help convincing decision-makers to go forward with a project; the technical assistance offered by Retrofit; and their interactions with ENS staff, especially the Business Development Managers (BDMs). A strong indication of the high satisfaction level is that all consultants and almost all participants indicated that they are or are planning to participate in the Retrofit service again. Moreover, one consultant and one participant, both with experience in using other efficiency programs elsewhere in Canada, described the ENS Retrofit service as exceptional in comparison to its peers.

For Retrofit, the Evaluator's review of project files and on-site visits resulted in minor adjustments made to variables used for the calculation of gross energy savings, such as the hours of operation. Despite the overall improvement in the availability and quality of project documentation, other improvements should still be made to the Measurement and Verification (M&V) procedures, because four projects lacked supporting M&V documentation. The lack of documented M&V data and information prevented the Evaluator from revising the tracked savings of these projects, which accounted for 19.4 percent of the tracked energy savings and 15.9 percent of the peak demand savings of the sampled projects.

A detailed technical review was performed for five of the projects completed under New Construction. All documented energy efficiency measures had been implemented. However, the Evaluator found discrepancies between the model used for the simulation and the reference building as well as errors in the subsequent savings calculations performed with the models' output values. Consequently, the five projects reviewed have been adjusted and the gross energy savings for New Construction were reduced by 27 percent. For similar reasons, Building Optimization's energy savings decreased by 12 percent upon evaluation.

The NTGR was not measured for Retrofit in 2017. The average free-ridership of the past five years was used, and no spillover was considered since it has been nil for the past three years. No free-ridership is calculated for New Construction because the participant-specific baseline used by ENS results in gross savings being net of free-ridership. Free-ridership for Building Optimization was confirmed in 2017 to be nil through interviews with participants.

Collectively, Retrofit, New Construction and Building Optimization aimed to achieve 24.8 GWh in net energy savings and 1.9 MW in net peak demand savings at the generator in 2017. The Evaluator found that together they achieved 21.005 GWh in net energy savings and 3.637 MW in net peak demand savings at the generator in 2017. These savings represent 13,719 tonnes of CO₂ eq in terms of annual avoided GHG emissions. By applying a weighted average EUL value of 14.9 years, Custom's net lifetime energy savings have been established at 313.977 GWh.

Based on the evaluation results, the Evaluator makes the following recommendations, as listed in Table 22, to optimize this program component.

Table 22: Recommendations for Custom

No.	Recommendations
Custom-R1.	Continue relying on BDMs to assist participants and find new markets. The 2017 evaluation showed that many participants heard about Retrofit from a BDM and those who worked with a BDM were satisfied with their interactions. This support included providing answers to the participants' inquiries, especially about eligibility requirements, and informing about the latest service changes. In some cases, these relationships also resulted in identifying additional projects. The BDMs have successfully brought in numerous participants from the aquaculture industry and are looking for new markets to replicate this success. To maintain a high level of participation in Custom, the Evaluator recommends that ENS continue to expand outreach efforts via BDM contacts with specific business groups in the industrial and agricultural sectors.
Custom-R2.	Continue conducting an in-depth review of energy models as part of the evaluation and improve ENS staff's capacity to identify discrepancies in energy models. The more in-depth review of energy models conducted during the 2017 evaluation identified discrepancies in all five projects and resulted in significant downward adjustments to savings. Modelling of heat pump systems and manual calculations to adjust baselines were most problematic. This showed that a systematic review should be conducted, even if energy models are prepared by experienced consultants. The Evaluator also recommends that ENS provide tools and training to their staff so that they are better able to conduct technical reviews of energy models. Those tools could include checklists of parameters to validate for certain types of projects or building systems.
Custom-R3.	Establish clear objectives for Building Optimization. The Building Optimization projects reviewed this year differed widely in scope. Some projects involved detailed investigative work to tap into deep energy savings, while others were limited to replacing known broken equipment or repairing recently installed mechanical systems that had never worked as intended. While all projects generated savings and all participants benefited from Building Optimization, the participants' needs were quite different from one another. The Evaluator believes that clearly establishing the objectives of the service would result in providing the right level of support to each participant and maximizing the added value of ENS support, that is, involving specialized consultants in retrocommissioning only when detailed investigation of energy-saving opportunities is a project's objective. Better defining objectives and eligibility criteria would also clarify how the basecase should be established. For example, the project whose mechanical systems had never worked as intended had a basecase with such a high number of hours of use that the cooling towers would have provided far too much cooling to the building. An analysis of what should qualify as an acceptable Building Optimization project would allow for distinguishing between the ordinary repairs that a building owner needs to make his or her building function normally and the real energy-saving opportunities for improving energy performance above a minimum level. Better objective-setting would allow

No.	Recommendations
	for allocating Building Optimization's financial and technical resources to those projects that will most benefit from them.
Custom-R4	Better document the basecase conditions for Building Optimization projects. The Evaluator observed that the basecase conditions were sometimes not measured or documented (using photos, for instance). Since these conditions cannot be verified because they no longer exist after project implementation, the Evaluator recommends that ENS gather more information about the pre-implementation conditions to support savings evaluation afterwards.

7.2.3 Energy Management Information Systems

In 2017, four participants reported savings, and they were the same participants that had generated savings in 2015 and 2016. Three additional projects were at different stages of Energy Management Information Systems and had not yet generated savings by the end of 2017.

The four participants with reported savings were asked questions regarding their satisfaction with Energy Management Information Systems, any barriers they encountered and their improvement suggestions. Overall, satisfaction with Energy Management Information Systems was high among all the participants and few challenges and barriers were mentioned. As for recommendations for improving Energy Management Information Systems, participants suggested that ENS could better help them develop a growth and sustainability plan, help to involve participating facilities' maintenance staff in the process, and that ENS could provide more support and manpower during the installation process.

In 2017, incremental savings were calculated by the service provider by establishing an incremental baseline⁸, or were estimated by ENS by finding the difference between 2017 and 2016 cumulative savings. As part of the incremental savings review, savings were adjusted for the two projects for which incremental savings were estimated. To review the incremental savings, the Evaluator established an incremental baseline based on the 2016 data. This resulted in a decrease of incremental energy savings. As with the cumulative savings, the Evaluator established peak demand savings for two additional projects, resulting in an increase in peak demand savings. For the two projects with incremental savings calculated by the service provider, the Evaluator found that the incremental baselines used by the service provider were adequate.

Again in 2017, free-ridership and spillover effects were assumed to be nil for Energy Management Information Systems, based on the limited market penetration of energy management information systems. This assumption was confirmed by the participant interviews conducted in 2015.

⁸ Referring to the systems, time period, energy use, or conditions that provide a reference to which later performance of an energy conservation measure can be compared to obtain incremental savings.

Energy Management Information Systems aimed to achieve 4.0 GWh in net energy savings and 0.1 MW in net peak demand savings at the generator for 2017. The Evaluator concluded that it achieved 1.402 GWh in net energy savings and 0.255 MW in net peak demand savings at the generator. These savings represent 916 tonnes of CO₂ eq in terms of annual avoided GHG emissions. By applying an EUL value of 2.9 years, Energy Management Information Systems net lifetime energy savings were established at 4.112 GWh.

Based on the evaluation results, the Evaluator makes the following recommendations, as listed in Table 23, to optimize this program component.

Table 23: Recommendations for Energy Management Information Systems

No.	Recommendations
EMIS-R1.	Ensure that the tracking sheet is complete and accurate. While reviewing the project documentation, the Evaluator found several discrepancies between the savings figures reported in the final tracking sheet and the savings figures documented in the annual savings reports. Also, two of the four projects claimed peak demand savings in their annual reports; however, this information was not tracked by ENS in the tracking sheet. The Evaluator recommends that, from now on, the final tracking sheet be updated with the final values documented in the annual reports and that annual peak demand savings be tracked.
EMIS-R2.	Design baseline regressions and plan M&V activities to ensure accurate savings calculations even when changes occur in the facility. This year, the Evaluator discovered that one project had an increase in the weekend production time, which impacted potential energy savings for the measures implemented through EMIS. Since the production level variable was not documented, the Evaluator could not adjust the savings accordingly. To avoid such an issue, the Evaluator suggests that ENS and the service provider proactively identify and track independent variables so that the baseline remains relevant even when changes in operations occur. The Evaluator also recommends that M&V activities and non-routine adjustments be planned as needed. In the case of the Custom Retrofit compressed-air projects implemented after the baseline period for instance, ENS and the service provider could have planned on the implementation of those Custom Retrofit projects by gathering the baseline data before their implementation and made the necessary baseline adjustments afterwards.

7.2.4 Small Business Energy Solutions

In 2017, among the 417 projects completed through Small Business Energy Solutions, 367 were implemented by following the DIY path and 50 were implemented by following the audit path. Those projects included 10 projects completed by two Affordable Multifamily Housing Pilot participants. In 2017, the DIY projects accounted for 88 percent of all the implemented projects and 82 percent of the total net savings achieved through Small Business Energy Solutions.

Overall, participants were very satisfied with Small Business Energy Solutions again this year. They reported a high level of satisfaction with the equipment installed in their businesses. Except for two participants who were less satisfied with their contractors, most participants were very satisfied with the services received from their contractors and the ease of finding one. Audit recipients were also largely satisfied with various aspects of the audit, such as professionalism of the auditor and usefulness of the audit. The other few participants who were less satisfied indicated dissatisfaction with the amount of the incentive (n=2) and the energy savings achieved (n=2).

The Evaluator reviewed ENS's gross savings estimates by conducting a desk review using the information contained in the tracking system, the CIRx Screening Tool and the findings from the on-site visits. The results of this review were similar to the previous evaluations, with some minor improvements observed compared to the 2016 evaluation results. Most of the discrepancies found were related to the operating conditions found on site, which did not match those assumed in the tracked savings calculations. Based on the site visits results, there were four commonly adjusted parameters: the baseline wattage, the efficient wattage, the hours of use and the peak coincidence factors for lighting projects. Given the sampling methodology used and the less-than-statistically-significant difference between the adjustment ratios of the audit and DIY paths, one single overall adjustment ratio was calculated for all the measures implemented via the two paths. For energy savings, the adjustment ratio was found to be equal to 0.889 and 0.744 for peak demand savings.

The Evaluator assessed the free-ridership and internal spillover effects associated with Small Business Energy Solutions by conducting a telephone survey and on-site visits with participants. The survey results revealed a free-ridership level of 7 percent for the audit path and 13 percent for the DIY path, and the spillover was found to be nil.

Small Business Energy Solutions aimed to achieve net electricity savings of 8.8 GWh and net peak demand savings of 1.9 MW at the generator in 2017. The Evaluator has determined that Small Business Energy Solutions achieved 7.887 GWh in net energy savings and 1.363 MW in net peak demand savings at the generator. These savings represent 5,151 tonnes of CO₂ eq in annual avoided GHG emissions. Based on a weighted average EUL value of 12.8 years, Small Business Energy Solutions's net lifetime energy savings are 100.854 GWh.

Based on the evaluation results, the Evaluator makes the following recommendations, as listed in Table 24, to optimize this program component.

Table 24: Recommendations for Small Business Energy Solutions

No.	Recommendations
SBES-R1.	Implement an internal procedure to identify and thoroughly review the most complex custom projects to ensure savings calculation accuracy. During the projects review, the Evaluator found one large custom project which was based on an incorrect energy model and that could not be revised with the limited information available. Modelling software or complex engineering equations are often used to estimate custom projects' savings. Validating their savings requires specialized technical knowledge and a more in-depth review procedure, unlike other more typical SBES projects. Since custom measures often represent the ones with the largest savings, ENS should review in greater detail the savings calculations for these custom measures. To that end, it may be advisable for the SBES team to seek assistance from the Custom Incentive Program's personnel, who already have the skills and expertise needed for reviewing this type of project.
SBES-R2.	Closely monitor the new lighting application forms' effectiveness to confirm that they are achieving their intended goals. Following last year's recommendations, ENS developed new lighting application forms to better document on-site operating conditions, thereby enabling more accurate savings estimates. Since these forms were not put in use until January 2018, the Evaluator could not judge the impact these new forms had with respect to their intended goals. Nonetheless, the similarities between this year and last year in the adjustments made to lighting projects suggest that these new forms, if properly used, could indeed help improve savings calculation accuracy. ENS should carefully monitor how participants complete these forms and how the collected information is used to calculate the savings. Special attention should be paid to the peak coincidence factor used to calculate the peak demand savings to ensure that the daily operating schedule coincides with the system peak demand period, since the Evaluator found multiple cases where adjustments were required.

No.	Recommendations
SBES-R3.	Investigate new ways to encourage the implementation of non-lighting measures to increase their share of savings and ultimately increase SBES's total savings. Although SBES offers a wide variety of measures, lighting retrofits accounted for 82 percent of SBES's total gross savings in 2017. This predominance is not surprising among DIY participants, because lighting upgrades are energy-saving opportunities which are easy to identify. Surveyed participants mentioned that a lack of knowledge about equipment is one main barrier to installing energy-efficiency upgrades; so this is consistent with the small number of projects that include technologies that are more complex than lighting. With SBES gaining in maturity and as the market for energy efficient lighting becomes saturated, the Evaluator believes that ENS would benefit from exploring various options to favor a wider variety of measures among the DIY participants to ensure SBES's continued strong performance. Such options could include the development of new marketing and educational materials to better promote non-lighting measures and educate DIY participants with respect to dormant energy-saving opportunities, other than lighting, in their facilities. Project analyses under in the audit path can be used to identify sector-specific opportunities and provide content for the development of success stories on non-lighting measures. Another option would be to provide additional support to participants who do not complete the audit path, for instance by having an ENS staff member follow up to help them consider non-lighting measures if the facility includes other large energy-consuming equipment.

7.2.5 Codes and Standards

The 2017 evaluation of Codes and Standards has estimated the 2017 annual impact in terms of energy and peak demand savings as a result of introducing new regulations into the Nova Scotia market governing the products targeted by the federal government's Amendment 13 to the Energy Efficiency Regulations and the provincial regulations imposing greater stringency and a wider scope on existing MEPS.

The overall energy and peak demand savings for Codes and Standards have been established at 21.914 GWh and 4.028 MW at the generator respectively. These savings represent 14,312 tonnes of CO₂ eq in terms of annual avoided GHG emissions.

The Evaluator makes the following recommendation (in Table 25) to optimize the evaluation of Codes and Standards.

Table 25: Recommendation for Codes and Standards

No.	Recommendation
CS-R1.	Include some Amendment 13 standards in the 2018 evaluation. The new standards set forth in Amendment 13 came into force at the end of June 2017. Most of these new standards were not included in the 2017 evaluation since their impact was expected to be limited until January 2018 while retailers sell their existing stocks. For the 2018 evaluation, these new standards should be considered for inclusion. However, a review of Amendment 13 shows that many of the new MEPS will only have a limited impact in terms of savings, since the new MEPS either bring very little change to the standard level or target products with small markets. The Evaluator therefore recommends selecting two or three products from the Amendment 13 standards based on their savings potential and a consideration of how much effort will be needed to estimate their market sizes. The 2017 evaluation showed that clothes washers (Amendment 13) provided considerable savings and should still be included in the 2018 evaluation, whereas refrigerators (Amendment 13), due to their low savings, should no longer be included. The Evaluator recommends continuing to evaluate the impacts associated with lighting, street-lighting and building codes in 2018 since they provide significant savings.

LIST OF APPENDICES

The following are presented in the 2017 DSM Programs Evaluation Executive Summary – Appendices.

Appendix I - Overall : Bibliography

Appendix II - Overall : Calculation of Margins of Error

Appendix III - Overall : NTGR Calculations



ECONOLER

2017 DSM PROGRAMS EVALUATION

EXECUTIVE SUMMARY

EFFICIENCY NOVA SCOTIA

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Appliance Retirement	DEER, <i>DEER2014 EUL Table</i> , May 2014.
	ECOX. <i>Technical Information Bulletin No. E-004-EN: SEER</i> , www.ecoxline.com , (Last accessed March 3, 2016).
	ENERGY STAR. <i>Program Requirements for Dehumidifiers Eligibility Criteria V4.0, Partner Commitments</i> , October 2016
	ENERGY STAR. <i>Program Requirements for Room Air Conditioners: Eligibility Criteria Version 4.0</i> , October 26, 2015.
	KEMA Inc., <i>Residential Refrigerator Recycling Ninth Year Retention Study</i> , Study ID Nos. 546B, 563, Prepared for Southern California Edison Company, June 22, 2004.
	NATIONAL RENEWABLE ENERGY LABORATORY (NREL). <i>The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 7: Refrigerator Recycling Evaluation Protocol</i> , Prepared by the Camus Group, April 2013.
	NATURAL RESOURCES CANADA. <i>Refrigerators, Refrigerators-Freezers and Wine Chillers</i> , http://www.nrcan.gc.ca/energy/regulations-codes-standards/products/6877 (Last accessed November 6, 2017).
	NATURAL RESOURCES CANADA. <i>Energy Efficiency Ratings: Search – Freezers</i> , http://oee.nrcan.gc.ca/pml-lmp/index.cfm?action=app.download-telecharger&appliance=FREEZERS (Last accessed January 19, 2018)
	NATURAL RESOURCES CANADA. <i>Registration and publication of Regulations Amending Canada's Energy Efficiency Regulations</i> , http://www.nrcan.gc.ca/energy/regulations-codes-standards/6965 (Last accessed December 6, 2017).
	NATURAL RESOURCES CANADA'S OFFICE OF ENERGY EFFICIENCY. <i>EnerGuide Room Air Conditioner Directory 2012</i> May 2012.
	NATURAL RESOURCES CANADA'S OFFICE OF ENERGY EFFICIENCY. <i>Air Conditioning Your Home</i> , 2003.
	NEW YORK DEPARTMENT OF PUBLIC SERVICE, <i>New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs Residential, Multi-Family, and Commercial/Industrial Measures</i> , October 15, 2010.
	ONTARIO POWER AUTHORITY (OPA). <i>2011 Prescriptive Measures and Assumptions, Release Version 1</i> , March 2011.
	RETScreen. <i>Climatic Data for Halifax International Airport</i> .
	STATISTICS CANADA. <i>Table 153-0145, Households and the environment survey, primary heating system</i> . http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=1530145&&pattern=&stByVal=1&p1=1&p2=31&tabMode=dataTable&csid= (Last accessed January 18, 2018).
	STATISTICS CANADA. <i>Table 153-0147 - Households and the Environment Survey, air-conditioners, Canada, provinces and census metropolitan areas, 2013</i> , CANSIM, March 10, 2015.
	U.S. DEPARTMENT OF ENERGY, OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY. <i>Energy Conservation: Program for Consumer Products: Energy Conservation Standards for Refrigerators, Refrigerator-Freezers and Freezers, 10 CFR Part 430</i> , April, 28, 1997
	U.S. EPA and DOE, <i>Savings Calculator for ENERGY STAR Qualified Appliances</i> , October 2016.

Program Components	Bibliographic References
Instant Savings	AD HOC RECHERCHE. <i>Rapport d'évaluation, Programme : Produits Mieux Consommer – Électroménagers Energy Star (Années 2008 et 2009).</i>
	ADS ASSOCIÉS. <i>Évaluations des effets énergétiques combinés des mesures d'économies d'énergie – résidence unifamiliale</i> , Report presented to Hydro-Québec, 1992.
	BARCLAY, D., VON TRAPP, K. AND MIZIOLEK C. <i>Party Like It's 2020: EISA Phase 2 – An Examination of DOE Rulemaking and Implications for Programs</i> , Poster presented at the 2017 International Energy Program Evaluation Conference, Baltimore, MD, 2017.
	CORPORATE RESEARCH ASSOCIATES INC., <i>2016 Socket Study</i> , Final Report Prepared for Efficiency Nova Scotia, December 2016.
	DATABASE FOR ENERGY EFFICIENCY RESOURCES (DEER). <i>DEER2014 EUL Table</i> , http://www.deeresources.com/index.php/23-deer-versions/27-deer-2014 .
	DAVID ROGERS, PowerSmart Engineering, <i>Smart Strip Electric Savings Usability</i> , October 2008
	EFFICIENCY MAINE. <i>Retail/Residential Technical Reference Manual Version 2018.1</i> , July 2017.
	EFFICIENCY VERMONT. <i>Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions</i> , March 2015.
	EFFICIENCY VERMONT. <i>Electric Usage Chart Tool</i> , www.efficiencyvermont.com/tips-tools/tools/electric-usage-chart-tool (Last accessed August 11, 2017).
	ENERGY STAR. <i>Certified Products – Find and Compare Products – Room Air Cleaners</i> , https://www.energystar.gov/productfinder/product/certified-room-air-cleaners/ (Last accessed August 11, 2017).
	ENERGY STAR. <i>Certified Residential Clothes Washers</i> , https://www.energystar.gov/productfinder/product/certified-clothes-washers/ (Last accessed January 8, 2018).
	ENERGY STAR. <i>Certified Residential Refrigerators</i> , https://www.energystar.gov/productfinder/product/certified-residential-refrigerators/ (Last accessed December 1, 2016)
	ENERGY STAR. <i>ENERGY STAR® Program Requirements Product Specification for Dehumidifiers – Eligibility Criteria 4.0</i> , https://www.energystar.gov/sites/default/files/ENERGY%20STAR Dehumidifiers V4%200 Specification Final 1.1.pdf (Last accessed August 2017).
	ENERGY STAR. <i>Learn About Brightness</i> , https://www.energystar.gov/products/lighting_fans/light_bulbs/learn_about_brightness (Last accessed January 04, 2018).
	ENERGY STAR. <i>Ventilating Fans</i> , http://www.nrcan.gc.ca/energy/products/categories/cooling-ventilating/ventilating/fans/16201 (Last accessed November 28, 2017).
	Environmental Protection Agency. <i>Savings Calculator for Energy Star Qualified Appliances (2014)</i> , http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx (Last accessed November 8, 2017).
	EVERETT ROGERS. <i>Diffusion of Innovations</i> , 1983.
	GDS Associates, Inc., <i>Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures</i> , Report prepared for the England State Program Working Group, June 2007.
	INDEPENDENT ELECTRICITY SYSTEM OPERATOR, <i>IESO Prescriptive Measures and Assumptions List</i> , October 2015.
	ILLINOIS ENERGY EFFICIENCY STAKEHOLDER ADVISORY GROUP. <i>Illinois Statewide Technical Reference Manual for Energy Efficiency Version 6.0, Volume 3</i> , February 2017.
	LIGHTING RESEARCH CENTER - RENSSELAER POLYTECHNIC INSTITUTE. <i>Lighting Patterns for Homes. Light Bulb Features</i> , www.lrc.rpi.edu/patternbook/resources/lamp_features.asp (Last accessed January 19, 2018).

Program Components	Bibliographic References
	MASSACHUSETTS ELECTRIC AND GAS ENERGY EFFICIENCY PROGRAM ADMINISTRATORS. <i>Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures, 2016-2018 Program Years – Plan Version</i> , October 2015.
	NATIONAL GRID. <i>Rhode Island Technical Reference Manual for Estimating Savings from Energy Efficiency Measures – 2016 Program Year</i> , October 2015.
	NATIONAL RENEWABLE ENERGY LABORATORY (NREL). 4.1.2. <i>In-service Rates</i> . http://ump.pnnl.gov/showthread.php/4839-4.12-In-Service-Rate (Last accessed February 16, 2014).
	NATIONAL RENEWABLE ENERGY LABORATORY (NREL). <i>Uniform Methods Protocol Chapter 6: Residential Lighting Evaluation Protocol</i> , February 2014.
	NATURAL RESOURCES CANADA. <i>Amendment 13, December 2016</i> , http://www.nrcan.gc.ca/energy/regulations-codes-standards/18419 (Last accessed January 26, 2018).
	NATURAL RESOURCES CANADA. <i>CANADA'S ENERGY STAR Simple Savings Calculator (v11.3)</i> , February 2017, http://oe.nrcan.gc.ca/residential/business/energystar/procurement/calculator.cfm (Last accessed November 29, 2017).
	NATURAL RESOURCES CANADA. <i>"Energy Efficiency Regulations. General Service Lamps and Modified Spectrum Incandescent Lamps"</i> , www.nrcan.gc.ca/energy/regulations-codes-standards/products/6869 (Last accessed January 19, 2018).
	Natural Resources Canada, <i>"Forward Regulatory Plan 2017-19"</i> , http://www.nrcan.gc.ca/energy/regulations-codes-standards/18318 (Last accessed January 19, 2018).
	NATURAL RESOURCES CANADA. <i>General Service Lamps</i> , http://www.nrcan.gc.ca/energy/regulations-codes-standards/products/6869 (Last accessed January 9, 2018).
	NATURAL RESOURCES CANADA. <i>Notice – Publication of Energy Efficiency Regulation, 2016-Amendment 13</i> . http://www.nrcan.gc.ca/energy/regulations-codes-standards/18419 (Last accessed February 5, 2018)
	NATURAL RESOURCES CANADA. <i>Refrigerators, Combined Refrigerator-Freezers and Freezers Energy Efficiency Regulations</i> , https://www.nrcan.gc.ca/energy/regulations-codes-standards/6965 (Last accessed December 1, 2016).
	NATURAL RESOURCES CANADA, <i>Regulations and Standards – Dehumidifiers</i> , http://www.nrcan.gc.ca/energy/regulations-codes-standards/products/6889 (Last accessed August 3, 2017).
	NATURAL RESOURCES CANADA. <i>Search: Clothes Washers Energy Efficiency Ratings</i> , http://oe.nrcan.gc.ca/pml-lmp/index.cfm?action=app.search-recherche&appliance=CLOTHESWASHERS . (Last accessed January 8, 2018).
	NMR GROUP INC. AND DNV GL. <i>Northeast Residential Lighting Hours-of-Use Study</i> , May 5, 2014.
	NORTHEAST ENERGY EFFICIENCY PARTNERSHIPS. <i>Mid-Atlantic Technical Reference Manual Version 7.0</i> , May 2017.
	ONTARIO POWER AUTHORITY (OPA). <i>2011 Prescriptive Measures and Assumptions Version 1</i> , March 2011.
	ROSENBERG M. AND HOEFGEN L. <i>Market Effects and Market Transformation: Their Role in Energy Efficiency Program Design and Evaluation</i> , Prepared for the California Institute of Energy and the Environment, 2009.
	U.S. DEPARTEMENT OF ENERGY, <i>DOE Life-Cycle Cost and Payback Period tool</i> , www1.eere.energy.gov/buildings/appliance_standards/residential/clothes_washers_support_stakeholder_negotiations.html (Last accessed May 2017).
	US EPA, <i>"Summary of the Energy Independence and Security Act. Public Law 110-140 (2007)"</i> , www.epa.gov/laws-regulations/summary-energy-independence-and-security-act (Last accessed January 19, 2018).

Program Components	Bibliographic References
	U.S. EPA and DOE, <i>Savings Calculator for ENERGY STAR Qualified Appliances</i> (2016), https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx (Last accessed December 4, 2017).
Home Energy Assessment	ASHRAE, <i>ASHRAE Equipment Life Expectancy Chart</i>, http://www.culluminc.com/wp-content/uploads/2013/02/ASHRAE_Chart_HVAC_Life_Expectancy%201.pdf. CENTER FOR ENERGY ADVANCEMENT THROUGH TECHNOLOGY INNOVATION (CEATI). <i>Drain Water Heat Recovery Energy Savings Calculator</i>, available at http://www.ceati.com/calculator/ (Consulted November 17, 2017) Database for Energy Efficiency Resources (DEER), <i>DEER2014 EUL Table</i>, 2014. EMERA INC. "Management's Discussion & Analysis As at February 10, 2017", December 17, 2017, http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693 GDS ASSOCIATES, INC., <i>Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures</i>, Report prepared for the England State Program Working Group, June 2007, https://energy.mo.gov/docs/default-source/energy_division/measure-life-report-2007.pdf. GDS ASSOCIATES INC. AND SUMMIT BLUE CONSULTING, <i>Natural Gas Energy Efficiency Potential in Massachusetts</i>, Report prepared for GasNetworks, 2009, http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potential-in-MA.pdf NATIONAL RENEWABLE ENERGY LABORATORY (NREL). <i>The Uniform Methods Project, Chapter 23: Estimating Net Savings, Common Practices</i>, September 2014. NATURAL RESOURCES CANADA. <i>Air-Source Heat Pumps</i>, Updated March 27, 2017, http://www.nrcan.gc.ca/energy/publications/efficiency/heating-heat-pump/6831 [Accessed November 9, 2017]. NATURAL RESOURCES CANADA. <i>Ground-Source Heat Pumps (Earth-Energy Systems)</i>, Updated March 27, 2017, http://www.nrcan.gc.ca/energy/publications/efficiency/heating-heat-pump/6833 [Accessed November 9, 2017]. NOVA SCOTIA POWER. "Total System Emissions", accessed December 17, 2017, http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx. PENNSYLVANIA PUBLIC UTILITY COMMISSION. <i>Technical Reference Manual</i> (Section 2.2.1 –Electric HVAC), (Consulted November 15, 2017) VERMONT ENERGY INVESTMENT CORPORATION. <i>State of Ohio Energy Efficiency Technical Reference Manual</i>, August 2010, http://s3.amazonaws.com/zanran_storage/amppartners.org/ContentPages/2464316647.pdf
Green Heat	ASHRAE, <i>ASHRAE Equipment Life Expectancy Chart</i>, http://www.culluminc.com/wp-content/uploads/2013/02/ASHRAE_Chart_HVAC_Life_Expectancy%201.pdf. CADMUS AND IESO, <i>Evaluation of Verifying Cold Climate Air Source Heat Pumps in Electrically Heated Residential Homes in Ontario, Canada</i>, Poster presented at the 2017 International Energy Program Evaluation Conference, Baltimore, MD, 2017, http://www.cadmusgroup.com/papers-reports/evaluation-of-verifying-cold-climate-air-source-heat-pumps-in-electrically-heated-residential-homes/. (Last accessed December 4, 2017). DATABASE FOR ENERGY EFFICIENCY RESOURCES (DEER), <i>DEER2014 EUL Table</i>, 2014. DUNSKY ENERGY CONSULTING. <i>Residential Fuel Substitution Pilot Program, Final Report</i>, December 2010. ECONOLER. <i>Green Heat 2013 DSM Evaluation for Efficiency Nova Scotia Corporation</i>, February 21, 2014. ECOTOPE. <i>Ductless Heat Pump Impact & Process Evaluation: Billing Analysis Report</i> (Report #13-262), 2013. GDS ASSOCIATES, INC. <i>Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures</i>, Report prepared for the New England State Program Working Group, June 2007, Table 1, pp. 1-3, https://energy.mo.gov/docs/default-source/energy_division/measure-life-report-2007.pdf. GOVERNMENT OF CANADA. <i>Station Results - 1981-2010 Climate Normals and Averages</i>, http://climate.weather.gc.ca

Program Components	Bibliographic References
	HAMELIN, M. C. ET AL. "Accounting for Real-Life Conditions in Mini-Split Heat Pump Savings: Findings from a Billing Analysis" in <i>Proceedings of the 2017 International Energy Program Evaluation Conference</i> , Baltimore, MD, 2017.
	MINNESOTA DEPARTMENT OF COMMERCE – DIVISION OF ENERGY RESOURCES. <i>State of Minnesota Technical Reference Manual for Energy Conservation Improvement Programs – Version 2</i> Effective January 1, 2017.
	NATIONAL RENEWABLE ENERGY LABORATORY (NREL). <i>The Uniform Methods Project, Chapter 23: Estimating Net Savings: Common Practices</i> , September 2014, p. 3, available at http://energy.gov/sites/prod/files/2015/02/f19/UMPChapter23-estimating-net-savings_0.pdf (Last accessed November 19, 2015).
	NATURAL RESOURCES CANADA. <i>Air-Source Heat Pumps</i> , Updated March 27, 2017, http://www.nrcan.gc.ca/energy/publications/efficiency/heating-heat-pump/6831 . [Accessed November 9, 2017].
	NATURAL RESOURCES CANADA (NRCAN), <i>Ground-Source Heat Pumps (Earth-Energy Systems)</i> , Updated March 27, 2017, http://www.nrcan.gc.ca/energy/publications/efficiency/heating-heat-pump/6833 . [Accessed November 9, 2017].
	NATURAL RESOURCES CANADA. <i>Single-Phase and Three-Phase Split-System Central Air Conditioners and Heat Pumps</i> . http://www.nrcan.gc.ca/energy/regulations-codes-standards/products/6895 . (Last accessed December 4, 2017)
	PENNSYLVANIA PUBLIC UTILITY COMMISSION (PUC). <i>Technical Reference Manual, Section 2.2 – HVAC</i> , June 2015.
	PROVINCE OF NOVA SCOTIA, <i>Nova Scotia Building Code Regulation</i> , December 31, 2014.
	ROSENBERG M. AND HOEFGEN L. 2009. Market Effects and Market Transformation: Their Role in Energy Efficiency Program Design and Evaluation. Prepared for California Institute of Energy and the Environment.
	THE CADMUS GROUP, INC. <i>Ductless Mini-Split Heat Pump Impact Evaluation</i> , Prepared for the Electric and Gas Program Administrators of Massachusetts and Rhode Island, December 30, 2016.
New Home Construction	GDS ASSOCIATES, INC. <i>Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures</i> , report prepared for the England State Program Working Group, June 2007, Table 1, pp. 1-3, https://energy.mo.gov/docs/default-source/energy_division/measure-life-report-2007.pdf .
	ILLINOIS ENERGY EFFICIENCY STAKEHOLDER ADVISORY GROUP. <i>Illinois Statewide Technical Reference Manual for Energy Efficiency Version 6.0, Volume 3</i> , February 2017.
	MASSACHUSETTS ELECTRIC AND GAS ENERGY EFFICIENCY PROGRAM ADMINISTRATORS. <i>Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures, 2016-2018 Program Years – Plan Version</i> , October 2015, p. 151.
	NATIONAL RENEWABLE ENERGY LABORATORY (REL). <i>The Uniform Methods Project, Chapter 23: Estimating Net Savings: Common Practices</i> , September 2014, p. 3. available at http://energy.gov/sites/prod/files/2015/02/f19/UMPChapter23-estimating-net-savings_0.pdf (Last accessed November 21, 2016).
	NATURAL RESOURCES CANADA. "Energy Efficiency Regulations. General Service Lamps and Modified Spectrum Incandescent Lamps." Online: www.nrcan.gc.ca/energy/regulations-codes-standards/products/6869 .
	NATURAL RESOURCES CANADA. <i>Forward Regulatory Plan 2017-19</i> , http://www.nrcan.gc.ca/energy/regulations-codes-standards/18318 (Last accessed January 24, 2018).
	NOVA SCOTIA BUILDING CODE LEGISLATION. <i>Nova Scotia Building Code Regulations – Users Version, 2014</i> , https://novascotia.ca/dma/firesafety/buildingcode/docs/141020FINALUSERSNSBCR141231.pdf (Last accessed December 11, 2017).
	REGIONAL TECHNICAL FORUM. <i>UES Measures – Built Green Washington</i> , https://rtf.nwcouncil.org/measure/built-green-washington (Last accessed February 15, 2018) US EPA. "Summary of the Energy Independence and Security Act. Public Law 110-140 (2007)." Online: www.epa.gov/laws-regulations/summary-energy-independence-and-security-act .

Program Components	Bibliographic References
Efficient Product Installation	ADS ASSOCIÉS, <i>Évaluations des effets énergétiques combinés des mesures d'économies d'énergie – résidence unifamiliale</i> , report presented to Hydro-Québec, 1992.
	Barclay, D., von Trapp, K. and Miziolek C., <i>Party Like It's 2020: EISA Phase 2 – An Examination of DOE Rulemaking and Implications for Programs</i> , Poster presented at the 2017 International Energy Program Evaluation Conference, Baltimore, MD.
	EMBERTEC – ENERGY EFFICIENCY TECHNOLOGIES, <i>Solution Provider Presentation, Maximum Savings – Zero Effort</i> .
	EMERA INC. "Management's Discussion & Analysis As at February 10, 2017", December 17, 2017, http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693
	DAVID ROGERS. PowerSmart Engineering, <i>Smart Strip Electric Savings Usability</i> , October 2008.
	DATABASE FOR ENERGY EFFICIENCY RESOURCES (DEER), <i>DEER2014 EUL Table</i> , 2014.
	GDS ASSOCIATES, INC. <i>Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures</i> , Report prepared for the England State Program Working Group, June 2007, Table 1.
	ILLINOIS ENERGY EFFICIENCY STAKEHOLDER ADVISORY GROUP. <i>Illinois Statewide Technical Reference Manual for Energy Efficiency Version 6.0, Volume 3</i> , February 2017.
	KAREBO SYSTEMS, <i>Audiovisual Standby Power Controller: Energy Savings Field Trial, South Africa - June-August 2012</i> , Field trial data analysis, March 6, 2013.
	Lighting Research Center. Rensselaer Polytechnic Institute. <i>Lighting Patterns for Homes. Light Bulb Features</i> , www.lrc.rpi.edu/patternbook/resources/lamp_features.asp . (Last accessed January 24, 2018).
	MASSACHUSETTS ELECTRIC AND GAS ENERGY EFFICIENCY PROGRAM ADMINISTRATORS. <i>Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures, 2016-2018 Program Years – Plan Version</i> , October 2015.
	MINISTER OF JUSTICE. Canada, <i>Energy Efficiency Regulations</i> , 2016, http://laws-lois.justice.gc.ca/PDF/SOR-2016-311.pdf .
	NATIONAL RENEWABLE ENERGY LABORATORY (REL). <i>Uniform Methods Protocol, Chapter 6: Residential Lighting Evaluation Protocol</i> , February 2014.
	NATURAL RESOURCES CANADA. <i>Energy Efficiency Regulations. General Service Lamps and Modified Spectrum Incandescent Lamps</i> , www.nrcan.gc.ca/energy/regulations-codes-standards/products/6869 (Last accessed January 24, 2018).
	Natural Resources Canada. <i>Forward Regulatory Plan 2017-19</i> , http://www.nrcan.gc.ca/energy/regulations-codes-standards/18318 (Last accessed January 24, 2018).
	NOVA SCOTIA POWER. Open Access Same-Time Information System, <i>Hourly Total Net Nova Scotia Load</i> , < http://oasis.nspower.ca/en/home/oasis/monthly-reports/hourly-total-net-nova-scotia-load.aspx > (Last accessed January 18, 2016).
	TTP://WWW.NSPOWER.CA/EN/HOME/ABOUT-US/ENVIRONMENTAL-COMMITMENT/AIR-EMISSIONS-REPORTING/TOTAL-SYSTEM-EMISSIONS-ALL-PLANTS.ASPX.
	NMR GROUP INC. AND DNV GL. <i>Northeast Residential Lighting Hours-of-Use Study</i> , May 5, 2014.
	ONTARIO POWER AUTHORITY (OPA). <i>Prescriptive Measures and Assumptions List</i> , December 2010.
	US EPA. Summary of the Energy Independence and Security Act. Public Law 110-140 (2007). Online : www.epa.gov/laws-regulations/summary-energy-independence-and-security-act

Program Components	Bibliographic References
Business Energy Rebates	DATABASE FOR ENERGY EFFICIENCY RESOURCES (DEER). <i>DEER 2008 EUL Table</i> , 2008.
	DIFFUSION OF INNOVATIONS. Everett Rogers, 1983.
	DNV-GL. <i>Massachusetts Commercial and Industrial Upstream Lighting Program: "In Storage" Lamps Follow-up Study</i> , March 2015.
	DUKE ENERGY PROGRESS. <i>Energy Efficiency for Business - Fixture Wattage Table</i> , 2013, available at https://www.progress-energy.com/assets/www/docs/business/Progress_App_Lighting_WattTable-083012.pdf (Last consulted on February 3, 2017).
	EFFICIENCY VERMONT. <i>Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions</i> , March 16, 2015.
	EMERA INC., "Management's Discussion & Analysis as at February 10, 2017", http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693 . (Last accessed December 17, 2017)
	GDS Associates. <i>Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures</i> , June 2007.
	MINNESOTA DEPARTMENT OF COMMERCE – DIVISION OF ENERGY RESOURCES. <i>State of Minnesota Technical Reference Manual for Energy Conservation Improvement Programs – Version 2</i> , Effective January 1, 2017.
	NATIONAL RENEWABLE ENERGY LABORATORY (NREL). <i>The Uniform Methods Project, Chapter 23: Estimating Net Savings: Common Practices</i> , September 2014, p.3, available at http://energy.gov/sites/prod/files/2015/02/f19/UMPCchapter23-estimating-net-savings_0.pdf (Last accessed on November 19, 2015).
	NATURAL RESOURCES CANADA. "Forward Regulatory Plan 2017-19". Online: http://www.nrcan.gc.ca/energy/regulations-codes-standards/18318 , Last modified July 25, 2017.
	NATURAL RESOURCES CANADA. <i>General Service Lamps and Modified Spectrum Incandescent Lamps: Energy Efficiency Regulations</i> , http://www.nrcan.gc.ca/energy/regulations-codes-standards/products/6869
	NOVA SCOTIA POWER. "Total System Emissions", accessed December 17, 2017, http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx .
	PA Consulting Group. <i>Focus on Energy Evaluation Business Programs: Measure Life Study</i> , August 25, 2009.
	PENNSYLVANIA PUBLIC UTILITY COMMISSION, <i>State of Pennsylvania Technical Reference Manual – June 2016</i> , Effective January 1, 2017.
	Rosenburg and Hoefgen, 2009. Market Effects and Market Transformation: Their Role in Energy Efficiency Program Design and Evaluation. Prepared for California Institute of Energy and the Environment.
	RUNDQUIST, Robert A. et al. <i>Calculating Lighting and HVAC Interactions</i> , in <i>ASHRAE Journal</i> , November 1993.
	TECMARKET WORKS. <i>The California Evaluation Framework</i> , June 2004.
	US EPA. "Summary of the Energy Independence and Security Act. Public Law 110-140 (2007)". Online : www.epa.gov/laws-regulations/summary-energy-independence-and-security-act

Program Components	Bibliographic References
Custom	DATABASE FOR ENERGY EFFICIENCY RESOURCES (DEER). <i>DEER 2008 EUL Table</i> , 2008.
	EMERA INC., “Management’s Discussion & Analysis as at February 10, 2017”, http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693 . (Last accessed December 17, 2017)
	ENERGY & RESOURCE SOLUTIONS. <i>Measure Life Study Report prepared for The Massachusetts Joint Utilities</i> , 2005.
	GDS ASSOCIATES. <i>Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures</i> , June 2007.
	NATIONAL RENEWABLE ENERGY LABORATORY (NREL). <i>The Uniform Methods Project, Chapter 23: Estimating Net Savings: Common Practices</i> , September 2014, p. 3, available at http://energy.gov/sites/prod/files/2015/02/f19/UMPCchapter23-estimating-net-savings_0.pdf (Last accessed November 19, 2015).
	NOVA SCOTIA POWER. “Total System Emissions”, accessed December 17, 2017, http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx .
	ROBERTS J. AND TSO B. (SBW CONSULTING), <i>Do Savings from Retrocommissioning Last? Results from an Effective Useful Life Study</i> , ACEEE Summer Study on Energy Efficiency in Buildings, 2010.
	RUNDQUIST, Robert A. et al. <i>Calculating Lighting and HVAC Interactions</i> , in <i>ASHRAE Journal</i> , November 1993.
Energy Management Information System	Efficiency Valuation Organization, <i>Core Concepts, International Performance Measurement and Verification Protocol</i> , October 2016.
	EMERA INC., “Management’s Discussion & Analysis as at February 10, 2017”, http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693 . (Last accessed December 17, 2017)
	NOVA SCOTIA POWER. “Total System Emissions”, accessed December 17, 2017, http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx .
Small Business Energy Solutions	DESIGNLIGHTS CONSORTIUM - SEARCH. https://www.designlights.org/search/ (Last accessed January 23, 2018)
	DUKE ENERGY PROGRESS. <i>Energy Efficiency for Business - Fixture Wattage Table</i> , 2013.
	EMERA INC., “Management’s Discussion & Analysis as at February 10, 2017”, http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693 . (Last accessed December 17, 2017)
	NATIONAL RENEWABLE ENERGY LABORATORY (NREL). <i>The Uniform Methods Project, Chapter 23: Estimating Net Savings: Common Practices</i> , September 2014, p. 3, available at http://energy.gov/sites/prod/files/2015/02/f19/UMPCchapter23-estimating-net-savings_0.pdf (Last accessed November 25, 2016).
	NORTHEAST ENERGY EFFICIENCY PARTNERSHIPS – SEARCH. http://www.neep.org/initiatives/high-efficiency-products/emerging-technologies/ashp/cold-climate-air-source-heat-pump (Last accessed January 24, 2018)
	NOVA SCOTIA POWER. “Total System Emissions”, accessed December 17, 2017, http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx .
	WASHINGTON STATE UNIVERSITY. <i>Energy Auditor Checklist</i> , May 2003, available at http://www.energy.wsu.edu/Documents/OMchecklists.pdf (Last accessed January 2018).

Program Components	Bibliographic References
Codes & Standards	ADS ASSOCIÉS. <i>Évaluations des effets énergétiques combinés des mesures d'économies d'énergie – résidence unifamiliale</i> , report presented to Hydro-Québec, 1992.
	CANETA RESEARCH. <i>Performance Simulation of Proposed Changes to NECB Relative to MNECB and ASHRAE 90.1-2007</i> , March 2011
	CORPORATE RESEARCH ASSOCIATES. <i>2011 ENS socket study</i>
	DMD & ASSOCIATES LTD. <i>Nova Scotia LED Roadway Lighting Pilot Installations</i> , March 19, 2010, available at http://docshare01.docshare.tips/files/25144/251443242.pdf (Last accessed January 5, 2018)
	DMD AND ASSOCIATES LTD. <i>Energy Efficient Street Lighting Strategies for Nova Scotia Municipalities</i> , July 16, 2009, available at https://unsm.ca/doc_download/1543-street-lighting-final-report-2009-07-16.html (Last accessed February 5, 2018)
	DUNSKY ENERGY CONSULTING. 2015. Update - Market and Technology Assessment for Residential Clothes Washers in Canada (Final Report submitted to Natural Resources Canada)
	EMERA INC., "Management's Discussion & Analysis as at February 10, 2017", http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693 . (Last accessed December 17, 2017)
	ENVIRONMENT CANADA. <i>Clean Air Regulatory Agenda: Background</i> , available at www.ec.gc.ca/default.asp?lang=En&n=56D4043B-1&news=295B1964-9737-4F80-B064-B3088D9910BE (Last accessed February 5, 2018)
	GOVERNMENT OF BRITISH COLUMBIA. <i>Information Bulletin – Building and Safety Standards Branch, New Energy Requirements</i> , May 22, 2013, available at http://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/construction-industry/building-codes-and-standards/bulletins/b13-05_new_energy_requirements.pdf (Last accessed February 5, 2018)
	GOVERNMENT OF ONTARIO - MINISTRY OF MUNICIPAL AFFAIRS AND HOUSING. <i>Ontario Building Code, Are you ready? 2012 Requirements for New Construction</i> , December 2011, available at http://www.oboa.on.ca/news/files/pamphlet2011.pdf (Last accessed February 5, 2018)
	ILLUMINATING ENGINEERING SOCIETY (IES) OF NORTH AMERICA. available at http://www.ies.org/
	NATIONAL LIGHTING PRODUCT INFORMATION PROGRAM. <i>Streetlights for Local Roads</i> , February 2011, available at http://www.lrc.rpi.edu/programs/NLPIP/PDF/VIEW/SR_StreetlightsLocal.pdf (Last accessed January 5, 2018)
	NATIONAL RESEARCH COUNCIL CANADA. <i>Energy Efficiency in Housing and Small Buildings – General Introduction</i> , March 2013, available at http://www.nrc-cnrc.gc.ca/eng/solutions/advisory/codes_centre/presentations/2013/overview2013.html (Last accessed February 5, 2018)
	NATURAL RESOURCES CANADA. <i>A cost-benefit analysis</i> , Canada Gazette, Part II, December 28, 2016.
	NATURAL RESOURCES CANADA. <i>Amendment to Canada's Energy Efficiency Regulations for Lighting Products</i> , January 2014, available at http://www.nrcan.gc.ca/energy/regulations-codes-standards/12342 (Last accessed February 5, 2018)
	NATURAL RESOURCES CANADA. <i>Energy Efficiency Act: Regulations Amending the Energy Efficiency Regulations</i> , September 22, 2011, available at http://canadagazette.gc.ca/rp-pr/p2/2011/2011-10-12/html/sor-dors182-eng.html (Last accessed February 5, 2018)
	NATURAL RESOURCES CANADA. <i>Guide to Canada's Energy Efficiency Regulations</i> , 2017, available at http://www.nrcan.gc.ca/energy/regulations-codes-standards/6861 (Last accessed February 5, 2018)
	NOVA SCOTIA CANADA. <i>New Law Means Road Lighting in Nova Scotia Must Be LED</i> , September 12, 2012, available at http://novascotia.ca/news/release/?id=20120912004 (Last accessed February 5, 2018)
	NATURAL RESOURCES CANADA. <i>Notice – Publication of Energy Efficiency Regulation, 2016-Amendment 13</i> . December 2016, available at http://www.nrcan.gc.ca/energy/regulations-codes-standards/18419 (Last accessed February 5, 2018)

Program Components	Bibliographic References
	NATURAL RESOURCES CANADA. <i>Publication of Regulations Amending Canada's Energy Efficiency Regulations</i> , 2011, available at http://oee.nrcan.gc.ca/regulations/14566 (Last accessed February 5, 2018)
	NATURAL RESOURCES CANADA. <i>Survey of Commercial and Institutional Energy Use – Buildings 2009</i> , December 2012, available at https://oee.nrcan.gc.ca/publications/statistics/scieu09/scieu_e.pdf (Last accessed January 15, 2018)
	NMR Group Inc. and DNV GL, <i>Northeast Residential Lighting Hours-of-Use Study</i> , May 5, 2014.
	NOVA SCOTIA CANADA, <i>Energy-efficient Appliances Regulations made under Section 5 of the Energy-efficient Appliances Act</i> , available at https://www.novascotia.ca/just/regulations/regs/eeappliances.htm (Last accessed February 5, 2018)
	NOVA SCOTIA CANADA. <i>New Law Means Road Lighting in Nova Scotia Must Be LED</i> , September 12, 2012, available at http://novascotia.ca/news/release/?id=20120912004 (Last accessed February 5, 2018).
	NOVA SCOTIA CANADA, <i>Nova Scotia Building Code Regulations – Made Under Section 4 of the Building Code Act</i> , available at https://novascotia.ca/just/regulations/regs/bcregs.htm (Last accessed February 28, 2017)
	NOVA SCOTIA CANADA. <i>Summary of Changes Nova Scotia Building Code Regulation</i> , July 2013, available at http://www.novascotia.ca/dma/firesafety/buildingcode/docs/130625summaryofchangesnovascotiabuildingcoderegulation2.pdf (Last accessed February 29, 2018)
	NOVA SCOTIA POWER, <i>Street and Area Lighting</i> , available at http://www.nspower.ca/en/home/about-us/electricity-rates-and-regulations/rates/street-and-area-lighting.aspx (Last accessed January 29, 2017).
	NOVA SCOTIA POWER. “Total System Emissions”, accessed December 17, 2017, http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx .
	OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY. <i>Demonstration Assessment of Lighting-Emitting Diode (LED) Roadway Lighting</i> , December 2011, available at https://www1.eere.energy.gov/buildings/publications/pdfs/ssl/2011_gateway_fdr-drive.pdf (Last accessed January 5, 2018).
	OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY. <i>Demonstration of LED Street Lighting</i> , June 2013, available at http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2013_gateway-msslc_kc.pdf (Last accessed January 5, 2018).
	OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY. <i>SSL Demonstration: Roadway Lighting Philadelphia</i> , June 2013, available at http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/philadelphia_brief.pdf (Last accessed January 5, 2018).
	STATISTICS CANADA. <i>Catalogue No. 64-001-X, Building Permits</i> , December 2015, available at http://www.statcan.gc.ca/pub/64-001-x/64-001-x2015012-eng.pdf (Last accessed January 15, 2018)
	STATISTICS CANADA. <i>Catalogue Table 026-0002 Building permits, dwelling units by type of dwelling and area</i> , 2016, available at http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=260002 (Last accessed January 15, 2018)

APPENDIX II **CALCULATION OF MARGINS OF ERROR**

This appendix presents some examples of how the Evaluator has established the margins of error of participant surveys, installation rates, adjustment ratios, free-ridership levels and measured energy consumption levels. The examples for the margins of error of the participant survey and installation rates are from the Efficient Product Installation program component, the margin of error of the adjustment ratios are from the Business Energy Rebates Mail-in program component, and the margins of error of the free-ridership levels and measured energy consumptions are from the Green Heat program component.

Margin of Error of the Surveys

The Efficient Product Installation non-low-income survey margin of error was established by using the following formula, which corresponds to the margin of error calculation for a proportion (i.e. a value between 0 percent and 100 percent):

$$\text{Margin of Error } (e) = Z\alpha \times \sqrt{\frac{p \times (1 - p)}{n}} \times \sqrt{\frac{N - n}{N - 1}}$$

Where

- › $Z\alpha$ is the coefficient used at a specific confidence level.
- › p is the proportion (typically conservatively established at 0.50, which yields the maximum error).
- › N is the population, or in this case the total number of unique participants.
- › n is the sample size.

This example's sample size is 100. Therefore, a $Z\alpha$ coefficient of 1.645 was used, as presented in Table 1 below.

Table 1: Distribution of Coefficients t

Sample size	Confidence Level		
	95%	90%	80%
2	12.71	6.31	3.08
3	4.30	2.92	1.89
4	3.18	2.35	1.64
5	2.78	2.13	1.53
10	2.26	1.83	1.38
15	2.14	1.76	1.35
20	2.09	1.73	1.33
25	2.06	1.71	1.32
30	2.05	1.70	1.31
∞*	1.96	1.64	1.28

* Coefficient z, which corresponds to the value of coefficient t for an infinite sample size, and is used for samples bigger than 30.

By using the formula mentioned above and assuming a confidence level of 90 percent, a proportion of 0.50, and a total number of Efficient Product Installation non-low-income participants equal to 7,625, the margin of error was established at 8.2 percent.

$$8.2\% = 1.64 \times \sqrt{\frac{0.50 \times (1 - 0.50)}{100}} \times \sqrt{\frac{7,625 - 100}{7,625 - 1}}$$

This calculation was performed for all program components, except Appliance Retirement and Custom (for which no participant survey was conducted this year) and EMIS (for which a census-based survey approach was used).

Margin of Error of the Installation Rates

In Efficient Product Installation, LED lamps are the most popular products. Therefore, the Evaluator chose to use the margin of error calculation for this product as an example. Below are the steps the Evaluator followed to calculate this margin of error.

Calculation of the Weighted Average of Installation Rates

The weighted average was calculated by using the following formula:

$$\text{Weighted Average IR} = \frac{\sum_{i=1}^N \text{Installation Rate}_i \times \text{Number of Tracked LED Lamps}_i}{\text{Total Number of Tracked LED Lamps}} = 98\%$$

Where N is the total number of on-site visits and i represents each individual participating household visited. The Evaluator established the LED lamps' average installation rate at 98 percent.

Calculation of the Weighted Standard Deviation

Since the overall installation rate is based on a weighted average, the Evaluator also used the weighted standard deviation of the installation rate for the calculation instead of the standard deviation. The following formula was used to calculate the weighted standard deviation.

$$\begin{aligned} & \text{Weighted Standard Deviation IR} \\ &= \sqrt{\frac{\sum_{i=1}^N \text{Number of Tracked LED Lamps}_i \times (\text{Installation Rate}_i - \text{Weighted Average IR})^2}{\frac{(N'-1) \times \sum_{i=1}^N \text{Number of Tracked LED Lamps}_i}{N'}}} = 0.085 \end{aligned}$$

Where N' represents the on-site visits for which the number of tracked LED lamps was higher than zero. In the case of LED lamps, N is 110 and N' is equal to 109.

Calculation of the Margin of Error

The margin of error of the LED lamps' installation rate was established by using the following formula, which applies to samples drawn from an infinite population (defined as being at least 10 times larger than the sample size):

$$\text{Margin of Error IR} = \frac{\text{Weighted Standard Deviation} \times t}{\sqrt{N}} = \pm 1.3\%$$

Where N is the number of surveyed participants (the sample size), while the coefficient t was determined by using **Erreur ! Source du renvoi introuvable.** It should be noted that for sample sizes bigger than 30, the coefficient z (1.64 at a confidence level of 90%) was used.

By using the formula shown above, the margin of error for the installation rate of LED lamps was established at 1.3 percent.

This calculation was only performed for the Efficient Product Installation program component for the 2017 evaluation.

Margin of Error of the Adjustment Ratios

Lighting measures are the most popular measures rebated in Business Energy Rebates Mail-in. Therefore, the Evaluator chose to use the margin of error calculation of the adjustment ratios for these measures as an example. Below are the steps to calculate the margin of error for the adjustment ratio used on energy savings generated by lighting measures.

Calculation of the Weighted Average of Adjustment Ratios

The weighted average was calculated by using the following formula and applying the adjustment ratios and the tracked energy savings generated by lighting measures:

$$\text{Weighted Average AR} = \frac{\sum_{i=1}^N \text{Adjustment Ratio}_i \times \text{Tracked Energy Savings}_i}{\text{Total Tracked Energy Savings}} = 0.927$$

Where N is the total number of evaluated measures (73) and i represents each individual measure evaluated. The Evaluator established the lighting measures' weighted average adjustment ratio at 0.927.

Calculation of the Weighted Standard Deviation

Since the overall adjustment ratio is based on a weighted average, the Evaluator also used the weighted standard deviation of the adjustment ratio for the calculation instead of the standard deviation. The following formula was used to calculate the weighted standard deviation.

$$\begin{aligned} \text{Weighted Standard Deviation AR} \\ &= \sqrt{\frac{\sum_{i=1}^N \text{Tracked Energy Savings}_i (\text{Adjustment Ratio}_i - \text{Weighted Average AR})^2}{\frac{(N'-1) \sum_{i=1}^N \text{Tracked Energy Savings}_i}{N'}}} \\ &= 0.360 \end{aligned}$$

Where N represents the number of measures reviewed as part of the impact evaluation and N' represents the number of reviewed measures for which the tracked energy savings were higher than zero. In the case of lighting measures, N is 73 and N' is 73. The weighted standard deviation for the adjustment ratio of energy savings for lighting measures was established at 0.360.

Calculation of the Margin of Error

The margin of error of the lighting measures' adjustment ratio was established by using the following formula, which applies to samples drawn from a small population (defined as being less than 10 times the sample size):

$$\text{Margin of Error AR} = \frac{\text{Weighted Standard Deviation} \times t}{\sqrt{\frac{N(M-1)}{(M-N)}}} = \pm 6.4\%$$

Where M is the population size and the coefficient t was determined by using **Erreur ! Source du renvoi introuvable.** Since N is larger than 30, the coefficient z was used in place of the coefficient t .

By using the formula shown above and a population size of 503, the margin of error for the adjustment ratio applied to the energy savings generated by lighting products was established at 6.4 percent.

This calculation was performed for the following program components: Small Business Energy Solutions, Business Energy Rebates (Mail-In service) and Custom (Retrofit service).

Margin of Error of the Free-ridership Levels

The Evaluator used the margin of error calculation of the free-ridership level for biomass and solar measures installed through Green Heat as an example. Below are the steps followed to calculate this margin of error.

Calculation of the Weighted Average of Free-ridership Levels

The weighted average was calculated by using the following formula:

$$\text{Weighted Average FR} = \frac{\sum_{i=1}^N \text{Free Ridership Level}_i \times \text{Revised Gross Energy Savings}_i}{\text{Total Revised Gross Energy Savings}} = 36\%$$

Where N is the total number of surveyed participants who installed biomass or solar measures and i represents each individual participant surveyed. The Evaluator established the weighted average free-ridership level at 36 percent.

Calculation of the Weighted Standard Deviation

Since the free-ridership level is based on a weighted average, the Evaluator used the weighted standard deviation of the free-ridership for the calculation instead of the standard deviation. The following formula was used to calculate the weighted standard deviation.

$$\begin{aligned} \text{Weighted Standard Deviation FR} \\ &= \sqrt{\frac{\sum_{i=1}^N \text{Revised Gross Energy Savings}_i (\text{Free Ridership}_i - \text{Weighted Average FR})^2}{\frac{(N'-1) \sum_{i=1}^N \text{Revised Gross Energy Savings}_i}{N'}}} \\ &= 0.262 \end{aligned}$$

Where N' represents the number of surveyed participants who had energy savings higher than zero. In the case of biomass and solar measures, both N and N' are 16. The weighted standard deviation for the free-ridership level of biomass and solar measures was established at 26.2 percent.

Calculation of the Margin of Error

The margin of error of the free-ridership level of biomass and solar measures was established by using the following formula, which applies to samples drawn from a small population:

$$\text{Margin of Error FR} = \frac{\text{Weighted Standard Deviation} \times t}{\sqrt{\frac{N(M-1)}{(M-N)}}} = \pm 4.9\%$$

Where N is the sample size, M is the population size and the coefficient t was determined by using **Erreur ! Source du renvoi introuvable.** Since the sample size was 16, the corresponding t coefficient was established at 1.75 for a confidence interval of 90 percent. By using the formula shown above and a population size of 86, the margin of error for the free-ridership level of biomass and solar measures was established at 4.9 percent.

This calculation was performed for all program components whose free-ridership rate was measured in 2017, so all the program components with the exception of Custom, Energy Management Information Systems, and Appliance Retirement (free-ridership levels from previous evaluations were applied to 2017 for these program components or, in the case of EMIS, was not measured as it is considered to be nil).

Margin of Error for Measured Energy Consumption

The Evaluator used the margin of error calculation of the unitary savings value established for mini-split heat pumps (MSHPs) installed through Green Heat in fully electrically heated households. This methodology was applied to calculate the margins of error of metered results. Below are the steps followed to calculate this margin of error.

Calculation of the Average of Unitary Savings Values

The simple average was calculated by using the following formula:

$$\text{Average Unitary Savings} = \frac{\sum_{i=1}^N \text{Unitary Savings}_i}{N} = 0.179 \frac{\text{kWh}}{\text{Btu/h}}$$

Where N is the number of fully electrically heated participating households for which the unitary savings value was calculated, and i represents each of those households. The Evaluator established the average unitary savings value at 0.179 kWh/Btu/h.

Calculation of the Standard Deviation

Since the simple average was used to establish the unitary savings value of MSHPs, the Evaluator used the standard deviation. The following formula was used to calculate the standard deviation.

$$\begin{aligned} \text{Standard Deviation Unitary Savings} &= \sqrt{\frac{\sum_{i=1}^N (\text{Unitary Savings}_i - \text{Average Unitary Savings})^2}{(N - 1)}} \\ &= 0.149 \frac{\text{kWh}}{\text{Btu/h}} \end{aligned}$$

The standard deviation of the unitary savings value for MSHPs installed in fully electrically heated households was established at 0.149 kWh/Btu/h.

Calculation of the Margin of Error

The margin of error of the unitary savings value was established by using the following formula, which applies to samples drawn from an infinite population.

$$\text{Margin of Error Unitary Savings} = \frac{\text{Weighted Standard Deviation} \times t}{\sqrt{N}} = \pm 0.022 \frac{\text{kWh}}{\text{Btu/h}}$$

Where N is the sample size, while the coefficient t was determined by using **Erreur ! Source du renvoi introuvable..** Since the sample size is bigger than 30, the coefficient z was used.

By using the formula shown above, the margin of error for the unitary savings of MSHPs installed in fully electrically heated households was established at 0.022 kWh/Btu/h.

This calculation was performed for Green Heat and Appliance Retirement (retired appliance measured energy consumption) as well as for the Residential Lighting Metering Study (hours of use).

APPENDIX III NTGR CALCULATIONS

This appendix presents some examples of how the Evaluator calculated free-ridership, internal spillover and net-to-gross ratio values in the 2017 evaluation. To demonstrate how to apply the algorithm for calculating these values, this appendix looks at some examples from the Green Heat and Small Business Energy Solutions program components. The Evaluator used a similar approach to assessing the free-ridership, internal spillover and net-to-gross ratio of other program components. More details can be found in the evaluation reports of the individual program components.

NTGR Calculations



2017 GH and
SBES_NTGR Example

How to open the Excel file:
Word: Double click on the icon

Green Heat - New Path - Mini-Split Heat Pump - Non-Electrically Heated							
Free-ridership algorithm		Low Free-ridership Participant		High Free-ridership Participant		Average Free-ridership Participant	
Questions	Calculation Algorithm	Answer	Calc. Result	Answer	Calc. Result	Answer	Calc. Result
FRM4. Were you aware of the availability of higher efficiency heat pumps that operate at temperatures below -15°C before you heard about Green Heat? (1=Yes, 2=No)	IF 1. Yes: Use FRM4a IF 2. No, DK OR REF: FRM4a = 0% and END	2	-	1	-	1	-
FRM4a. [ASK IF FRM4=1] Before you heard about the Green Heat Program, had you already made the decision to install a high-efficiency heat pump model? (1=Yes, 2=No)	IF 1. Yes: FRM4a=100% IF 2. No, DK OR REF: FRM4a = 0%	NA	0%	1	100%	2	0%
FRM5. [ASK IF FRM4=1] If you had not received the rebate from Efficiency Nova Scotia, would you have paid the total cost of your high-efficiency heat pump? (Scale 0 to 10)	FRM5 = Answer x 10% IF DK OR REF: FRM5 = EMPTY	9	90%	10	100%	10	100%
FRM6. Level of influence (Scale 0 to 10)	FRM6 = (10 - MAX(a;b;c))*10%	-	20%	-	50%	-	0%
Factor a. The program rebate		7		0		8	
Factor b. Information on the benefits of high efficiency heat pumps provided by Efficiency Nova Scotia		8		0		5	
Factor c. Information on the benefits of high efficiency heat pumps provided by the retailers		8		5		10	
Inconsistency Test - FRM4a	IF FRM4a = 100% and FRM5 < 70% FRM4a = EMPTY, OTHERWISE FRM4a = FRM4a	-	0%	-	100%	-	0%
PA2 Score	IF FRM4<>1: PA2 = 0%, OTHERWISE, MEAN VALUE OF: (FRM4a;FRM5;FRM6)	-	0%	-	83%	-	33%
Free-ridership	PA2	-	0%	-	83%	-	33%
CI2/4a. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] was a major factor in your decision to install a [EQUIPMENT] in your home. (Agree or Disagree)	CI = IF(CI2a OR CI4a=Agree) + IF(CI2b OR CI4b=Agree) + IF(CI2c OR CI4c=Agree)	1	3	0	1	0	2
CI2/4b. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted you to ask a contractor or a distributor about energy efficient heating systems for your home. (Agree or Disagree)		1		0		1	
CI2/4c. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted you to take into account the savings on your energy bill when evaluating different heating systems for your home. (Agree or Disagree)		1		1		1	
Revised Free-ridership	IF CI = 0 OR 1, Revised FR = FR IF CI = 2, Revised FR = FR*.75 IF CI = 3, Revised FR = FR*.50	-	0%	-	83%	-	25%

Green Heat - New Path - Mini-Split Heat Pump - Electrically Heated									
Free-ridership algorithm			Low Free-ridership Participant		High Free-ridership Participant		Average Free-ridership Participant		
Questions		Calculation Algorithm		Answer	Calc. Result	Answer	Calc. Result	Answer	Calc. Result
FRM1. Had you already decided to install a heat pump before you heard about the Green Heat Program? (1=Yes, 2=No)		IF 1. Yes: Use FRM1a IF 2. No OR DK OR REF: FRM1a = 0%		2	-	1	-	1	-
FRM1a. I just want to make sure - before you learned about the Green Heat Program, had you already made the decision to install a heat pump? (1=Yes, 2=No)		IF 1. Yes: FRM1a = 100% IF 2. No OR DK OR REF: FRM1a = 0%		-	0%	1	100%	1	100%
FRM2. [ASK IF FRM1a<>1] If the program had not been offered, which of the following actions would you have taken? 1. Kept your existing heating system 2. Purchased a new electric heating system 3. Purchased a new non-electric heating system (e.g. oil or gas system) 4. Purchased a heat pump		IF 1, 2 or 3: END IF 4: ASK FRM3		4	-	NA	-	NA	-
FRM3. [ASK IF FRM2=4] If the program had not been offered, what is the likelihood that you would have postponed the purchase of a heat pump by at least one year? (Scale 0 to 10)		FRM3 = (10 – Answer) x 10% IF DK OR REF: FRM3 = EMPTY		9	10%	NA	-	NA	-
PA1 Score		MEAN VALUE OF: (FRM1a ; FRM3)		-	5%	-	100%	-	100%
FRM4. Were you aware of the availability of higher efficiency heat pumps that operate at temperatures below -15°C before you heard about Green Heat? (1=Yes, 2=No)		IF 1. Yes: Use FRM4a IF 2. No, DK OR REF: FRM4a = 0% and END		2	-	1	-	2	-
FRM4a. [ASK IF FRM4=1] Before you heard about the Green Heat Program, had you already made the decision to install a high-efficiency heat pump model? (1=Yes, 2=No)		IF 1. Yes: FRM4a=100% IF 2. No, DK OR REF: FRM4a = 0%		NA	0%	1	100%	NA	0%
FRM5. [ASK IF FRM4=1] If you had not received the rebate from Efficiency Nova Scotia, would you have paid the total cost of your high-efficiency heat pump? (Scale 0 to 10)		FRM5 = Answer x 10% IF DK OR REF: FRM5 = EMPTY		9	90%	10	100%	8	80%
FRM6. Level of influence (Scale 0 to 10)		FRM6 = (10 - MAX(a;b;c))*10%		-	10%	-	0%	-	0%
	Factor a. The program rebate			9		0		10	
	Factor b. Information on the benefits of high efficiency heat pumps provided by Efficiency Nova Scotia			9		0		10	
	Factor c. Information on the benefits of high efficiency heat pumps provided by the retailers			7		10		10	
Inconsistency Test - FRM4a		IF FRM4a = 100% and FRM5 < 70% FRM4a = EMPTY, OTHERWISE FRM4a = FRM4a		-	0%	-	100%	-	0%
PA2 Score		IF PA1<=50% OR FRM4<>1: PA2 = 0%, OTHERWISE MEAN VALUE OF: (FRM4a;FRM5;FRM6)		-	0%	-	67%	-	0%

Free-ridership	0.75xPA1+0.25xPA2	-	4%	-	92%	-	75%
CI2/4a. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] was a major factor in your decision to install a [EQUIPMENT] in your home. (Agree or Disagree)	CI = IF(CI2a OR CI4a=Agree) + IF(CI2b OR CI4b=Agree) + IF(CI2c OR CI4c=Agree)	1	3	0	1	1	3
CI2/4b. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted you to ask a contractor or a distributor about energy efficient heating systems for your home. (Agree or Disagree)		1		0		1	
CI2/4c. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted you to take into account the savings on your energy bill when evaluating different heating systems for your home. (Agree or Disagree)		1		1		1	
Revised Free-ridership	IF CI = 0 OR 1, Revised FR = FR IF CI = 2, Revised FR = FR*.75 IF CI = 3, Revised FR = FR*.50	-	2%	-	92%	-	38%

Overall free-ridership level (%) for the MSHP

$$FR_{Category} = \frac{\sum_{i=1}^n (FR_i \times Gross\_Savings_i)}{\sum_{i=1}^n Gross\_Savings_i}$$

Where n represents the number of participants surveyed
FR calculated for 3 categories: (1) Old Path, (2) New Path
Electrically Heated, (3) New Path Non-Electrically Heated

Since gross savings were established based on participant main heating source, the FR levels obtained for old and new paths were used to calculate weighted average FR levels by participant main heating source: (1) mainly electrically heated; (2) fully electrically heated; and (3) non-electrically heated.

$$FR_{Fully\ Electrically\ Heated} = \frac{FR_{Old\ Path} \times Gross\_Savings_{Old\ Path\ Fully\ Electrically\ Heated} + FR_{New\ Path\ Electrically\ Heated} \times Gross\_Savings_{New\ Path\ Fully\ Electrically\ Heated}}{Gross\_Savings_{Fully\ Electrically\ Heated}}$$

$$FR_{Mainly\ Electrically\ Heated} = \frac{FR_{Old\ Path} \times Gross\_Savings_{Old\ Path\ Mainly\ Electrically\ Heated} + FR_{New\ Path\ Electrically\ Heated} \times Gross\_Savings_{New\ Path\ Mainly\ Electrically\ Heated}}{Gross\_Savings_{Mainly\ Electrically\ Heated}}$$

$$FR_{Non-Electrically\ Heated} = \frac{FR_{Old\ Path} \times Gross\_Savings_{Old\ Path\ Non-Electrically\ Heated} + FR_{New\ Path\ Non-Electrically\ Heated} \times Gross\_Savings_{New\ Path\ Non-Electrically\ Heated}}{Gross\_Savings_{Non-Electrically\ Heated}}$$

FR_{Fully Electrically Heated} = 42%
FR_{Mainly Electrically Heated} = 39%
FR_{Non-Electrically Heated} = 33%

NTGR calculation

$$NTGR = 1 - FR_{Total}$$

NTGR_{Fully Electrically Heated} = 58%
NTGR_{Mainly Electrically Heated} = 61%
NTGR_{Non-Electrically Heated} = 67%

Small Business Energy Solutions - Audit Path							
Free-ridership algorithm			Low Free-ridership Participant		High Free-ridership Participant		Average Free-ridership Participant
Questions	Calculation Algorithm	Answer	Calculation Result	Answer	Calculation Result	Answer	Calculation Result
FR2ab. If your organization had not received the rebate or the financing from ENS, would you have paid for the full cost of the energy-efficient upgrades you installed? (Scale 0 to 10)	FR2ab = Answer x 10% IF DK OR REF: FR2 = EMPTY	0	0%	7	70%	4	40%
FR3a. If the audit, rebate and/or financing had not been offered, what is the likelihood that you would have installed standard equipment or that you would have simply kept your old equipment instead of installing energy-efficient equipment in your facility? (Scale 0 to 10)	FR3a = (10 - Answer) x 10% IF DK OR REF: FR3a = EMPTY	10	0%	10	0%	7	30%
PA1 Score	MEAN VALUE OF: (FR2ab ; FR3a)	-	0%	-	35%	-	35%
FR1. Before having your facility evaluated by a SBEA, did your organization have plans to install the specific energy-efficient upgrades that were installed as part of SBES program ? Did you... 1. Have plans to implement all of the upgrades 2. Have plans to implement some of the upgrades 3. Have no plan to implement any of the upgrades	IF 1 OR 2: GO TO FR1a IF 3 OR DK OR REF: FR1a = 0%	1	-	1	-	2	-
FR1a. [ASK IF FR1=1 OR 2] I just want to make sure I understand - Before you had your facility evaluated by a SBEA, you had already made the decision to install [all/some of] the energy efficiency upgrades that were installed as part of the program?	IF 1. Yes and FR1 = 1: FR1a = 100% IF 1. Yes and FR1 = 2: FR1a = 25% IF 2. No OR DK OR REF: FR1 = 0%	2	0%	1	100%	1	25%
PA2 Score	FR1a	-	0%	-	100%	-	25%
FR4. Level of influence – 7 factors (Scale 0 to 10)	FR4 = MAX(a; b; c; d; e; f; g)	-	9	-	5	-	10
a. The free audit	-	8	-	5	-	10	-
b. Information or advice from the small business energy auditor.	-	0	-	5	-	10	-
c. [IF REBATE=YES] The program rebate	-	9	-	3	-	10	-
d.[IF FINANCING =YES] d. The program on-bill financing	-	NA	-	NA	-	10	-
e. Information or advice provided by Efficiency Nova Scotia's staff.	-	0	-	0	-	10	-
f. Information or advice provided by a contractor	-	9	-	0	-	10	-
g. The availability of a list of contractors through the Efficiency Trade Network	-	0	-	0	-	5	-
PA3 Score	(10 – FR4) × 10%	-	10%	-	50%	-	0%

FR3b. [ASK IF TOTAL MEASURE QTY>1] If the audit, rebate and/or financing had not been offered, what is the likelihood that you would have installed exactly the same quantity of energy-efficient upgrades that were installed through the SBES program? (Scale 0 to 10)	FR3b = Answer x 10% IF 98 OR 99: FR3b = EMPTY	NA	-	NA	-	NA	-
FR3c. [ASK IF FR2a or b ≥5] If the audit, rebate and/or financing had not been offered, what is the likelihood that you would have postponed making energy efficient upgrades to your facility by at least one year? (Scale 0 to 10)	FR3c = (10 – Answer) x 10% IF DK OR REF: FR3b = EMPTY	NA	-	10	0%	NA	-
PA4 Score	Min (FR3b; FR3c)	-	-	-	0%	-	-
Inconsistency Test - PA1	IF ABS(FR2ab – FR3a) ≥ 50% : PA1 = MIN(FR2ab; FR3a)	-	0%	-	0%	-	35%
Inconsistency Test - PA2	IF FR1a = 100% AND FR2ab < 70%: PA2 = EMPTY	-	0%	-	100%	-	25%
Free-ridership	IF PA4 < MEAN (PA1; PA2; PA3): MEAN (PA1; PA2; PA3; PA4) OTHERWISE MEAN (PA1; PA2; PA3)	-	3%	-	38%	-	20%
CI2/4a. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] was a major factor in your decision to install energy efficient upgrades in your facility. (Agree or Disagree)	CI = IF(CI2a OR CI4a = Agree; 1) + IF(CI2b OR CI4b = Agree; 1) + IF(CI2c OR CI4c = Agree; 1)	1	3	1	1	1	3
CI2/4b. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted a company representative to examine the energy efficiency options for the facility or to ask for an energy audit of your facility. (Agree or Disagree)		1		0		1	
CI2/4c. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted a company representative to take into account the cost-effectiveness of energy efficient upgrades when evaluating different options for the facility. (Agree or Disagree)		1		0		1	
Revised Free-ridership	IF CI = 0 OR 1, Revised FR = FR IF CI = 2, Revised FR = FR*.75 IF CI = 3, Revised FR = FR*.50	-	2%	-	38%	-	10%

Small Business Energy Solutions - DIY Path - Lighting							
Free-ridership algorithm		Low Free-ridership Participant		High Free-ridership Participant		Average Free-ridership Participant	
Questions	Calculation Algorithm	Answer	Calculation Result	Answer	Calculation Result	Answer	Calculation Result
FR2ab. If your organization had not received the rebate or the financing from ENS, would you have paid for the full cost of the lighting upgrades? (Scale 0 to 10)	FR2ab = Answer x 10% IF DK OR REF: FR2 = EMPTY	0	0%	10	100%	6	60%
FR3d. Were you aware that the lighting products rebated through the Small Business Energy Solution Program are premium products certified by Design Light Consortium or ENERGY STAR®	IF 1. Yes: Use FR3a IF 2. No OR DK OR REF: FR3a = 0%	1	-	1	-	1	-
FR3a. [ASK IF FR3d=1] If the program rebate or financing had not been offered, what is the likelihood that you would have installed the exact same model of lighting products? (Scale 0 to 10)	FR3a = Answer x 10% IF DK OR REF: FR3a = EMPTY	0	0%	10	100%	5	50%
PA1 Score	MEAN VALUE OF: (FR2ab ; FR3a)	-	0%	-	100%	-	55%
FR1. Had your organization already decided to install the energy-efficient lighting system before learning about the SBES program?	IF 1. Yes: Use FR1a IF 2. No OR DK OR REF: FR1 = 0%	2	0%	1	-	2	0%
FR1a. [ASK IF FR1=1] I just want to make sure I understand - Before you learned about the SBES program and the rebates offered through the program, you had already made the decision to install the energy-efficient lighting?	IF 1. Yes: FR1 = 100% IF 2. No OR DK OR REF: FR1 = 0%	-	-	1	100%	-	-
PA2 Score	FR1	-	0%	-	100%	-	0%
FR4. Level of influence– 5 factors (Scale 0 to 10)	FR4 = MAX(a; b; c; d; e)	-	9	-	0	-	10
a. [ASK IF REBATE=YES] The program rebate	-	9	-	0	-	10	-
b.[IF FINANCING =YES] The program on-bill financing	-	8	-	NA	-	NA	-
c. Information or advice received by Efficiency Nova Scotia's staff.	-	7	-	0	-	0	-
d. Information or advice provided by a contractor	-	7	-	0	-	8	-
e. The availability of a list of contractors through the Efficiency Trade Network	-	0	-	0	-	10	-
PA3 Score	(10 – FR4) × 10%	-	10%	-	100%	-	0%

FR3b.[IF TOTAL LIGHTING QTY >1] If the program rebate or financing had not been offered, what is the likelihood that you would have installed exactly the same quantity of lighting products that you installed through the program? (Scale 0 to 10)	FR3b = Answer x 10% IF DK OR REF: FR3b = EMPTY	0	0%	10	100%	5	50%
FR3c. [ASK IF FR2 a or b ≥5] If the program rebate or financing had not been offered, what is the likelihood that you would have postponed installing the lighting upgrades by at least one year? (Scale 0 to 10)	FR3c = (10 – Answer) x 10% IF DK OR REF: FR3b = EMPTY	NA		0	100%	5	50%
PA4 Score	Min (FR3b; FR3c)	-	0%	-	100%	-	50%
Inconsistency Test - PA1	IF ABS(FR2ab – FR3a) ≥ 50% : PA1 = MIN(FR2ab; FR3a)	-	0%	-	100%	-	55%
Inconsistency Test - PA2	IF FR1a = 100% AND FR2ab < 70%: PA2 = EMPTY	-	0%	-	100%	-	0%
Free-ridership	IF PA4 < MEAN (PA1; PA2; PA3): MEAN (PA1; PA2; PA3; PA4) OTHERWISE MEAN (PA1; PA2; PA3)	-	3%	-	100%	-	18%
CI2/4a. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] was a major factor in your decision to install energy efficient upgrades in your facility. (Agree or Disagree)	CI = IF(CI2a OR CI4a = Agree; 1) + IF(CI2b OR CI4b = Agree; 1) + IF(CI2c OR CI4c = Agree; 1)	1	2	0	1	1	2
CI2/4b. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted a company representative to examine the energy efficiency options for the facility or to ask for an energy audit of your facility. (Agree or Disagree)		0		1		0	
CI2/4c. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted a company representative to take into account the cost-effectiveness of energy efficient upgrades when evaluating different options for the facility. (Agree or Disagree)		1		0		1	
Revised Free-ridership	IF CI = 0 OR 1, Revised FR = FR IF CI = 2, Revised FR = FR*.75 IF CI = 3, Revised FR = FR*.50	-	2%	-	100%	-	14%

Small Business Energy Solutions - DIY Path HVAC							
Free-ridership algorithm		Low Free-ridership Participant		High Free-ridership Participant		Average Free-ridership Participant	
Questions	Calculation Algorithm	Answer	Calculation Result	Answer	Calculation Result	Answer	Calculation Result
FR2ab. If your organization had not received the rebate or the financing from ENS, would you have paid for the full cost of the HVAC upgrades? (Scale 0 to 10)	FR2ab = Answer x 10% IF DK OR REF: FR2 = EMPTY	0	0%	6	60%	5	50%
FR3a. If the program rebate or financing had not been offered, what is the likelihood that you would have installed exactly the same energy-efficient HVAC upgrades that were rebated or financed through the Program? (Scale 0 to 10)	FR3a = Answer x 10% IF DK OR REF: FR3a = EMPTY	4	40%	5	50%	5	50%
PA1 Score	MEAN VALUE OF: (FR2ab ; FR3a)	-	20%	-	55%	-	50%
FR1. Had your organization already decided to install the energy-efficient HVAC system before learning about the SBES program?	IF 1. Yes: Use FR1a IF 2. No OR DK OR REF: FR1 = 0%	1	-	1	-	2	0%
FR1a. [ASK IF FR1=1] I just want to make sure I understand - Before you learned about the SBES program and the rebates offered through the program, you had already made the decision to install the energy-efficient HVAC upgrades?	IF 1. Yes: FR1 = 100% IF 2. No OR DK OR REF: FR1 = 0%	1	100%	98	0%	-	-
PA2 Score	FR1	-	100%	-	0%	-	0%
FR4. Level of influence– 5 factors (Scale 0 to 10)	FR4 = MAX(a; b; c; d; e)	-	10	-	3	-	10
a. [ASK IF REBATE=YES] The program rebate	-	10	-	0	-	8	-
b.[IF FINANCING =YES] The program on-bill financing	-	10	-	NA	-	10	-
c. Information or advice received by Efficiency Nova Scotia's staff.	-	5	-	0	-	8	-
d. Information or advice provided by a contractor	-	5	-	3	-	5	-
e. The availability of a list of contractors through the Efficiency Trade Network	-	10	-	0	-	0	-
PA3 Score	(10 – FR4) × 10%	-	0%	-	70%	-	0%

FR3c. [ASK IF FR2 a or b ≥5] If the program rebate or financing had not been offered, what is the likelihood that you would have postponed installing the HVAC upgrades by at least one year? (Scale 0 to 10)	FR3c = (10 – Answer) x 10% IF DK OR REF: FR3b = EMPTY	NA	-	2	80%	9	10%
PA4 Score	FR3c	-	-	-	80%	-	10%
Inconsistency Test - PA1	IF ABS(FR2ab – FR3a) ≥ 50% : PA1 = MIN(FR2ab; FR3a)	-	20%	-	55%	-	50%
Inconsistency Test - PA2	IF FR1a = 100% AND FR2ab < 70%: PA2 = EMPTY	-		-	0%	-	0%
Free-ridership	IF PA4 < MEAN (PA1; PA2; PA3): MEAN (PA1; PA2; PA3; PA4) OTHERWISE MEAN (PA1; PA2; PA3)	-	10%	-	42%	-	15%
CI2/4a. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] was a major factor in your decision to install energy efficient upgrades in your facility. (Agree or Disagree)	CI = IF(CI2a OR CI4a = Agree; 1) + IF(CI2b OR CI4b = Agree; 1) + IF(CI2c OR CI4c = Agree; 1)	1	3	0	0	1	2
CI2/4b. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted a company representative to examine the energy efficiency options for the facility or to ask for an energy audit of your facility. (Agree or Disagree)		1		0		0	
CI2/4c. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted a company representative to take into account the cost-effectiveness of energy efficient upgrades when evaluating different options for the facility. (Agree or Disagree)		1		0		1	
Revised Free-ridership	IF CI = 0 OR 1, Revised FR = FR IF CI = 2, Revised FR = FR*.75 IF CI = 3, Revised FR = FR*.50	-	5%	-	42%	-	11%

Overall free-ridership level (%) for the program component

$$FR_{category} = \frac{\sum_{i=1}^n (FR_i \times Gross\_Savings_i)}{\sum_{i=1}^n Gross\_Savings_i}$$

Where n represents the number of participants surveyed
FR calculated for 3 categories of participants:
Audit, DIY-Lighting and DIY-HVAC

$$FR_{Total} = \frac{FR_{Audit} \times Gross\_Savings_{Audit} + FR_{DIY-Lighting} \times Gross\_Savings_{DIY-Lighting} + FR_{DIY-HVAC} \times Gross\_Savings_{DIY-HVAC}}{Gross\_Savings_{Total}}$$

$$FR_{total} = 12\%$$

Spillover Algorithm		Example participant (none with spillover this year)	
Questions	Calculation Algorithm	Answer	Calculation Result
SO1. Have you installed additional energy efficiency measures other than those implemented through this program?	IF 1. Yes: CONTINUE IF 2. No OR DK OR REF: END	1	-
SO2. Did you receive, or plan on requesting, financing or rebates from other agencies other than Efficiency Nova Scotia for these additional energy efficiency upgrades?	IF 2. No: CONTINUE IF 1. Yes OR DK OR REF: END	2	-
SO4. Describe these additional measures.	SO4 = SUM of kWh associated with each upgrade	Measures implemented before participating in BER program	0
Additional Upgrade Savings	SO4	-	0
SO3. Did your experience with this program influence your decision to implement these additional energy efficiency measures on your own? (Scale 0 to 10)	SO3 = Answer x 10%	0	0%
Attribution Level	SO3	-	0%
Spillover Savings	SO3 x SO4	-	0%

Overall spillover level (%) for the program component

$$SO_{total} = \frac{\sum_{i=1}^n SO\_Savings_i}{\sum_{i=1}^n Gross\_Savings_i}$$

Where n represents the number of participants surveyed

$$SO_{total} = 0\%$$

NTGR calculation

$$NTGR = 1 - FR_{total} + SO_{total}$$

$$NTGR = 88\%$$



ECONOLER

RESIDENTIAL EFFICIENT PRODUCT REBATES PROGRAM

2017 DSM EVALUATION

EFFICIENCY NOVA SCOTIA

Final Report

March 15, 2018



ECONOLER

ABBREVIATIONS

ARet	Appliance Retirement
ATO	Appliance tracking order
CADR	Clean air delivery rate
CFL	Compact fluorescent lamp
CRA	Corporate Research Associates
DA	Delivery agent
DEER	Database for Energy Efficiency Resources
DHW	Domestic hot water
DSM	Demand-side management
EER	Energy efficiency ratio
EISA	Energy Independence and Security Act
ENS	Efficiency Nova Scotia
EPI	Efficient Product Installation
EUL	Effective useful life
GHG	Greenhouse gas
HRSB	Halifax Regional School Board
IMEF	Integrated modified energy factor
LED	Light-emitting diode
MEF	Modified energy factor
NERHOU	Northeast Residential Hours of Use
NRCan	Natural Resources Canada
NTGR	Net-to-gross ratio
PF	Power factor

RUL	Remaining useful life
SEER	Seasonal energy efficiency ratio
SKU	Stock keeping unit
TRM	Technical Reference Manual
UEC	Unitary energy consumption
UMP	Uniform Methods Project

DEFINITIONS

Accuracy	Reflects the proximity of measurements to the true value.
Adjustment ratio	The ratio of evaluated results to tracked results. This ratio expresses the adjustment made to tracked savings or other tracked values such as effective useful life.
Base case	To determine gross savings, a base case is established providing detailed information about the reference (e.g. pre-existing or standard) measure or equipment chosen to be compared with the efficient measure or equipment. For the reference measure or equipment, the base case may include such information as the hours of operation, wattage and the base consumption.
Bias	Systematic deviations of measurements from the true value.
Billing calibration	An activity that consists of adjusting the expected energy savings based on the relative difference between the results of the energy simulations and the actual energy consumption of the building or system.
Confidence interval	The estimated range of values which is likely to include the unknown population parameters.
Displaced wattage	The displaced wattage is defined as the difference between the wattage values of the baseline equipment or product and the efficient equipment or product.
EnerGuide rating	An EnerGuide (official brand of Natural Resources Canada) rating is a standard measure of the home's energy performance. It is a measure of the efficiency of the building only and does not take into account occupant behaviour. It shows how energy efficient the home is through modelled heat losses of the home, based on several factors including building envelope characteristics, heated volume, heating systems and air leakage.
Effective useful life	The period a measure is expected to be in service and provide both energy and peak demand savings. This value combines the equipment life and the measure persistence, which includes factors such as business turnover or early retirement.
Equipment life	The number of years installed equipment will operate before it fails.
Equivalent CO ₂	A unit of measurement indicating the amount of carbon dioxide to which various kinds of emitted greenhouse gases are equivalent in terms of warming effects. In this report, the gases' global-warming potential is estimated over a timescale of 100 years.
Equivalent effective useful life	The number of years by which the first-year savings estimate is multiplied to obtain lifetime energy savings. This value takes into account variations in annual energy savings throughout the effective useful life due to increased baselines.

Evaluated savings	Gross and net savings calculated by the Evaluator using the parameters (unitary savings values, installation rates, interactive effects, net-to-gross ratio, etc.) validated or measured during the evaluation process. Unless otherwise specified, the evaluated savings are the first-year savings.
Evaluation plan	The evaluation plan summarizes the program description, objectives, base cases, documentation, evaluation methodology, budget and schedule.
First-year savings	The first full year of energy savings generated by an energy efficiency measure.
Free-ridership	Percentage of gross savings attributable to participants who would have implemented the same or similar energy efficiency measures, with no change in timing, in the absence of the program.
Gross energy savings	Energy savings generated by energy efficiency measures, before applying the net-to-gross ratio.
Induced consumption	Energy consumption of appliances that would have been unplugged and not replaced by participants in the absence of the program.
Interactive effects	Effects on the energy consumption of other systems in the building (such as heating and cooling) due to the installation of an energy efficiency measure.
Internal spillover	Savings attributable to participants who continue to implement the energy efficiency measure introduced by a program after participating in it once, without participating in the program a second time.
In-service rate	The proportion of incentivized products that are installed and operating. This rate is usually applied to programs through which rebates are offered in-store and products are likely to be stored for a certain period before being installed, such as LED bulbs.
Lifetime energy savings	The energy savings that occur over the lifetime of an energy efficiency measure. Lifetime energy savings account for a measure's effective useful life and any increase in the baseline efficiency level (which reduces attributable annual savings) over its lifetime.
Line loss factor	The multiplier to convert savings at the customer meter to savings at the utility generator. It accounts for the electrical losses of the transmission and distribution system.
Margin of error	The amount of random sampling error.
Market effects	The impact of the program on the market (such as increased product availability, practices, and prices) that extends beyond changing the program participants' behaviour. This includes spillover among non-participants.
Net energy savings	Energy savings that can be reliably attributed to a program. This includes effects, such as free-ridership and spillover, that negatively or positively affect the energy savings attributable to a program.
Net-to-gross ratio	The ratio of net energy savings to gross energy savings.

Non-sampling error	Errors arising during the course of all survey activities other than sampling. Non-sampling errors tend to lead to bias in measurements and are very difficult to quantify.
Peak coincidence factor	The percentage of measure demand savings that coincide in time with the annual peak demand of the entire electricity system.
Peak demand savings	The demand savings that coincide in time with the expected annual peak demand period of the entire electricity system.
Precision	The extent to which repeated measurements agree with one another.
Random sampling error	The error in measurement due to the fact that measurements are taken from a subset of the population and not the entire population.
Sample size	The number of observations or replicates included in a statistical sample.
Secondary market impacts	Energy consumption of appliances that would have been transferred to the secondary market if said appliances had not been retired.
Tracked savings	Gross and net savings calculated by ENS in the tracking system, based on various parameters such as number of participants, unitary savings values, installation rates, interactive effects, and the net-to-gross ratio.
Unitary savings	Energy or peak demand savings established on a unitary basis. This unit can either be a product (e.g., an 8 W LED lamp), a capacity (e.g., one-ton capacity of an air-source heat pump) or a participant (e.g., one participant taking part in a behaviour-based program).

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EXECUTIVE SUMMARY

This report presents the results of the 2017 demand-side management (DSM) evaluation of the Residential Efficient Product Rebates program, which is comprised of two components: (1) Appliance Retirement (ARet) and (2) Instant Savings.

Table 1 lists the number of participants, the gross savings and the net savings for each Residential Efficient Product Rebates program component and the whole program.

Table 1: Overall Participation and Savings for Residential Efficient Product Rebates

	Participation Level	Gross Savings	NTGR	Net Savings
ARet				
Energy Savings	6,138 appliances	5.266 GWh	0.59	3.094 GWh
Lifetime Energy Savings ¹		40.321 GWh	0.57	23.050 GWh
Peak Demand Savings		0.740 MW	0.60	0.443 MW
Instant Savings				
Energy Savings	710,540 products sold	22.343 GWh	0.87	19.543 GWh
Lifetime Energy Savings		203.959 GWh	0.88	179.116 GWh
Peak Demand Savings		2.993 MW	0.85	2.558 MW
Total				
Energy Savings		27.609 GWh		22.637 GWh
Lifetime Energy Savings		244.280 GWh		202.166 GWh
Peak Demand Savings		3.733 MW		3.001 MW

Appliance Retirement

Efficiency Nova Scotia (ENS) promotes the retirement of inefficient household appliances, including full-sized and small refrigerators, full-sized and small freezers, and room air conditioners. ARet is designed to educate Nova Scotians about the cost of maintaining old appliances and encourage them to retire their inefficient appliances by offering free pick-ups from their homes and a cash incentive.

The following incentives are offered through ARet:

- › \$30 for each retired refrigerator
- › \$30 for each retired freezer
- › \$10 for each retired air conditioner
- › \$10 for each retired small refrigerator or freezer

¹ Throughout this report, energy savings always refer to first-year energy savings rather than lifetime energy savings, unless specified otherwise.

In addition, the replacement of inefficient dehumidifiers, refrigerators and freezers paid by DSM funds through HomeWarming are claimed under ARet.

In the fall of 2016, the Halifax Regional School Board (HRSB) partnered with ENS on a pilot project and conducted an audit of all the refrigeration appliances (refrigerators and freezers) in HRSB schools. The audit resulted in an opportunity for schools to retire the surplus appliances through the ARet regular channel. Savings associated with this pilot project are also claimed under ARet.

The 2017 evaluation of ARet was based on a program component documentation review, an interview with the program manager, three visits to the recycling facility, an interview with a representative of the HRSB and a unitary savings review.

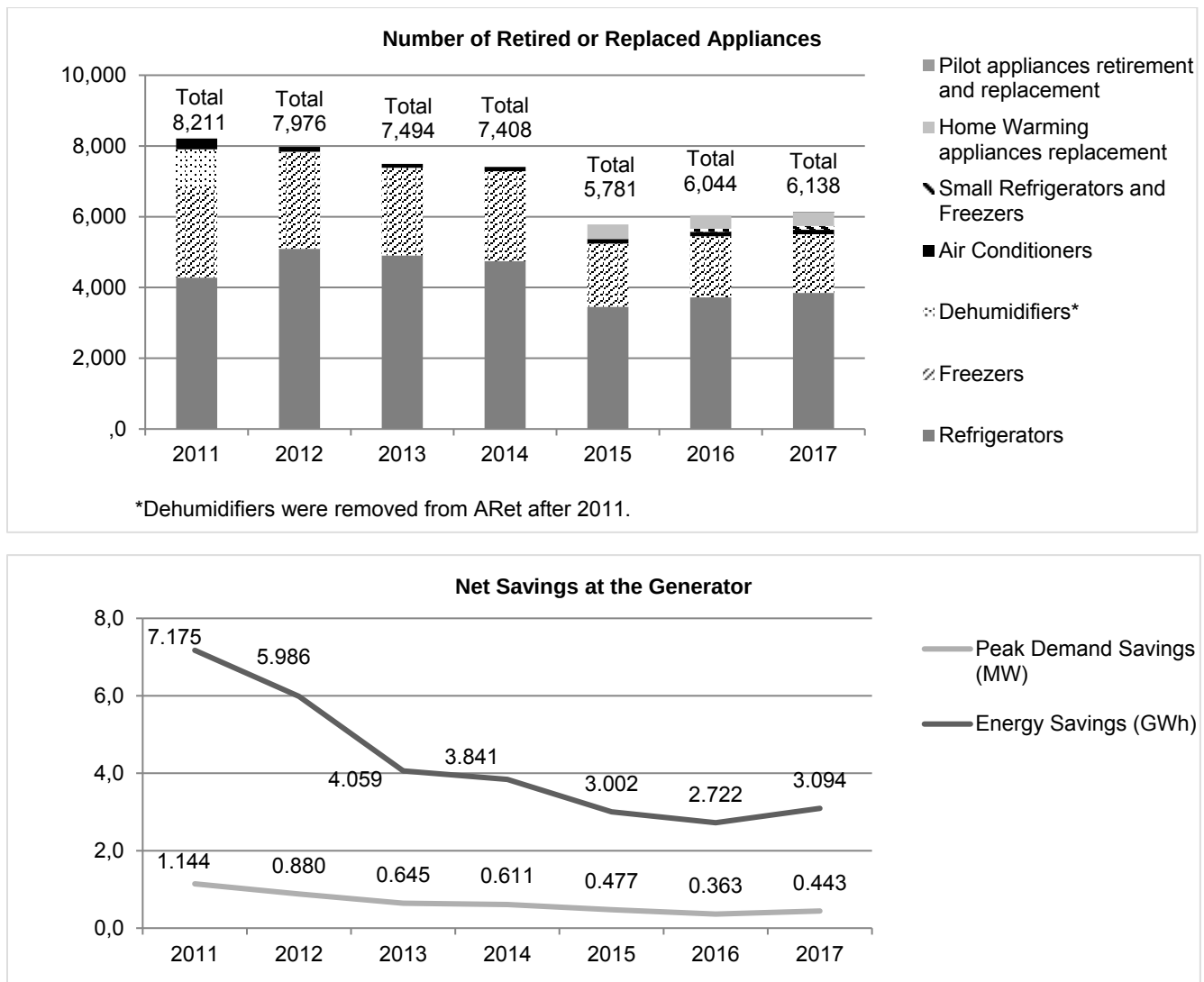
ARet Key Findings

ARet Performance

ARet aimed to achieve 2.6 GWh in net energy savings and 0.3 MW in net peak demand savings at the generator in 2017. The Evaluator found that it achieved 3.094 GWh in net energy savings and 0.443 MW in net peak demand savings at the generator in 2017. These savings represent 2,021 tonnes of CO₂ eq in terms of annual avoided greenhouse gas (GHG) emissions. By applying a weighted average equivalent effective useful life (EUL) value of 7.4 years, the net lifetime energy savings have been established at 23.050 GWh.

A total of 5,739 appliances were retired through ARet in 2017, including 3,847 refrigerators, 1,659 freezers, 124 air conditioning units and 109 small refrigerators/freezers. Additionally, 59 refrigerators, 203 freezers and 124 dehumidifiers were replaced through HomeWarming and 10 refrigerators, two freezers and one small refrigerator were retired through the pilot. Altogether, a total of 6,138 inefficient appliances were retired or replaced through ARet, the pilot and HomeWarming in 2017, as displayed by the performance overview in Figure 1 below.

The participant level was stable compared to the previous year, because the number of appliances retired through ARet in 2017 was less than 2 percent higher than in 2016.

Figure 1: Overview of ARet Performance, 2011-2017


ARet Energy Savings

As part of the 2017 ARet evaluation, the Evaluator reviewed the metering protocol and improved it notably by measuring the interior temperature of appliances and by using new metering tools. Three on-site visits to the appliance-recycling facility were conducted to validate the metering process. While the metering protocol was much improved, the margins of error were higher than expected since the sample size was not large enough, notably because of the quantity of unusable data that this new approach allowed for identifying. Nevertheless, the Evaluator considers that this approach has not only helped identify the reasons for energy-consumption variations among different types of appliances, but also shown that increasing the number of units metered is the key element for reducing the margins of error. The average annual consumption values of metered appliances retired were within ranges similar to those of 2016, with the exception of freezers manufactured in 1994 and earlier.

To calculate ARet's net energy savings, the Evaluator once again used the savings calculation methodology developed for the 2013 evaluation in compliance with the Uniform Methods Project (UMP) general guidelines for refrigerator recycling evaluations. The unitary savings values of each type of appliance retired through ARet and HomeWarming were revised based on the results of the 2017 metering study, the characteristics of the retired appliances documented in the tracking system, as well as the information obtained from the 2016 participant survey. The Evaluator established specific unitary savings for appliances retired through the ARet Pilot to account for the usage patterns of surplus appliances found in schools.

To establish an equivalent net-to-gross ratio (NTGR), the Evaluator took into consideration the free-ridership value and secondary market impact value applicable to the unitary savings and the level of spillover applicable to the program's overall gross savings by using the following formula:

$$NTGR_{equiv} = \frac{Net\ Unitary\ Savings}{Gross\ Unitary\ Savings} + Spillover\%$$

Table 2 shows the equivalent NTGR for each appliance type.

Table 2: ARet Equivalent Net-to-gross Ratios

Appliance Type	Number of Units	Gross Savings	Effects			Net Unitary Savings (kWh)	Internal Spillover	Equival. NTGR
		Consumption of Retired Appliances (kWh)	Free-ridership (kWh)	Secondary Market Impact (kWh)	Induced Consump. (kWh)			
Refrigerators	3,847	751	278	53	10	410	1%	0.55
Freezers	1,659	863	345	44	9	465		0.55
Air Conditioners	124	215	129	20	0	66		0.32
Small Fridges	78	209	92	14	0	103		0.50
Small Freezers	31	327	144	21	0	162		0.50

As for the appliances retired through HomeWarming, an NTGR of 1 was assumed, considering the nature of the program component (direct replacement) and the participant demographic. Similarly, a NTGR of 1 was assumed for the appliances retired through the pilot.

The impact evaluation revealed that ARet generated 3.094 GWh in net energy savings and 0.443 MW in net peak demand savings respectively at the generator in 2017, as summarized in Table 3.

Table 3: Comparison of ARet Tracked and Evaluated Savings at the Generator

	Initial Gross Savings	Adjusted Gross Savings	NTGR	Net Savings
Energy Savings				
Tracked Savings from ENS	4.852 GWh	4.852 GWh	0.57	2.761 GWh
Evaluation Results	5.266 GWh	5.266 GWh	0.59	3.094 GWh
Peak Demand Savings				
Tracked Savings from ENS	0.653 MW	0.653 MW	0.56	0.368 MW
Evaluation Results	0.740 MW	0.740 MW	0.60	0.443 MW

The overall evaluated net energy savings are 12 percent higher than those tracked by ENS. This difference is mainly due to the increase in freezers' unitary savings values for both ARet and HomeWarming. This increase has resulted from the increase in retired freezers' average energy consumption values obtained from the 2017 metering activities.

The evaluated net peak demand savings are 21 percent higher than the tracked net peak demand savings, which is attributable to the higher revised energy savings and the increase in the peak-demand-to-energy ratio for dehumidifiers (from 0.000 to 0.335).

ARet Recommendations

ARet continues to achieve considerable levels of participation and savings, despite having been in the market for several years. Considering that the majority of participants would not have recycled their appliances on their own if ARet had not been in place (as revealed by last year's participant survey), the program component is still useful in encouraging the retirement of inefficient appliances and educating people about the cost of maintaining old appliances.

In addition to the general recommendations made for all the ENS program components in the 2017 DSM Programs Evaluation Executive Summary, the Evaluator has two major recommendations to improve ARet, which are presented below and can also be found in Appendix I.

2017 ARet-R1. Continue to perform the metering activity to increase sample sizes. This year, the Evaluator developed a new metering protocol, which greatly improved the quality of the metering data. Although the metering approach used in 2017 was improved, the sample sizes were not large enough to provide acceptable margins of error on gross energy consumption values. Therefore, the Evaluator recommends continuing the metering activity in 2018 using the same age categories and the same protocol as used in 2017 to increase the sample size of each age category. As for the metering activity to be performed next year, the Evaluator also suggests implementing some minor changes, such as using a better tool to measure the power factor of each appliance type and measuring old appliances' inside temperature at the time of pick-up, as recommended in the Metering Review section of this report.

2017 ARet-R2. Improve the process for tracking appliances retired through the pilot. This year, the savings of those appliances retired through the ARet pilot were tracked using the same parameters and methodology as for full-sized residential appliances. After conducting an interview with a representative of HRSB schools, the Evaluator used different unitary gross and net savings values for the pilot. Going forward, the Evaluator recommends using the unitary savings values established in this year's evaluation for appliances retired through the pilot. The Evaluator also recommends improving the tracking process by clearly identifying the appliances retired through the pilot.

Instant Savings

Instant Savings works in collaboration with a delivery agent (DA) and participating retailers to offer participants rebates on the purchase of various energy-efficient products that include ENERGY STAR® certified light-emitting diode (LED) lamps and fixtures, dimmer switches, programmable thermostats, refrigerators and clothes washers. Rebates on eligible products were offered during two campaigns that took place in the spring and fall, while rebates on appliances were offered throughout the year.

During the fall 2017 campaign, ENS tested out new products related to indoor air quality to assess retailer and consumer responses to ENERGY STAR certified room air purifiers, dehumidifiers and bathroom fans.

The 2017 Evaluation of Instant Savings was based on a program component documentation review, interviews with eight retailers, an intercept survey of 100 participants conducted during the fall campaign and a unitary savings review.

Instant Savings Key Findings

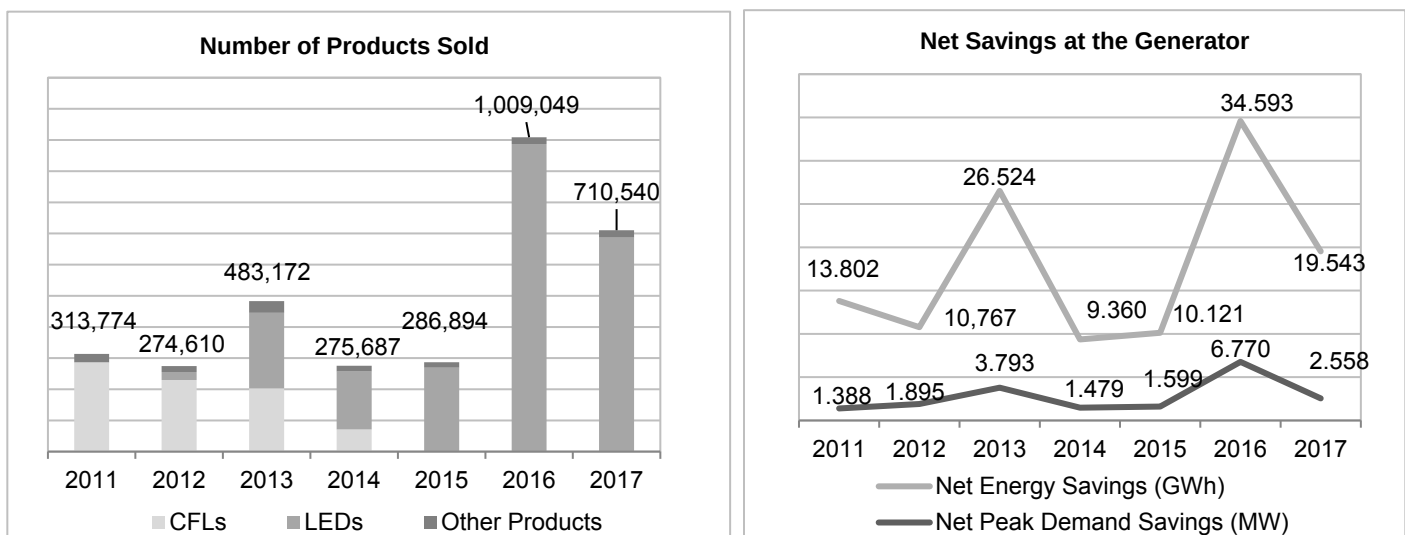
Instant Savings Performance

Instant Savings aimed to achieve 20.0 GWh in net energy savings and 3.3 MW in net peak demand savings at the generator in 2017. The Evaluator concluded that it achieved 19.543 GWh in net energy savings and 2.558 MW in net peak demand savings at the generator, as illustrated in Figure 2 below. These savings represent 12,764 tonnes of CO₂ eq in terms of annual avoided GHG emissions. Based on a weighted average effective useful life value of 9.2 years, the net lifetime energy savings are 179.116 GWh.

In 2017, a total of 710,540 eligible products were sold in participating stores across Nova Scotia. Among these products, 651,968 were LED lamps (512,096 A-type and 139,872 Non-A-type LED lamps), which represents a decrease compared to 2016 participation levels. This lower number of LEDs sold is mainly due to the introduction of a price floor to prevent retailers from selling LEDs at very low prices, a situation that had resulted in extraordinary sales in 2016. However, 2017 sales are still much higher than any other previous year.

Net energy savings generated by Instant Savings in 2017 decreased compared to 2016, but remained higher than previous years. These lower savings are a direct result of the lower number of products sold, but also of the significant decrease in the spillover level between 2016 and 2017.

Figure 2: Overview of Instant Savings Performance, 2011-2017



Instant Savings Market Evaluation Highlights

Overall satisfaction with Instant Savings varied among retailers in 2017. While the majority of retailers mentioned fairly high levels of satisfaction with the program component, the remaining retailers expressed some frustration with the introduction of a product price floor in 2017. It should be noted that the price floor did not affect all eligible products, mostly the packs of one or two LED lamps. In 2017, retailers continue to have good relationships with the DA; they were generally pleased with DA helpfulness, responsiveness, support, reliability, and the thorough information provided about the campaigns.

Retailers were asked to assess the influence of Instant Savings. Overall, Instant Savings was generally seen to have influenced the quantity of ENERGY STAR certified LED lamps stocked in stores in 2017. Retailers were also asked to identify what prevents consumers from purchasing energy-efficient products. Five retailers identified cost as the main barrier, while three retailers believe that insufficient knowledge now trumps price as the key barrier to LED adoption. This is a first in the history of the program component.

Similarly to 2016, the intercept participant survey indicated that ENS marketing was the most common way for participants to find out about Instant Savings, primarily through in-store promotions, followed by TV ads, the ENS website and word-of-mouth.

Instant Savings Energy Savings

This year, the Evaluator reviewed the unitary savings values used for LED lamps and fixtures, which generate by far the most savings, as well as clothes washers and refrigerators whose baselines changed as a result of new federal regulations. The Evaluator also established the unitary savings values of the three new products tested during the fall campaign. To do so, the Evaluator conducted a literature review, consulted technical information from manufacturers or ENERGY STAR certified product lists, and performed engineering calculations.

Net energy savings, which result from applying an NTGR, represent the portion of gross program component savings that can be reliably attributed to the program. The NTGR was measured for the best-selling product, LED lamps, and included free-ridership and spillover. As shown in Table 4, the intercept survey revealed a free-ridership level of 32 percent, while retailer interviews and sales data revealed a spillover of 16 percent, which is considerably lower than the 2016 level of 47 percent. This drop is mainly explained by improved sales data that revealed a lower number of LED lamp sales outside the campaigns. In 2017, the NTGR for LED lamps was established at 0.84. As for all other products, the NTGR was established at 1.

Table 4: Instant Savings Net-to-gross Ratio

Product Category	Free-ridership	Spillover	NTGR
LED Lamps	32%	16%	0.84
All Other Products	-	-	1.00

In 2017, Instant Savings generated 19.543 GWh in net energy savings and 2.588 MW in net peak demand savings at the generator. Table 5 compares tracked and evaluated savings at the generator.

Table 5: Comparison of Tracked and Evaluated Savings at the Generator

	Initial Gross Savings	Revised Gross Savings	NTGR*	Net Savings
Energy Savings				
ENS Tracked Savings	23.562 GWh	23.562 GWh	1.11	26.162 GWh
Evaluation Results	22.343 GWh	22.343 GWh	0.87	19.543 GWh
Peak Demand Savings				
ENS Tracked Savings	4.615 MW	4.615 MW	1.12	5.186 MW
Evaluation Results	2.993 MW	2.993 MW	0.85	2.558 MW

*NTGRs varied for each product category. The NTGRs presented in this table correspond to the rounded averages obtained by dividing net savings by installed gross savings (with interactive effects taken into account).

The evaluated net energy savings are 25 percent lower than the tracked energy savings. This difference is mainly due to two reasons: (1) the decrease in gross unitary savings associated with LED A-type lamps which were decreased by 6 percent and accounted for more than 60 percent of the total savings; and (2) the lower market effects established this year compared to those of 2016. Based on the 2017 participant survey, the LED unitary savings adjustment resulted mainly from the decreasing number of participants replacing incandescent lamps in favor of compact fluorescent lamp (CFL) and LED lamps.

The evaluated net peak demand savings are 51 percent lower than the tracked net peak demand savings. This difference is mainly due to the same reasons as for the difference in the energy savings, but is further explained by the lower evaluated peak demand-to-energy ratios used for lighting products based on the findings of the Efficient Product Installation (EPI) Residential Lighting Metering Study and the Northeast Residential Hours of Use (NERHOU) study.

Market Evolution

ENS has been active in the LED market since 2011 through Instant Savings. In 2017, the Evaluator analyzed market indicators to monitor the evolution of the lighting market, especially A-type LEDs, and help identify whether program component support should be withdrawn or reduced in light of the changes observed in the market.

A socket study² indicated that LED lamp socket saturation was 21 percent in permanent fixture lamps and 24 percent in plug-in lamps in Nova Scotia and that 59 percent of Nova Scotians had at least one LED lamp in 2016. In 2017, LED lamp shipments accounted for approximately one third of all lamps shipped in Atlantic Canada, among which A-types remained the dominant LED lamp type.

LED lamps are available at major retailers as well as at independent stores, as indicated by the varied retailers participating in Instant Savings. LED products are also now available in some discount stores. Instant Savings data indicate that LED lamp prices have declined significantly since 2012 and A-type is the least expensive LED type.

The increased share of LEDs in the lighting market, greater availability and price reductions indicate that the barriers to LED purchases continue to diminish. The results of the retailer interviews also confirmed that barriers have been reduced. Furthermore, customers surveyed through the socket study reported stronger intentions to use LED bulbs in their light fixtures in 2016 than in 2011.

As suggested by the socket saturation of LEDs established by the 2016 socket study, LEDs are still in a growth phase, although they are approaching maturity as more and more Nova Scotia residents adopt them. Growth is expected to continue in future years since no more efficient technology is currently available and an update to the Canadian energy efficiency regulations might make LEDs the baseline technology within approximately seven years.

Instant Savings Recommendations

Overall, the Evaluator determined that Instant Savings was again effectively delivered in 2017. In addition to the general recommendations made for all the ENS program components in the 2017 DSM Programs Evaluation Executive Summary, the Evaluator makes the following recommendations aimed at optimizing Instant Savings. These recommendations are also presented in Appendix I.

² Corporate Research Associates Inc., *2016 Socket Study*, Final Report Prepared for Efficiency Nova Scotia, December 2016.

- 2017 Instant-R1** **Continue providing program component support to expand the share of LED bulbs in the Nova Scotia residential lighting market while beginning to plan an exit strategy for A-type bulbs.** Given the high participation level in this program component, high purchase volume of A-type bulbs and reductions in LED prices, ENS should consider decreasing incentive levels for A-type bulbs. In addition, ENS should consider possible opportunities for shifting the focus of the program component, for example to bulb types with lower market adoption, to extend Instant Savings beyond the short-term.
- 2017 Instant-R2** **Continue monitoring market indicators and collect additional information to further characterize the LED market.** Because the lighting market is in a period of change, the Evaluator recommends continuing to monitor market indicators such as market share of lighting technologies, socket saturation and LED prices. Also, to better characterize the current state of the lighting market, the Evaluator recommends collecting data about the following aspects: (1) Different LED and halogen bulb types installed in homes. This information could be collected during site visits in future socket studies; and (2) Customer knowledge of LEDs. This information could be collected using questions included in a periodic Omnibus survey. An Omnibus survey is a cost-effective method where data on a wide variety of subjects is collected during the same interview.

INTRODUCTION

Efficiency Nova Scotia (ENS) is a franchise held by EfficiencyOne³ and is responsible for helping Nova Scotians improve the energy efficiency of their homes and workplaces. ENS designs, markets and delivers energy efficiency and conservation programs for various segments of the population. ENS receives funding for its activities from Nova Scotia Power and the Province of Nova Scotia. The funds received from Nova Scotia Power cover the costs of activities designed to help reduce electricity consumption, whereas funds from the Province of Nova Scotia are primarily used for activities designed to help reduce the use of other fuels by households with lower incomes.

Econoler was commissioned to evaluate ENS's 2017 demand-side management (DSM) program portfolio comprised of six electricity efficiency programs and assess the impact of energy efficiency codes and standards introduced in Nova Scotia. To carry out this assignment, Econoler collaborated with Research Into Action, Equilibrium Engineering and Corporate Research Associates (CRA).

Econoler served as team leader in the 2017 evaluation and was involved in every aspect of the evaluation. Specifically, Econoler was in charge of coordinating and supervising all activities, conducting final reviews of all data collection instruments, performing impact evaluation calculations, as well as preparing and reviewing the evaluation reports. Research Into Action carried out the process evaluations, while Equilibrium Engineering conducted the on-site visits and contributed to some impact evaluation analyses. CRA conducted the interviews and surveys with participants and partners, as well as analyzed and reported on the data collected from these activities. Throughout this report, this team is referred to as the Evaluator.

For each program, the Evaluator prepared a DSM evaluation report presenting the general findings, electrical first-year and lifetime energy savings, peak demand savings and avoided greenhouse gas (GHG) emissions.

Table 6 below lists the various programs assessed as part of the 2017 evaluation and indicates their respective components and the types of evaluations conducted. In this table, "C" means a complete evaluation, and "R" indicates that reduced evaluation activities were performed, as compared to 2016. Section 1 of the DSM Programs Evaluation Executive Summary presents the scope of work in further detail, along with the rationale for the types of evaluation performed for each program component. The methodology sections of this report also highlight the differences in evaluation activities among the components.

³ On January 1, 2015, ENS became a franchise owned by the Province of Nova Scotia and was licensed to the new not-for-profit organization EfficiencyOne.

Table 6: Types of Evaluations Conducted for Each Program Component

Program	Program Component	2016			2017		
		Process	Market	Impact	Process	Market	Impact
Residential Efficient Product Rebates Program	Appliance Retirement		C	C			R
	Instant Savings		C	C		R	R
Existing Residential Program	Home Energy Assessment		C	C		C	C
	Green Heat		C	C	C	C	C
	Efficient Product Installation		C	C		C	C
New Residential Program	New Home Construction		C	C		C	C
Efficient Product Rebates Program	Business Energy Rebates		C	C		C	R
Custom Incentives Program	Custom		C	C	C*	C	R
	Energy Management Information Systems	C	C	C		C	C
	Strategic Energy Management**	C	C	C			
Direct Installation Program	Small Business Energy Solutions	C	C	C		C	C
*The process evaluation specifically targets the Retrofit service of the Custom program component. ** Due to the start date of the latest Strategic Energy Management (SEM) cohort, SEM did not have any participants who achieved savings in 2017; therefore, no evaluation was conducted for 2017.							

This evaluation report is for the Residential Efficient Product Rebates program, which is comprised of two components: Appliance Retirement (ARet); and Instant Savings. Each program component's description, evaluation methodology and main evaluation findings are presented in the following sections.

1 ARET OVERVIEW

This evaluation report first discusses the ARet evaluation results and then the results from the Instant Savings program component.

This section describes the ARet program component, follows up on the 2016 evaluation recommendations and gives an overview of its participation history.

1.1 Description

Through ARet, ENS promotes the retirement of old inefficient household appliances, such as refrigerators, freezers, room air conditioners and small refrigerators or freezers. ARet educates Nova Scotians about the cost of maintaining old and inefficient appliances, provides free pick-up from their homes (not from the roadside) and offers a financial incentive for the retirement.

In addition to removing old appliances from participants' homes, ARet also recycles these appliances by transporting them to a local recycling depot, where over 95 percent of the components are recycled. ARCA Canada Inc. is the delivery agent (DA) responsible for appliance transportation and recycling. To have their appliances picked up, participants must register with a call centre or register online using the booking portal available on the ENS website. With the assistance of ENS, ARCA Canada Inc. streamlined the appointment booking process and their decommissioning procedures in 2017.

Eligible appliances must be plugged in and still in working condition and must be 10 years of age or older. In 2017, this meant that eligible appliances had to be manufactured before 2007. In addition, full-sized refrigerators must have a standard size between 10 and 25 cubic feet. Since 2016, small refrigerators and freezers have also been eligible for retirement and rebates. To save on fuel and ensure that the trip is worthwhile for the pick-up team, room air conditioners, and small refrigerators and freezers are only picked up together with full-sized refrigerators or freezers to be retired. To participate in ARet, participants must own the appliances they want to retire.

The following rebates are offered through ARet:

- › \$30 for each retired refrigerator
- › \$30 for each retired freezer
- › \$10 for each retired air conditioner
- › \$10 for each retired small refrigerator or freezer

In addition, the replacement of inefficient dehumidifiers, refrigerators and freezers paid for by DSM funds through HomeWarming are claimed under ARet. HomeWarming is another program component administered by ENS and provides energy efficiency upgrades (building envelope measures and appliance replacements) at no cost to income-eligible owners of non-electrically heated homes. HomeWarming funding for building envelope measures is provided by the Province of Nova Scotia, while funding for replacing old, inefficient appliances with new high-efficiency models is provided by electricity DSM funds.

In the fall of 2016, the Halifax Regional School Board (HRSB) partnered with ENS and conducted an audit of all the refrigeration appliances (refrigerators and freezers) in HRSB schools. The audit revealed surplus appliances for school needs and a large number of appliances 15 years old or older, resulting in an opportunity for schools to either retire or replace the appliances through ARet. This pilot project continued, resulting in some appliances being retired in 2017. ENS continues to work with representatives of the HRSB to retire appliances and, where necessary, replace inefficient refrigerators and freezers from school properties. The pilot includes three elements:

- › The removal of privately owned appliances, where owners are encouraged to retire their appliances through ARet
- › The retirement of HRSB and school-owned appliances through the regular ARet channel
- › The replacement of essential appliances targeted for retirement, purchased through ARCA or Instant Savings

As part of the ARet Pilot, ENS offers the same incentive and free removal services as for regular participants.

ARet aimed to achieve 2.6 GWh in net electricity savings and 0.3 MW in peak demand savings for 2017.

1.2 Follow-up on 2016 Evaluation Report Recommendations

The ARet component was evaluated in 2016 and recommendations were made by the Evaluator for its improvement. Table 7 below provides a brief summary of the implementation status of the recommendation presented in the executive summary section of the 2016 evaluation report.

Table 7: Implementation Status of the Recommendations in the 2016 Executive Summary

Recommendation	Status
2016 ARet-R1. Continue to perform metering activity and keep improving its quality and effectiveness.	Implemented

To implement this recommendation, a new round of metering was performed on full-sized appliances in 2017 and allowed for including more recent appliances in the metering sample. The last time metering was conducted on full-sized appliances was in 2015. At that time, no appliances manufactured after 2001 were eligible for ARet. Beginning in 2016, the eligibility criteria were changed to “10 years or older”, thus allowing for more recently manufactured appliances to be retired through ARet. As a result, more energy-efficient appliances manufactured between 2002 and 2007 are now accounted for in the new metering data set. Moreover, to improve metering data’s precision, the metering protocol was reviewed and necessary changes were made in 2017. The changes included continuously recording the internal temperatures of each appliance and the use of new, more accurate data-collection devices. This is further discussed in Section 3.1.

1.3 Participation History

In 2017, 5,739 appliances were retired through ARet, including 3,847 refrigerators, 1,659 freezers, 124 air conditioning units and 109 small refrigerators or freezers. Additionally, 59 refrigerators, 203 freezers and 124 dehumidifiers were replaced through HomeWarming and 10 refrigerators, two freezers and one small refrigerator were retired through the pilot. A total of 6,138 appliances were retired or replaced through ARet, the pilot and HomeWarming, as summarized in Figure 3 below. The total number of appliances retired in 2017 was less than 2 percent higher than in 2016, showing a stable level of participation.

As a result of a bigger number of appliances retired in 2017, the savings increased compared to 2016, as shown in Figure 4. ARet achieved 5.266 GWh in gross energy savings and 0.740 MW in gross peak demand savings in 2017. The unitary savings values that were updated based on the 2017 metering activities were another reason for this increase.

Since 2011, 47,860 old and inefficient appliances have been retired from homes and more recently from schools and recycled so that they could not have been refurbished, sold second-hand, or left plugged in. Although the participation level dropped significantly in 2015 indicating the stock of older appliances was diminishing, changing the eligibility criteria to 10 years of age or older has meant that every year, more appliances become eligible for retirement through ARet. This ensures good participation levels with only marginal reduction in per-appliance energy savings. Indeed, as shown in Figure 3, the number of appliances retired has remained steady since 2015. Moreover, a similar number of retired appliances can be expected in the next few years since the expected life of more recent appliances is less than 15 years. This suggests that ARet is still useful in encouraging the retirement of inefficient appliances and that the market has not yet been transformed.

Figure 3: Overview of Participation in ARet, 2011-2017

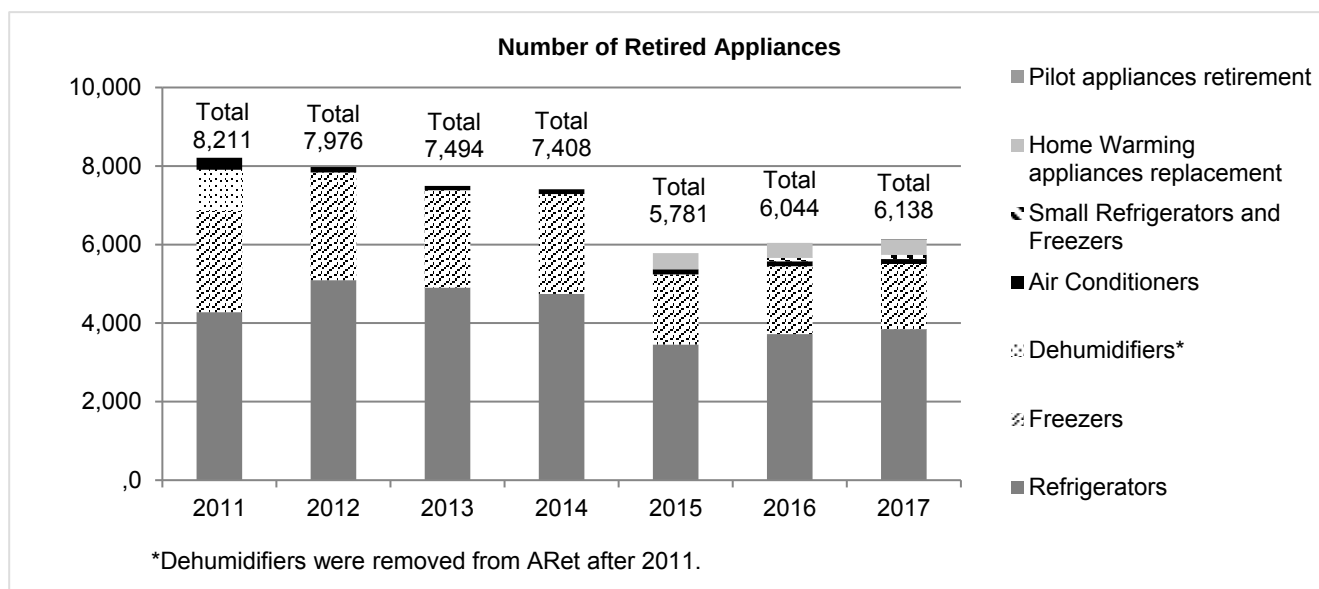
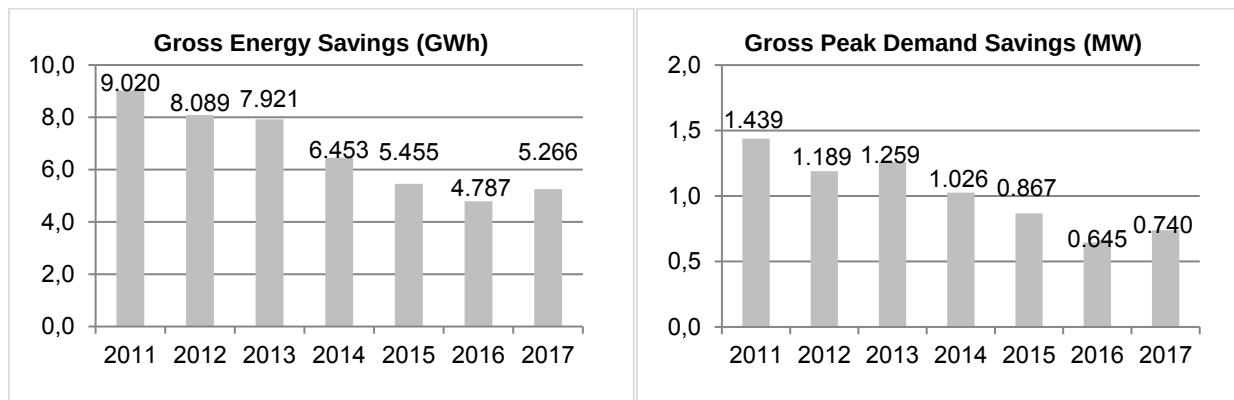


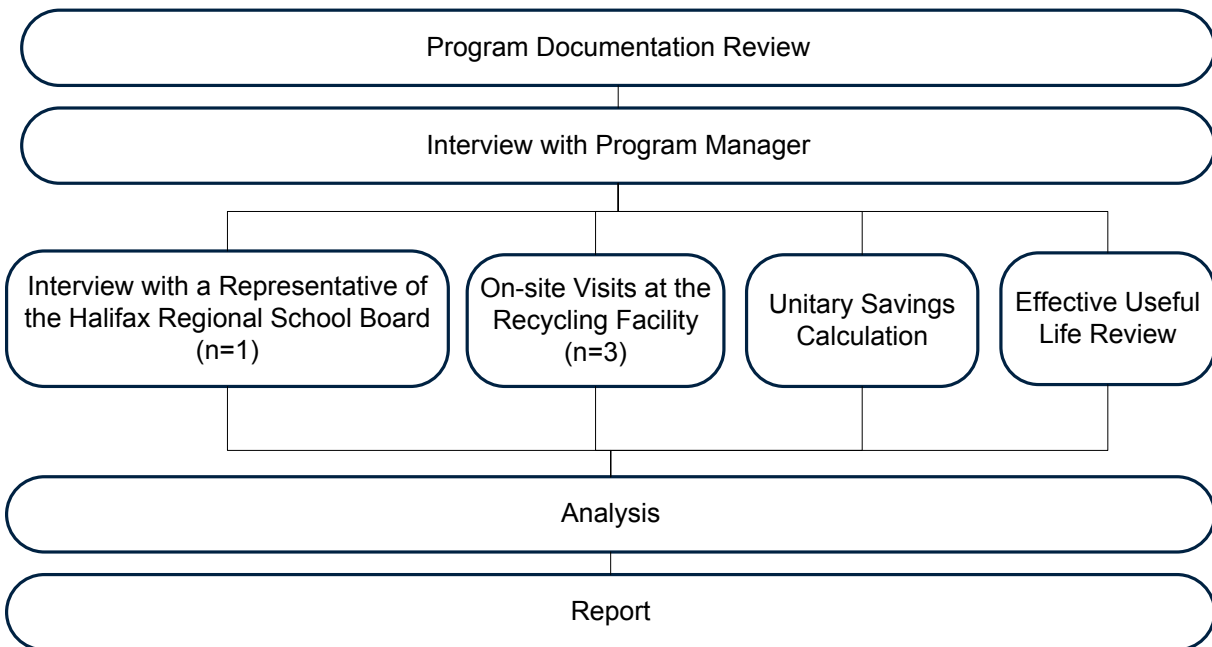
Figure 4: Summary of Gross Savings for ARet, 2011-2017



2 ARET EVALUATION METHODOLOGY

This section presents the methodology used and the activities carried out for the ARet 2017 evaluation. Figure 5 illustrates the research strategy employed and data-collection activities carried out in the evaluation.

Figure 5: Methodological Model



The Evaluator reviewed the program component documentation and then met with the program manager in August 2017 to verify the implementation status of the previous evaluation recommendations and learn about the program component changes made in 2017. Based on the information obtained from this meeting, a list of questions and topics to be included in the data collection instruments were prepared.

Once the meeting with the program manager and the program component documentation review were completed, specific evaluation activities were undertaken, as described in the following sub-sections.

For evaluation activities that were based on a sample and yielded quantitative results, the Evaluator aimed to achieve a maximum margin of error of 10 percent at a confidence level of 90 percent. This means that if measurement was conducted many times with different samples, the data would be within 10 percentage points above or below the percentage reported 90 percent of the time. Thus, the margin

of error indicates the relative level of precision⁴ of the measurement, while its associated confidence level indicates the probability of a measurement falling within this margin of error.⁵

As part of this evaluation, the Evaluator calculated the margin of error for survey samples, free-ridership levels and the energy consumption metering, where applicable. The margins of error are listed alongside the results in the specific sections. Examples of the calculations used to establish margins of error are shown in Appendix II of the 2017 DSM Programs Evaluation Executive Summary.

Interview with a Representative of the Halifax Regional School Board

In December 2017, an interview with a representative of the Halifax Regional School Board was conducted to establish the free-ridership of the Appliance Retirement Pilot participant.

The interview guide is provided in Appendix II.

On-site Visits at the Recycling Facility

In the fall 2017, the Evaluator conducted three visits at the recycling facility where the appliances retired through ARet were decommissioned and recycled. The main purpose of these visits was to ensure that the metering was conducted properly once appliances were delivered to the recycling facility.

Unitary Savings Calculation

For ARet, the Evaluator reviewed the unitary savings of the retired refrigerators, freezers, air conditioners and small appliances based on the metering data collected by ENS and information found in the literature or in appliance directories. Since the net-to-gross ratios (NTGR) obtained in the two previous ARet evaluations were stable, no participant survey was conducted in 2017 and the 2016 survey results were used to establish the free-ridership level, secondary market impacts and induced consumption and the associated NTGR.

For HomeWarming, the data collected in the tracking system, manufacturer information and the ARet metering results were used to establish the energy consumption differences between the old and new appliances.

⁴ Precision refers to how reproducible a set of measurements is. It does not take into account, however, how close the measured values are to the true values, as this would refer to accuracy.

⁵ As part of this evaluation, the confidence level and the margin of error only take random sampling errors into account; they do not reflect non-sampling errors or biases, such as data entry errors, inaccurate responses from respondents or the inability to contact certain people.

Effective Useful Life Review

As part of the 2017 evaluation, to examine the effective useful life (EUL) values used by ENS to calculate lifetime energy savings, the Evaluator conducted a thorough literature review by consulting technical reference manuals (TRMs), evaluation reports and relevant studies.

Comparison with 2016 Evaluation Scope

No market evaluation took place for ARet in 2017; so no participant survey was conducted. The impact evaluation scope was considered reduced since NTGRs were not measured in 2017. The rationale behind those choices is based on analysis of 2017 evaluation objectives, key results of the previous evaluations and recent changes made to each program. Further explanation can be found Section 1 of the DSM Programs Evaluation Executive Summary.

3 ARET IMPACT EVALUATION

This section presents the findings of the metering review and the results of the impact evaluation for 2017. This impact evaluation includes the assessment of the gross and net unitary savings for each of the five retired appliance types, the interactive effects and the overall gross and net savings.

3.1 Metering Review

The Evaluator ensured that the appliances retired in 2017 were adequately and properly metered by (1) developing a sampling plan, (2) assisting ENS in implementing the 2016 recommendations concerning new metering equipment and procedures, (3) conducting three site visits to the appliance recycling facility to observe the metering process and (4) analyzing the raw data obtained from the metering activities to calculate average energy consumption.

3.1.1 Development of the Sampling Plan

Metering activities for the 2017 evaluation targeted full-sized refrigerators and freezers representing three age ranges: (1) appliances from 1994 and earlier, (2) appliances between 1995 and 2001, and (3) appliances from 2002 onward. The selected age categories correspond to major updates in energy efficiency regulations. The Evaluator recommended metering 130 appliances, whose sample-size targets were broken down by appliance type and age range, as shown in Table 8 below.

Table 8: ARet Metering Sample Size Targets by Appliance Age and Type

Appliance Type and Age Range	Metering Sample
Refrigerators	
2002 and later	30
1995-2001	20
1994 and earlier	20
Freezers	
2002 and later	20
1995-2001	20
1994 and earlier	20

The Evaluator used the same total sample size as used in previous years and attributed at least 20 appliances to each category to ensure obtaining acceptable margins of error. Ten more appliances were added to the 2002 and later age category for refrigerators because this category is the most popular category of retired appliances.

3.1.2 Changes to Metering Equipment

Until 2016, the tracked metered savings were established based on the data collected using the Kill-A-Watt® plug-in meter manufactured by P3 International, which records instantaneous data about amperage, voltage, power factor (PF), as well as the total energy consumption over the metering period in kWh. The Kill-A-Watt® meters were used together with Smart Reader Plus3® data loggers with current transformers manufactured by ACR Systems Inc. Although the data from the current transformer was available for all the appliances metered, only the energy consumption values from the plug-in meter were used by ENS to track savings. In 2016, the Evaluator used the raw data from the current transformer and an Excel workbook created by ENS to calculate the revised energy consumption values, and recommended ENS implement this change to the metering protocol.

In 2016, the Evaluator recommended that ENS calibrate loggers each year to maintain accuracy. ENS implemented this change in 2017 and added individual internal temperature sensors for each appliance. As well, ENS used new HOBO® 4-channel analog data collection devices with matched split-core AC current sensors. These changes allowed ENS to implement the Evaluator's recommendation to calibrate loggers because the new equipment was already calibrated. Also, adding an internal temperature sensor for each appliance provided not only accurate data about the interior conditions during the metering period, but also a more robust method for screening out unusable data. The changes made to the metering protocol were documented by ENS in both the updated program component manual, and in the on-site data collection form.

3.1.3 Site Visit Observations

The Evaluator observed the metering process on three separate occasions at the recycling facility to ensure that ENS was following the documented protocol. This metering protocol was adapted from the New York State Department of Public Service protocol,⁶ with the exception that ENS's metering is done at the recycling facility instead of in-situ.

During the first site visit, the Evaluator met with ENS to review the on-site data collection form, review the equipment setup, and do a trial process run by following the new protocol. The visit revealed that a diagram for the metering setup was missing from the documentation, and that there was a communication problem between the staff's laptop and the loggers. As a result, the ENS IT department installed and tested software updates on a computer that was only used for the data logging process at the recycling facility. Apart from the technical problem found with the computer, the rest of the first visit went smoothly, clearly indicating that ENS was comfortable with adopting the procedural changes made to the metering protocol and following the metering process.

⁶ New York Department of Public Service, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs Residential, Multi-Family, and Commercial/Industrial Measures*, October 15, 2010, p.16-21.

The second and third metering visits were performed several weeks apart. During each visit, the Evaluator observed ENS as its staff went through the process by following the steps of the revised metering protocol. During the two final visits, the setup and completion of the metering process were observed for a total of 16 appliances. Each visit started by first wrapping up the previous metering round and starting a new round. As specified in the metering protocol, the room temperature was maintained at approximately 21°C to reflect typical conditions expected in a home. A separate HOBO® data logger was used to continuously measure the room temperature, thereby ensuring that it was maintained within an acceptable range.

At the start of each metering event, ENS collected the required information about the appliance manufacturer, the appliance tracking order (ATO) number, the general description of the unit and the appliance type. To prevent mix-ups in post-metering analysis, each data logger used was given a name (such as Logger “A” = Adele, Logger “B” = Barbara, Logger “C” = Chloe and Logger “D” = Denise), which was documented by ENS in the on-site data collection sheet. Photos of the ATO number, the appliance, the EnerGuide label where available, and the dial position for the temperature setting were collected in case off-site information was required. ENS did not adjust any of the temperature set-point controls for the metered appliances to ensure that the metering results were indicative of how the previous owner had the equipment set at the time of data collection. Once the information about an appliance was collected, ENS reset the HOBO® logger and connected the current and the internal temperature sensors. Special care was taken to ensure that the cable for the internal temperature probe did not affect the seal on the appliance, and, where necessary, tape was used to seal any gaps around the cable.

Because of several small technical delays, such as the communication problem with the loggers and the laptop, and waiting for the new HOBO® loggers to arrive, ENS had to accelerate the metering periods by having its staff start a new set of three or four appliances every morning and another set of three or four at the end of the work day. As a result, some appliances were metered over approximately an eight-hour period (morning samples) and others were metered over a period of 12-18 hours. In previous years, this would have caused a problem because the Kill-A-Watt® meters could not provide any detailed information about the number of cycles an appliance went through during the period. However, thanks to newly added HOBO® loggers and the internal temperature profile, the metering periods’ lengths were deemed effective because both ENS and the Evaluator were able to use the loggers’ data to confirm whether an appliance was functional. In addition, these new loggers allow the post-metering analysis to select specific start and finish points of the metering period, and provide an additional means of controlling and/or screening out unusable data from the sample.

Overall, the Evaluator was pleased to observe that the modifications made to the metering process had been properly documented and that ENS had implemented all the changes made during the metering activities. One recommendation to be made about the metering would be to take multiple PF readings for each device to provide a more representative value, or to use a third-party-reviewed PF factor that is typical of the appliance type and age. Because the spot measurements from the Kill-A-Watt® meters only provide a snap shot, the applied value is likely to negatively impact the actual tracked savings value. Another recommendation is to send the HOBO® data loggers back to the manufacturer every year at the end of the metering process to have the loggers recalibrated and get them ready for the upcoming year.

3.1.4 Processing Metering Data

ENS performed a post-metering review of the metering files before delivering the data sample to the Evaluator. Such a post-metering review involved verifying whether an appliance had reached the set-point temperatures specified in the protocol and whether the sample had gone through enough operating cycles, and identifying any unusual variations in internal temperature or amperage. The Evaluator reviewed the raw data or log files to determine the overall quality of the data sets in the sample and then used the information to determine the individual appliances' savings.

Additional screening of raw data was carried out by the Evaluator by focusing on those appliances that failed to meet or maintain their set-point temperatures or that had unusual amperage or temperature data. The newly added HOBO® loggers and the associated HOBOWare® software suite provided the raw data, which was then exported to a Microsoft Excel format and used to draw amperage and temperature curves over time and was used by the Evaluator to quickly screen out unusable or poor data. The samples were classified into four data-quality categories, as summarized below, based on a set of criteria.

Usable Data

- › Most samples showed the following data: (1) a current with an amperage of below 8 amp when the compressor was on; (2) a current with an amperage near zero when the compressor was off; (3) temperatures fluctuating around a reasonable set-point, namely between 0°C and 10°C for refrigerators and between -40°C and 0°C for freezers. While the usual set-points are closer to 4°C for refrigerators and -15°C for freezers, the Evaluator assumed that a refrigerator or a freezer with a temperature within the identified ranges could have been used by participants even though it might have been warmer or colder than the usual set-points.

Excluded Data

- › **Logger errors:** Some samples were removed due to apparent errors related to logger connection, as indicated by low (under 0.1 amp), high (over 8 amp) or flat-line current values, combined with variable temperature logs or inconsistent temperature values (below -40°C or over 30°C).

- › **Temperatures not maintained:** Some files or records were screened out because, although the appliances of these samples reached an operating temperature within the acceptable ranges, their compressors did not cycle again in the sampling period and their internal temperatures rose until they reached the room temperature. This would suggest that either the compressor functioned intermittently or the temperature sensor failed in the appliances; thus, these units were not considered functional. The Evaluator believes that probably these appliances broke down during their transport to the recycling facility, because sometimes transportation can damage appliances (especially welded points and compressor parts). Since it cannot be established with certainty that these appliances had the same problem in the participants' homes, they were excluded from the analysis.
- › **Refrigerant losses:** Some appliances showed decreases in their temperature and current, which is a common signal indicating a refrigerant loss. This type of damage is common when old refrigerators or freezers are moved. It was impossible to establish the average power consumption because these units did not reach a steady temperature. Since their current decreased with the temperature, the current would have stabilized at a lower level than what was metered. It was also possible that their compressors failed, since compressor failure is a common result caused by a refrigerant loss. For these reasons, as well as those mentioned above for those appliances whose temperature was not maintained, these units were not considered in the analysis.

Table 9 summarizes the samples screened out because of the reasons mentioned above.

Table 9: ARet Metering Sample Sizes by Data Category

Data Category	Freezers	Refrigerators	Total	Proportion
Usable Data	40	56	96	69%
Excluded Data				
Logger Error	1	10	11	8%
Temperature not Maintained	8	7	15	11%
Refrigerant Losses	12	4	16	12%
Total	61	77	138	100%

In most cases, the metering data had good quality and the data logged provided clear proof of the retired appliances' cyclic operation. However, more than 30 percent of the data could not be used for the analysis, and this percentage exceeded the expected volume of unusable data. The small percentage represented by logger-related issues seemed reasonable to the Evaluator, considering that the metering protocol was new to the staff applying it. Among the unusable appliance data, 23 percent can be identified as from non-working appliances, namely those that did not maintain their temperatures or seemed to have refrigerant losses. Further investigation would be required to establish the proportion of appliances that were in a non-working state prior to their transport to the recycling facility. Those appliances should be considered in the average energy consumption, since non-working appliances could generate no savings.

Since the appliances identified as non-working represented 23 percent of all the metered units, verification of old appliances' working condition at the time of pick-up should be improved to determine whether an appliance was damaged during the transport or was already in non-working condition. The Evaluator recommends that (1) old appliances be plugged in on the evening before the pick-up to ensure that a reasonable temperature is reached if the appliance works and (2) old appliances' inside temperature be measured on-site, instead of having the delivery agent's staff feel the coldness with their hands. If the temperature metered at the moment of pick-up is not in the expected ranges (below 10°C for refrigerators and below 0°C for freezers), the appliance should be considered non-functional and its savings should be considered nil. ENS can still pick up such appliances (potentially without providing the incentive) at its discretion. Another option would be to meter the consumption in-situ (in participants' homes), as recommended by the UMP. Doing so would not only provide a more accurate estimate of appliances energy consumption, since their performance would not be altered by transport, but also eliminate the need for making assumptions about the proportion of appliances that still work. However, this option is more expensive than the current metering approach and may not be considered cost-effective for ARet because of this program component's limited size.

3.1.5 Average Energy Consumption Analysis

The Evaluator first calculated each appliance's average energy consumption for the three age groups mentioned above. Only the appliance data identified as usable were included in the analyses and the values outside the two standard deviations were removed since they were considered outliers. Since the difference between the average consumption values of freezers in age categories 1995-2001 and 2002 or later was negligible (the margin of error for these two categories was over 25%), those two categories were combined. Table 10 shows the average energy consumption values by age category for both types of appliances and the corresponding sample sizes and margins of error.

Table 10: Retired Units' Average Energy Consumption by Appliance Age and Type

Age Category	Average Energy Consumption	Final Sample Size	Margin of Error
Refrigerators			
1994 and earlier	58.9 kWh/cu. Ft	13	23.9%
1995-2001	41.1 kWh/cu. Ft	20	18.1%
2002 and later	49.2 kWh/cu. Ft	20	18.9%
Freezers			
1994 and earlier	117.8 kWh/cu. ft	12	21.4%
1995 and later	56.2 kWh/cu. ft	23	19.3%

The changes made to the metering protocol not only improved data quality, but also allowed for better identifying the unusable data, thus leading to a higher percentage of the sample screened out. Although this smaller-than-expected sample led to high margins of error, the Evaluator decided to use the 2017 metering results since they were based on thoroughly screened and more complete data. This year's results also provided a consumption value specific to the "2002 and later" refrigerators, which was not possible to determine with the previous metering data since they were collected when those appliances were not eligible. While it was expected that the consumption value of "2002 and later" refrigerators would be lower than that of 1995-2001 refrigerators since a new regulation came into force in 2002, the metering data showed that refrigerators from the "2002 and later" age group consume more than their predecessors. The Evaluator assumes that this increase is due to newer refrigerators having larger freezer compartments and more accessory features, such as the water distributor and the ice-maker, which both increase per-cubic-foot energy consumption. However, the tracked data did not provide enough information for the Evaluator to validate this assumption.

Although the age categories in the 2016 evaluation were slightly different, the Evaluator compared the 2016 evaluation's values and those of the 2017 evaluation, as shown in Table 11 below.

Table 11: Comparison of the 2016 and 2017 Metered Average Energy Consumption

2017 Age Category	2017 Average Energy Consumption	2016 Average Energy Consumption	2016 Age Category
Refrigerators			
1994 and earlier	58.9 kWh/cu. ft	75.3 kWh/cu. ft	1984 and earlier
		62.4 kWh/cu. ft	1985-1993
1995-2001	41.1 kWh/cu. ft	42.4 kWh/cu. ft	1994 and later
2002 and later	49.2 kWh/cu. ft	-	-
Freezers			
1994 and earlier	117.8 kWh/cu. ft	60.0 kWh/cu. ft	All
1995 and later	56.2 kWh/cu. ft		

As shown in the table above, the average consumption values established fell in similar ranges, except those for the freezers manufactured in 1994 and earlier, whose average consumption value was established at a much higher level in this year's evaluation. While this higher consumption level was significantly higher than the values established based on metered data in previous years, the Evaluator thoroughly reviewed the freezers' data and concluded that this value was reasonable since more than 75 percent of the metered freezers in this age category had an annual energy consumption level of over 100 kWh/cu. ft.

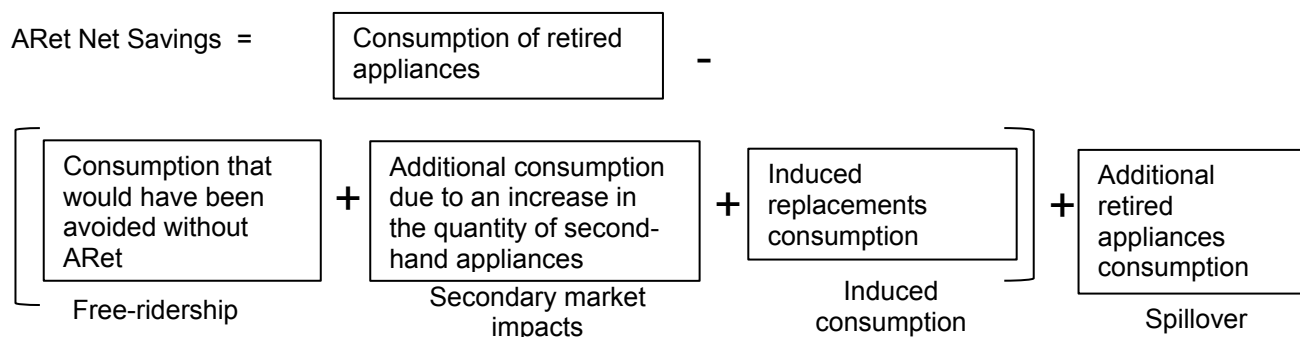
Although the metering protocol was greatly improved this year, the margins of error were higher than expected since the sample size was not large enough, notably because of the quantity of unusable data that this new approach succeeded in screening out. Nevertheless, the Evaluator believes that this approach has not only helped identify possible reasons causing variations in energy consumption between different age groups and types of appliances, but also proven that increasing the number of units metered is a key element in reducing the margins of error.

3.2 Calculation Methodology and Tracked Savings

ARet's impact evaluation has been conducted using the savings calculation methodology developed for the 2013 evaluation to comply with the general guidelines of the UMP for refrigerator recycling evaluation.⁷

The logic model of the UMP method is summarized in Figure 6 below.

Figure 6: Logic Model of the UMP for Net Savings Calculation



In Figure 6 above, the retired appliances' consumption is equivalent to the gross savings multiplied by the part-use factor applied; while the free-ridership, secondary market impacts and induced consumption values are used to calculate the per-unit net energy savings value. Spillover is not evaluated on a per-unit basis and is applied to ARet's overall net savings for each type of appliance.

Table 12 summarizes the tracked savings values used by ENS for ARet in 2017. These values for refrigerators, freezers and air conditioners are based on the results of the 2016 evaluation.

⁷ NREL, *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 7: Refrigerator Recycling Evaluation Protocol*, Prepared by the Camus Group, April 2013.

Table 12: Tracked Savings by Appliance Type

Appliance Type	Metered Energy Consumption (kWh)	Occupant Adjustment Factor	Part-Use Factor	Gross Unitary Savings (kWh)	Net Unitary Savings (kWh)	Ratio of Net to Gross	Internal Spillover	Equivalent NTGR
Refrigerators	821	1.12	0.81	745	406	0.54	1%	0.55
Freezers	900	1.12	0.75	756	398	0.53	1%	0.54
Air conditioners	251	NA	NA	251	77	0.31	1%	0.32
Small Refrigerators	275	1.12	0.63	194	95	0.49	1%	0.50
Small Freezers	420	1.12	0.63	296	145	0.49	1%	0.50

For the 2017 evaluation, the Evaluator updated these tracked savings values using a methodology similar to that used in the four previous evaluations. This methodology is described in detail for each type of appliance in the following subsections. This year, the Evaluator updated the energy consumption of retired appliances based on the latest metering results for full-size refrigerators and freezers. Since full-sized appliances' metering results are also used to calculate savings for small refrigerators and freezers, the Evaluator updated the parameters to take into account the data from the 2017 metering activity as well as the manufacture years and volumes specific to the appliances retired in 2017. This year, no participant survey was conducted since the participants' answers were stable in previous years. Therefore, the Evaluator used the 2016 participant survey's results for the impact evaluation.

This year, a new pilot project was jointly undertaken by ENS and the HRSB to encourage school principals to remove surplus or old appliances from their schools. The savings for the appliances retired through this pilot were reviewed and included in this year's ARet evaluation report.

The unitary savings values applied to the appliances replaced through HomeWarming were also reviewed and claimed in the ARet evaluation report.

3.3 Refrigerators Unitary Savings

This section presents the methodology and the calculations used to determine the unitary savings of full-sized refrigerators retired through ARet in 2017. The calculations of the gross unitary savings are first described, followed by the net unitary savings.

3.3.1 Gross Unitary Savings

The Evaluator revised the gross unitary savings value by updating the following key parameters:

- › The average energy consumption of retired refrigerators
- › The average energy consumption of replacement refrigerators
- › Part-use factors

Average Energy Consumption of Retired Refrigerators

In order to provide a more accurate estimate of the average annual consumption, the Evaluator classified the metered refrigerators by the manufacture year, based on the approximate years in which the energy-efficiency regulations and standards for refrigerators were promulgated. Major energy-efficiency regulations for refrigerators came into effect around 1994 and 2001^{8,9,10}, and age categories were defined accordingly.

Table 13 below lists the average annual per-cubic-foot energy consumption values established based on the 2017 metering activity. The average consumption value for each manufacture-year class was assigned weight based on their respective proportion of retired refrigerators in the 2017 tracking system. As a result, the average consumption value was established at 48.7 kWh/ft³.

Table 13: Average Metered Annual Consumption for Retired Refrigerators

Manufacture-year Class	Average Per-cubic-foot Annual Consumption (kWh/cu.ft.)	Proportion of Refrigerators in the 2017 Tracking System
2002 and later	49.2	48%
1995-2001	41.1	31%
1994 and earlier	58.9	21%
Average Annual Consumption	48.7 kWh/cu. ft	

The average size of the refrigerators retired in 2017 was 17 cubic feet, based on the values documented in the 2017 tracking system. Therefore, the Evaluator calculates the average annual consumption value as follows:

$$\text{Average Annual Consumption of Retired Refrigerators} = 48.7 \frac{\text{kWh}}{\text{cu. ft.}} \times 17 \text{ cu. ft.} = 828 \text{ kWh}$$

Based on the metering protocol of the New York Department of Public Service¹¹, an occupant adjustment factor of 1.12 was applied to the annual energy consumption value in the equation shown above. This occupant adjustment factor was also used in the previous impact evaluations and allows for compensating for the difference between the metering conditions and actual usage conditions in a residential setting related to refrigerator door openings, since an appliance's energy consumption increases as the number of door openings increases.

⁸ U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Energy Conservation: Program for Consumer Products: Energy Conservation Standards for Refrigerators, Refrigerator-Freezers and Freezers*, 10 CFR Part 430, April 28, 1997.

⁹ Natural Resources Canada, *Energy Efficiency Regulations: Refrigerators, Refrigerators-Freezers and Wine Chillers*, <http://www.nrcan.gc.ca/energy/regulations-codes-standards/products/6877> (Last accessed November 10, 2015).

¹⁰ Natural Resources Canada, *Registration and publication of Regulations Amending Canada's Energy Efficiency Regulations*, <http://www.nrcan.gc.ca/energy/regulations-codes-standards/6965> (Last accessed December 6, 2017)

¹¹ New York Department of Public Service, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs Residential, Multi-Family, and Commercial/Industrial Measures*, October 15, 2010, p.20.

By applying this occupant adjustment factor of 1.12, the average annual energy consumption value is established at 927 kWh per year.

Average Energy Consumption of Replacement Refrigerators

The average annual energy consumption of replacement refrigerators was used to take into account the effects of the secondary market and induced consumption. To do so, refrigerators were divided into new and used categories, as well as high and standard efficiencies. Three different annual energy consumption levels were assigned to these categories, as shown in Table 14. Based on the UMP methodology, it was assumed that the new standard-efficiency refrigerators consume about the same amount of energy as high-efficiency refrigerators.

Table 14: Energy Consumption Level Assigned to Each Replacement Appliance Category

Replacement Appliance Category	High Efficiency	Standard Efficiency
New	New - Efficient	New - Standard
Used	New - Standard	Used – Standard

The “New - Efficient” energy consumption has been established by multiplying (1) the average per-cubic-foot energy consumption of refrigerators sold through Instant Savings in 2017 (20.8 kWh/ft. cu.) by (2) the average volume of the refrigerators retired through the program component (17 cu. ft.). The “New – Standard” energy consumption has been established based on the maximum allowable energy consumption values of the types of units equivalent to those sold through Instant Savings, according to the Canadian energy-efficiency standard in force.¹² Because a new regulation came into effect in June 2017, the Evaluator believes that an energy consumption value based on the new regulation should be applied and has started applying the “New – Standard” consumption value since June 1, 2017. Therefore, an average of the previous and new regulation values weighted according to the number of units retired during each period was applied to the whole year of 2017, as shown Table 15 below.

¹² Natural Resources Canada (NRCan), *Refrigerators, Refrigerator-Freezers and Wine Chillers Energy Efficiency Regulations*, <http://www.nrcan.gc.ca/energy/regulations-codes-standards/products/6877> (Last accessed November 6, 2017).

Table 15: The Average Annual Consumption Values per Cubic Foot

Retirement Period	Proportion of Refrigerators Retired	Average Annual Consumption per Cubic Foot
After June 1, 2017	74%	23.1 kWh/cu. ft.
Before June 1, 2017	26%	26.1 kWh/cu. ft.
Weighted Average Annual Consumption per Cubic Foot		23.9 kWh/cu. ft.

For the “Used – Standard” levels, as with last year, the energy consumption of the most recent age category of retired refrigerators (in this case, manufactured after 2001) was applied. Table 16 lists the average annual energy consumption for all replacement categories.

Table 16: Average Annual Energy Consumption by Replacement Refrigerator Category

Replacement Appliance Category	High-efficiency (kWh/year)	Standard-efficiency (kWh/year)
New	354	406
Used	406	937

The 2016 participant survey results were used to establish the types of refrigerators used to replace the retired ones (new or used, high or standard efficiency). Based on the answers from the surveyed participants, the average annual energy consumption value of replacement refrigerators has been established at 391 kWh per year, as summarized in Table 17 below.

Table 17: Average Annual Consumption for Refrigerator Replacement

Type of Replacement	Annual Energy Consumption (kWh/year)	Proportion
New High-efficiency Refrigerator	354	79%
Used High-efficiency Refrigerator	406	16%
New Standard-efficiency Refrigerator	406	0%
Used Standard-efficiency Refrigerator	937	5%
Average Annual Consumption	391 kWh/yr	

Part-use Factor

Part-use factors¹³ are applied to adjust the savings calculations to account for the fact that not all refrigerators are plugged in all year round. A secondary refrigerator in a principal residence or a primary refrigerator in a secondary residence is likely to be unplugged over certain periods of the year and since they were eligible for the program component, their savings were calculated and an overall part-use factor was applied in these calculations.

The 2016 participant survey data was used to estimate the amount of time during which participants had their refrigerators plugged in all year round prior to retirement; so, the part-use factor was set at 0.81.

By multiplying this factor of 0.81 by the refrigerators' average annual energy consumption value measured (927 kWh/year), the retired refrigerators' annual energy consumption value is established at 751 kWh. By using the same calculation method, replacement refrigerators' annual energy consumption level is established at 317 kWh. The final annual consumption values are listed in Table 18 below.

Table 18: Final Energy Consumption Values for Refrigerators

	Measured Consumption (kWh/year)	Part-use Factor	Final Consumption (kWh/year)
Retired Refrigerator	927	0.81	751
Replacement Refrigerator	391	0.81	317

3.3.2 Net Unitary Savings

To calculate the overall unitary savings for refrigerators, three effects were considered: (1) free-ridership; (2) secondary market impacts; and (3) induced consumption. The Evaluator used the 2016 participant survey responses to determine these effects. As previously mentioned, internal spillover is calculated separately from the unitary savings of each appliance category in ARet, and is discussed in Section 3.14.

Table 19 presents the unitary savings value calculated for the refrigerators retired through ARet. The first section of the table presents the unitary savings value, with the proportions attributable to free-ridership and secondary market impacts deducted. This unitary savings value was obtained by calculating a weighted average of all the scenarios. The second section shows the induced consumption, which was deducted from the unitary savings value (from which the portions attributable to free-ridership and secondary market impacts have already been removed). This resulted in an overall net savings value of 410 kWh per unit retired.

¹³ According to the UMP, the part-use factors for refrigerators that would have run full-time would be 1.0 and 0.0 for those that would have not run at all. The part-use factor for refrigerators that would have been used for a portion of the year varies between 0.0 and 1.0.

Table 19: Net Savings Value per Refrigerator Unit

Free-ridership and Secondary Market Impacts											
Would Have Kept the Unit	%	Discard Scenario	%	Would-be Acquirer Finds an Alternative Unit	%	Alternative Type	%	Overall Proportion	Energy Consumption (kWh/year)		Savings
									Without ARet	With ARet	Net Reduction
Yes	43%							43%	751	0	751
No	57%	Transferred	35%	Yes	50%	Old Unit	50%	5%	751	751	0
						New Unit	50%	5%	751	317	434
				No	50%			10%	751	0	751
		Disposed	65%					37%	0	0	0
								100%	Weighted Average (kWh/unit)		420
Induced Consumption											
				Replaced Recycled Unit	%	ARet-induced Replacement	%	Overall Proportion	Energy Consumption (kWh/year)		Induced Consumption kWh
									Without ARet	With ARet	
				Yes	85%	Yes	4%	3%	0	317	317
						No	96%	82%	317	317	0
				No	15%			15%	0	0	0
				100%	Weighted Average (kWh/unit)		10				
Overall Savings (kWh/unit)											410

3.4 Freezers Unitary Savings

This section presents the methodology employed and the calculations made to evaluate the unitary savings of the full-sized freezers retired in 2017 and describes how the gross unitary savings and the net unitary savings are determined.

3.4.1 Gross Unitary Savings

The Evaluator revised the gross unitary savings value tracked by ENS by updating the same key parameters as for refrigerators.

Average Energy Consumption of Retired Freezers

As with refrigerators, the Evaluator revised the annual energy consumption value of the retired freezers using the data from the metering activity conducted this year. The Evaluator categorized the metered freezers by the manufacture year based on the years in which the energy-efficiency regulations and standards for refrigerators were promulgated. Major energy-efficiency regulations for refrigerators came into effect around 1994 and 2001,^{14,15,16} and the age categories were defined accordingly. However, the Evaluator combined the two most recent age categories into one since the results did not significantly differ.

Table 20 below lists the average annual per-cubic-foot energy consumption values established based on the 2017 metering activity. The average consumption value for each manufacture-year class was assigned weight based on their respective proportion among all the retired freezers in the 2017 tracking system. As a result, the average consumption value was established at 79.0 kWh per cu. ft.

Table 20: Average Metered Annual Consumption for Retired Refrigerators

Manufacture-year Class	Average Per-cubic-foot Annual Consumption (kWh/cu.ft.)	Proportion of Refrigerators in the 2017 Tracking System
1995 and later	56.2	63%
1994 and earlier	117.8	37%
Average Annual Consumption	79.0 kWh/cu. ft	

¹⁴ U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Energy Conservation: Program for Consumer Products: Energy Conservation Standards for Refrigerators, Refrigerator-Freezers and Freezers*, 10 CFR Part 430, April 28, 1997.

¹⁵ Natural Resources Canada, *Energy Efficiency Regulations: Refrigerators, Refrigerators-Freezers and Wine Chillers*, <http://www.nrcan.gc.ca/energy/regulations-codes-standards/products/6877> (Last accessed November 10, 2015).

¹⁶ Natural Resources Canada, *Registration and publication of Regulations Amending Canada's Energy Efficiency Regulations*, <http://www.nrcan.gc.ca/energy/regulations-codes-standards/6965> (Last accessed December 6, 2017)

The average size of retired freezers in Nova Scotia in 2017 was 13 cubic feet, based on the 2017 tracking system. Therefore, the Evaluator calculates the average annual consumption as follows:

$$\text{Average Annual Consumption of Retired Freezers} = 79.0 \frac{\text{kWh}}{\text{cu. ft.}} \times 13 \text{ cu. ft.} = 1,027 \text{ kWh}$$

To account for the difference between the metering conditions and on-site conditions in a residential setting (i.e., door openings), the same occupant adjustment factor of 1.12 as used for refrigerators was applied to the metered consumption of the retired freezers, resulting in an average annual consumption value of 1,150 kWh per year.

Average Energy Consumption of Replacement Freezers

Three energy consumption levels are assigned to possible categories of freezer replacement, based on the same principles as discussed in Section 3.3.1 about refrigerators.

As with the 2016 evaluation, the Evaluator did not use the list of ENERGY STAR® certified units to establish the energy consumption of new high-efficiency and standard-efficiency freezers. To match the more stringent United States energy-efficiency standard, the new ENERGY STAR specifications were put into effect in late 2014 and are much more stringent than their previous version. Furthermore, the Canadian energy-efficiency standard for freezers was not updated at the same time as the U.S., resulting in differences between the two markets. Therefore, few non-compact chest freezers (representing 85% of all the freezers retired through ARet) reach the ENERGY STAR performance level in Canada.

Hence, the Evaluator first calculated the maximum energy consumption of a 13-cubic-foot freezer for both chest and upright freezers by applying the Canadian standard, and then calculated the weighted average based on the proportion taken up by each type in all the retired freezers. This resulted in a value of 309 kWh, which was used as the new standard-efficiency freezer consumption value. To estimate the energy consumption of the equivalent new high-efficiency freezer, this value of 309 kWh was reduced by 10 percent. Indeed, the ENERGY STAR certification requires freezers to be 10 percent more efficient than the U.S. standard; so, the same logic was applied to the Canadian standard. The resulting value of 278 kWh is considered as the new high-efficiency freezer's energy consumption level.

For the "Used – Standard" levels, the metered energy consumption of the most recent age category of retired freezers (in this case, manufactured after 1994) was applied.

The results of these calculations are presented in Table 21.

Table 21: Average Annual Energy Consumption by Replacement Freezer Category

Replacement Appliance Category	High-efficiency (kWh/year)	Standard-efficiency (kWh/y)
New	278	309
Used	309	818

As with refrigerators, the 2016 participant survey results were used to establish the types of freezers used to replace the retired ones (new or used, high or standard-efficiency). Based on these results, replacement freezers' average annual energy consumption has been established at 302 kWh, as summarized in Table 22 below.

Table 22: Average Annual Consumption for Freezer Replacement

Type of Replacement	Annual Energy Consumption (kWh/yr)	Proportion
New High Efficiency Freezer	278	88%
Used High Efficiency Freezer	309	8%
New Standard Efficiency Freezer	309	0%
Used Standard Efficiency Freezer	818	4%
Average Annual Consumption	302 kWh/year	

Part-use Factors

All the freezers were considered primary ones; this means that they were all assumed to have had the same level of use. Therefore, only one part-use factor value was calculated for freezers, based on the results of the 2016 Annual Survey. To establish the value of the part-use factor for freezers used part-time, participants were asked about the number of months per year during which they had kept their freezers plugged in; based on the participants' responses, a weighted average part-use factor was established at 0.75.

By multiplying this part-use factor by retired freezers' measured annual energy consumption value (1,150 kWh/year), the retired freezers' final average annual consumption value was established at 863 kWh. The same calculation was done for replacement freezers, and their average annual energy consumption value was established at 227 kWh. The annual average energy consumption values are listed in Table 23.

Table 23: Final Energy Consumption Values for Freezers

	Measured Consumption (kWh/year)	Part-use Factor	Final Consumption (kWh/year)
Retired Freezer	1,150	0.75	863
Replacement Freezer	302	0.75	227

3.4.2 Net Unitary Savings

To calculate the freezers' unitary savings, three effects were taken into account, namely free-ridership, secondary market impacts and induced consumption. The Evaluator used the 2016 participant survey responses to determine these effects. As previously mentioned, internal spillover is calculated separately from the unitary savings of each appliance category in ARet, and is discussed in Section 3.14.

Table 24 presents the unitary savings value calculated for the freezers retired through ARet. The first section of the table presents the unitary savings value after the portions attributable to free-ridership and secondary market impacts were deducted. This unitary savings value is obtained by calculating a weighted average of all the scenarios. The second section shows the induced consumption value; it was deducted from the unitary savings value (from which the portions attributable to free-ridership and secondary market impacts were already removed). This resulted in an overall net savings value of 465 kWh per unit retired.

Table 24: Net Savings per Freezer Unit

Free-ridership and Secondary Market Impacts											
Would Have Kept the Unit	%	Discard Scenario	%	Would-be Acquirer Finds an Alternative Unit	%	Alternative Type	%	Overall Proportion	Energy Consumption (kWh/year)		Savings
									Without ARet	With ARet	Net Reduction
Yes	45%							45%	863	0	863
No	55%	Transferred	26%	Yes	50%	Old Unit	50%	4%	863	863	0
						New Unit	50%	4%	863	227	636
		No	50%			7%	863	0	863		
		Disposed of	74%			40%	0	0	0		
								100%	Weighted Average (kWh/unit)		474
Induced Consumption											
				Replaced the Recycled Unit	%	ARet-induced Replacement	%	Overall Proportion	Energy Consumption (kWh/year)		Induced Consumption kWh
									Without ARet	With ARet	
				Yes	73%	Yes	6%	4%	0	227	227
						No	94%	69%	227	227	0
				No	27%			27%	0	0	0
				100%	Weighted Average (kWh/unit)		9				
Overall Savings (kWh/unit)											465

3.5 Room Air Conditioners Unitary Savings

This section presents the methodology employed and the calculations made to evaluate the unitary savings of the room air conditioners retired in 2017.

3.5.1 Gross Unitary Savings

ENS uses a gross unitary savings value of 251 kWh per year for the retirement of a room air conditioner, according to the literature review findings in the 2016 evaluation report. The annual energy consumption of a room air conditioner is determined by dividing the product of the appliance capacity (Q) and the hours of operation by the seasonal energy efficiency ratio (SEER), as shown in the following equation.

$$\text{Annual Energy Consumption} \left[\frac{kWh}{yr} \right] = \frac{Q \left[\frac{Btu}{hr} \right] \times HOU \left[\frac{hr}{yr} \right]}{SEER \left[\frac{Btu}{W \cdot hr} \right] \times \frac{1}{1,000} \left[\frac{kW}{W} \right]}$$

In the above equation, the retired room air conditioner's capacity (Q), hours of operation and SEER are assumed to be respectively 6,395 Btu/hr (based on the units retired in 2016), 350 hours/yr (according to the local data provided by Natural Resources Canada (NRCan) for four cities, namely Halifax, Yarmouth, Sydney and Greenwood in Nova Scotia) and 8.9 Btu/W.hr (based on an article published by NRCan¹⁷ and the Ecox Technical Information Bulletin on SEER¹⁸).

Average Consumption of Retired Room Air Conditioners

The Evaluator reviewed the assumptions used by ENS for the calculation of the average energy consumption of replaced room air conditioners.

Hours of Operation

In the 2016 evaluation, the Evaluator used the annual hours of operation of room air conditioners found through the literature review of the 2015 evaluation; that literature review compared different studies about climate zones similar to Nova Scotia. Since no major metering studies for room air conditioners were published recently, the Evaluator has continued to rely on the literature review done in the 2015 evaluation, and maintained the conclusion that NRCan's hours of use are the most appropriate values.

¹⁷ NRCan's Office of Energy Efficiency. *Air Conditioning Your Home*, 2003, p. 15.

¹⁸ Ecox, *Technical Information Bulletin No. E-004-EN: SEER*, www.ecoxline.com (Last accessed March 3, 2016).

NRCan's EnerGuide Room Air Conditioner Directory¹⁹ provides local data for four cities in Nova Scotia, namely Halifax, Yarmouth, Sydney and Greenwood. Room air conditioners' hours of use can be calculated using the annual energy consumption equation and such variables as the annual energy consumption, the capacity and the energy efficiency ratio listed on NRCan's website. The hours of operation per year established by NRCan for Halifax, Yarmouth, Sydney and Greenwood are respectively 346, 144, 250 and 374. Since the hours of operation vary widely from one location to another, the Evaluator recalculated this variable for this evaluation by taking into account the proportion accounted for by those participants who each retired a room air conditioner in each of the regions of these four cities in 2017. The participants' postal codes recorded in the tracking system were used to determine their locations. The following formula was used to calculate the weighted average hours of operation across the province:

$$\begin{aligned} \text{Annual Hours of Operation} \left[\frac{\text{hr}}{\text{yr}} \right] &= (\%_{\text{people}} \times \text{HOU})_{\text{Halifax}} \\ &+ (\%_{\text{people}} \times \text{HOU})_{\text{Yarmouth}} (\%_{\text{people}} \times \text{HOU})_{\text{Sydney}} (\%_{\text{people}} \times \text{HOU})_{\text{Greenwood}} \end{aligned}$$

Using the equation above, the annual hours of operation have been established at 312 hours.

Capacity

With the information available in the tracking system, the retired units' average capacity has been established at 6,146 Btu/hr.

SEER

The 2017 ARet tracking report showed that 95 percent of the room air conditioners retired were between 10 and 22 years old. Therefore, the assumption that most air conditioners retired through ARet met the efficiency level of 8 (in effect since 1995) is still considered valid. In order to account for seasonal temperature changes, the Evaluator decided to use a SEER rather than an energy-efficiency ratio (EER). To do so, the EER of 8 is multiplied by a factor of 1.11, according to the Ecox Technical Information Bulletin on SEER.²⁰ The resulting SEER is 8.9 Btu/W·hr.

Using the hours of operation of 312 hours per year, a room air conditioner capacity of 6,146 Btu/hr and a SEER of 8.9, the average annual energy consumption for retired room air conditioners is established at 215 kWh.

¹⁹ NRCan's Office of Energy Efficiency, *EnerGuide Room Air Conditioner Directory 2012* May 2012, p. 88.

²⁰ Ecox, *Technical Information Bulletin No. E-004-EN: SEER*, ecoxline.com (Last accessed March 3, 2016).

Average Energy Consumption of Replacement Room Air Conditioners

The Evaluator assumes that the replacement units meet the current minimum level of energy efficiency required to meet ENERGY STAR performance levels, which is EER 11.2 Btu/W·hr for units with a capacity below 8,000 Btu/hr.²¹ This assumption is supported by the fact that the majority of participants who replaced their retired units declared, in the 2016 Evaluation participant survey, that they had bought a new high-efficiency model.²² The corresponding SEER is 12.4 Btu/W·hr.

The same capacity (6,146 Btu/hr) and hours of operation (312 hr/year) as used for the retired room air conditioners have been used, resulting in an annual energy consumption value of 155 kWh.

Part-use Factor

No part-use factor has been applied to the annual energy consumption calculations because all room air conditioners are assumed to operate 310 hours per year during the cooling season.

3.5.2 Net Unitary Savings

To calculate the net savings value for the air conditioners retired, three effects were taken into account, namely free-ridership, secondary market impacts and induced consumption. The Evaluator used the 2016 participant survey responses to determine these effects. As previously mentioned, internal spillover is calculated separately from the unitary savings of each appliance category in ARet, and is discussed in Section 3.14.

Table 25 presents the unitary savings value calculated for the room air conditioners retired through ARet. The first section of the table presents the unitary savings value after free-ridership and secondary market impacts were deducted. This unitary savings value is obtained by calculating a weighted average of all the scenarios. The second section shows the induced consumption; it was deducted from the unitary savings (from which the portions attributable to free-ridership and secondary market impacts were already removed). This resulted in an overall savings value of 66 kWh per unit retired.

²¹ ENERGY STAR, *ENERGY STAR Program Requirements for Room Air Conditioners: Eligibility Criteria Version 4.0*, October 26, 2015.

²² The 2016 Evaluation data were used since no participant survey was conducted in the 2017 Evaluation.

Table 25: Net Savings per Room Air Conditioning Unit

Free-ridership and Secondary Market Impacts											
Would Have Kept the Unit	%	Discard Scenario	%	Would-be Acquirer Finds an Alternative Unit	%	Alternative Type	%	Overall Proportion	Energy Consumption (kWh/year)		Savings
									Without ARet	With ARet	Net Reduction
Yes	18%							18%	215	0	215
No	82%	Transferred	27%	Yes	50%	Old Unit	50%	5.5%	215	215	0
						New Unit	50%	5.5%	215	155	60
				No	50%			11%	215	0	215
		Disposed	73%					60%	0	0	0
								100%	Weighted average (kWh/unit)		66
Induced Consumption											
				Replaced the Recycled Unit	%	ARet-induced Replacement	%	Overall Proportion	Energy Consumption (kWh/year)		Induced Consumption kWh
									Without ARet	With ARet	
				Yes	54%	Yes	0%	0%	0	155	155
						No	100%	54%	155	155	0
				No	46%			46%	0	0	0
								100%	Weighted Average (kWh/unit)		0
Overall Savings (kWh/unit)											66

3.6 Small Appliance Retirement

This section presents the methodology used and the calculations made to determine the unitary savings of small refrigerators and small freezers retired through ARet in 2017. The gross unitary savings are discussed first, followed by the net unitary savings.

3.6.1 Gross Unitary Savings

The Evaluator revised the gross unitary savings value tracked by ENS for small appliances by updating the following key parameters:

- › Average energy consumption of retired small appliances
- › Average energy consumption of replacement small appliances
- › Part-use factors

Average Energy Consumption of Small Appliances Retired

The Evaluator used the same methodology as in the 2016 Evaluation to establish the unitary savings of small appliances. This methodology involves using the average of the full-sized appliances' metered annual per-cubic-foot consumption values to revise the small appliances' annual energy consumption value.

Small Refrigerators

For refrigerators, the average consumption value of each manufacture-year class was assigned a weight based on the proportion accounted for by the retired small refrigerators in the 2017 tracking system. As a result, the average consumption value was established at 49.3 kWh/cu. ft as presented in Table 26.

Table 26: Average Annual Consumption of Retired Small Refrigerators

Manufacture-year Class	Average Per-cubic-foot Annual Consumption (kWh/cu.ft.)	Proportion of Small Refrigerators
2002 and later	49.2	59%
1995-2001	41.1	22%
1994 and earlier	58.9	19%
Average Annual Consumption	49.3 kWh/cu. ft	

The average size of the retired small refrigerators in 2017 was 6 cubic feet, based on the values found in the 2017 tracking system. Therefore, the Evaluator calculates their average annual consumption as follows:

$$\text{Average Annual Consumption of Retired Small Fridges} = 49.3 \frac{\text{kWh}}{\text{cu. ft.}} \times 6 \text{ cu. ft.} = 296 \text{ kWh}$$

To account for the difference between the metering conditions and the on-site conditions in a residential setting (i.e., door openings), the same occupant adjustment factor of 1.12 as used for full-sized appliances was applied to the metered consumption of the small refrigerators, resulting in an average annual consumption of 332 kWh per year.

Small Freezers

For small freezers, the average consumption value of each manufacture-year class was assigned a weight based on the proportion accounted for by the retired small freezers in the 2017 tracking system. As a result, the average consumption value was established at 66.1 kWh/cu. ft as presented in Table 27.

Table 27: Average Annual Consumption of Retired Small Freezers

Manufacture-year Class	Average Per-cubic-foot Annual Consumption (kWh/cu.ft.)	Proportion of Small Freezers
1995 and later	56.2	84%
1994 and earlier	117.8	16%
Average Annual Consumption	66.1 kWh/cu. ft	

Based on the 2017 tracking system, the average size of the retired small freezers is 7 cubic feet. Therefore, the Evaluator calculates their average annual consumption as follows:

$$\text{Average Annual Consumption of Retired Freezers} = 66.1 \frac{\text{kWh}}{\text{cu. ft.}} \times 7 \text{ cu. ft.} = 463 \text{ kWh}$$

By applying the occupant adjustment factor of 1.12, the average annual consumption was established at 519 kWh per year.

Average Energy Consumption of Replacement Small Appliances

The 2016 participant survey results were used to identify the types of small refrigerators or freezers that replaced the retired ones (new or used, high or standard-efficiency). All the surveyed participants declared that they chose a new high-efficiency model. Therefore, the annual energy consumption value of replacement small appliances corresponds to that for a new high-efficiency model.

Using an approach consistent with that used for the retired full-sized appliances, the Evaluator calculated these consumption values by applying the annual energy consumption values established for full-sized new high-efficiency refrigerators and freezers adjusted to the average volume of small refrigerators and freezers.

For replacement small refrigerators, the average annual energy consumption value was established at 125 kWh using the following calculation equation:

$$\text{Average Annual Consumption of Replacement Refrigerators} = \frac{354 \text{ kWh}}{17 \text{ cu. ft.}} \times 6 \text{ cu. ft.} = 125 \text{ kWh}$$

For replacement small freezers, the average annual energy consumption value was established at 150 kWh using the following calculation equation:

$$\text{Average Annual Consumption of Replacement Freezers} = \frac{278 \text{ kWh}}{13 \text{ cu. ft.}} \times 7 \text{ cu. ft.} = 150 \text{ kWh}$$

Part-use Factors

The 2016 participant survey results were used to estimate the amount of time during which participants had their small appliances plugged in per year prior to retirement; as a result, the part-use factor was established at 0.63.

The energy consumption values established for the retired and replacement appliances were adjusted by multiplying this part-use factor. The final annual energy consumption values are summarized in Table 28 below.

Table 28: Final Energy Consumption Values of Small Appliances

	Measured Consumption (kWh/year)	Part-use Factor	Final Consumption (kWh/year)
Retired Small Refrigerators	332	0.63	209
Replacement Small Refrigerators	125	0.63	79
Retired Small Freezers	519	0.63	327
Replacement Small Freezers	150	0.63	95

3.6.2 Net Unitary Savings

To calculate the net savings value for the small appliances retired in 2017, three effects were taken into account, namely free-ridership, secondary market impacts and induced consumption. The Evaluator used the 2016 participant survey responses to determine these effects. As previously mentioned, internal spillover is calculated separately from the unitary savings of each appliance category in ARet, and is discussed in Section 3.14.

Considering the smaller number of participants in this category of appliance and thus the smaller sample of respondents in the survey, small refrigerators and small freezers were analyzed together in the net savings calculation.

Table 29 and Table 30 present the unitary savings values calculated for the small appliances retired through ARet. The first section of the table presents the unitary savings value after the proportions attributable to free-ridership and secondary market impacts were deducted. This unitary savings value was obtained by calculating a weighted average of all the scenarios. The second section shows the induced consumption; it was deducted from the unitary savings value (from which the proportions attributable to free-ridership and secondary market impacts were already removed).

Table 29: Net Savings per Small Refrigerator

Free-ridership and Secondary Market Impacts											
Would Have Kept the Unit	%	Discard Scenario	%	Would-be Acquirer Finds an Alternative Unit	%	Alternative Type	%	Overall Proportion	Energy Consumption (kWh/year)		Savings
									Without ARet	With ARet	Net Reduction
Yes	37%							37%	209	0	209
No	63%	Transferred	30%	Yes	50%	Old Unit	50%	5%	209	209	0
						New Unit	50%	5%	209	79	130
				No	50%			9%	209	0	209
		Disposed	70%					44%	0	0	0
								100%	Weighted average (kWh/unit)		103
Induced Consumption											
				Replaced the Recycled Unit	%	ARet-induced Replacement	%	Overall Proportion	Energy Consumption (kWh/year)		Induced Consumption kWh
									Without ARet	With ARet	
				Yes	25%	Yes	0%	0%	0	79	79
						No	100%	25%	79	79	0
				No	75%			75%	0	0	0
								100%	Weighted Average (kWh/unit)		0
Overall Savings (kWh/unit)											103

Table 30: Net Savings per Small Freezer

Free-ridership and Secondary Market Impacts											
Would Have Kept the Unit	%	Discard Scenario	%	Would-be Acquirer Finds an Alternative Unit	%	Alternative Type	%	Overall Proportion	Energy Consumption (kWh/year)		Savings
									Without ARet	With ARet	Net Reduction
Yes	37%							37%	327	0	327
No	63%	Transferred	30%	Yes	50%	Old Unit	50%	5%	327	327	0
						New Unit	50%	5%	327	95	232
				No	50%			9%	327	0	327
		Disposed	70%					44%	0	0	0
								100%	Weighted average (kWh/unit)		162
Induced Consumption											
				Replaced the Recycled Unit	%	ARet-induced Replacement	%	Overall Proportion	Energy Consumption (kWh/year)		Induced Consumption kWh
									Without ARet	With ARet	
				Yes	25%	Yes	0%	0%	0	95	95
						No	100%	25%	95	95	0
				No	75%			75%	0	0	0
								100%	Weighted Average (kWh/unit)		0
Overall Savings (kWh/unit)											162

3.7 Appliances Retired through the Pilot

This subsection describes the methodology used and the calculations made to determine the unitary savings of refrigerators and freezers retired through the 2017 ARet pilot project to audit the refrigeration appliances (refrigerators and freezers) in schools throughout the Halifax Regional School Board (the Pilot).

3.7.1 Gross Unitary Savings

In 2017, a total of 10 refrigerators, two freezers and one small refrigerator were retired through the ARet Pilot. In order to establish the gross unitary savings associated with the appliances retired through the pilot, the Evaluator used a methodology similar to that used for full-size refrigerators (see Section 3.3.1) and freezers (see Section 3.4.1), as well as that for small refrigerators (see Section 3.6.1).

The Evaluator used the average metered annual consumption data of the manufacture-year classes to determine the average annual consumption (in kWh per cubic foot) of retired refrigerators and freezers from the pilot:

Consumption of Retired Appliances [kWh]

$$= \text{Average Annual Consumption per Unit Size} \left[\frac{\text{kWh}}{\text{cu. ft.}} \right] \times \text{Average Size [cu. ft.]}$$

Calculation details for refrigerators and freezers are shown in Table 31 and Table 32 respectively.

Table 31: Average Metered Annual Consumption for Retired Refrigerators from the Pilot

Manufacture-year Class	Average Per-cubic-foot Annual Consumption (kWh/cu.ft.)	Proportion of Refrigerators in the 2017 Tracking System - Pilot
2002 and later	49.2	40%
1995-2001	41.1	40%
1994 and earlier	58.9	20%
Average Annual Consumption	47.9 kWh/cu. ft.	

Table 32: Average Metered Annual Consumption for Retired Freezers from the Pilot

Manufacture-year Class	Average Per-cubic-foot Annual Consumption (kWh/cu.ft.)	Proportion of Freezers in the 2017 Tracking System - Pilot
1995 and later	56.2	100%
1994 and earlier	117.8	0%
Average Annual Consumption	56.2 kWh/cu. ft.	

The average size of the refrigerators retired through the pilot in 2017 was 17 cubic feet, based on the values documented in the 2017 tracking system. Therefore, the Evaluator established the average annual consumption value of retired refrigerators at 814 kWh.

Similarly, the average size of the freezers retired through the pilot in 2017 was 12 cubic feet, resulting in an average annual consumption value of 674 kWh.

For the small refrigerator retired through the pilot, the annual consumption per cubic foot value corresponding to the full-size appliance of the same age group was multiplied by its size to obtain the annual consumption. This appliance was identified as one in the 2002 and later age group (49.2 kWh/cu. ft.) with a size of 6 cubic feet. Using the same equation as for other appliances retired through the pilot, a annual consumption value of 295 kWh was established.

As for the occupant adjustment factor, compensating for the difference between the metering conditions and actual usage conditions, the Evaluator applied a factor of 1.00 since it is assumed that all appliances retired so far through the pilot were rarely used since they were considered at as surplus appliances.

According to the HRSB representative interviewed, all the retired appliances were found plugged in when the audit was conducted. Therefore, a part-use factor of 1.00 was applied to the savings of the units retired through the pilot.

The final annual consumption values are listed in Table 33 below.

Table 33: Final Energy Consumption Values for Appliances Retired through the Pilot

	Measured Consumption (kWh/year)	Occupant Adjustment Factor	Part-use Factor	Final Consumption (kWh/year)
Retired Refrigerators	814	1.00	1.00	814
Retired Freezers	674	1.00	1.00	674
Retired Small Refrigerators	295	1.00	1.00	295

3.7.2 Net Unitary Savings

The Evaluator conducted a phone interview with a representative of the HRSB, who provided information on the HRSB's and the school principals' roles and responsibilities in developing and implementing the pilot. Questions for assessing free-ridership were also included in the interview to determine what actions the HRSB would have taken in the absence of the pilot.

The interview revealed that the audit of all the refrigeration appliances in HRSB schools was the main activity enabling the HRSB to first identify the appliances to be retired and then retire the targeted units. According to the HRSB representative interviewed, it would have been very unlikely for the HRSB to have completed the appliance retirement process without ENS's support, because they would not have had the resources to conduct the audit in the first place. In addition to the support provided by ENS in conducting the audit, the HRSB representative mentioned that ARet's convenient appliance removal process was a major factor that positively influenced their decision to collaborate with ENS to dispose of the old appliances in HRSB's schools.

Considering the big influence that ENS's support and resources had on the HRSB decision to retire their old appliances, the Evaluator decided to set the free-ridership level at 0 percent for the ARet pilot.

3.8 Appliance Replaced through HomeWarming

This subsection describes the methodology used and the calculations made to determine the unitary savings of the refrigerators, freezers and dehumidifiers replaced through HomeWarming in 2017.

HomeWarming offers income-eligible participants the opportunity to replace their old refrigerators, freezers and dehumidifiers with more efficient models. These replacements' savings are claimed under ARet.

Based on the nature of the HomeWarming program component (direct replacement) and its participant demographics, an NTGR of 1.00 has been assumed.

3.8.1 Refrigerator Replacement

Tracked Savings

For the replacement of refrigerators through HomeWarming, ENS uses a unitary savings value of 938 kWh per year. This value is based on the metered consumption values for the old appliances retired through ARet in 2015 and the unitary energy consumption (UEC) ratings of the new ENERGY STAR certified refrigerators installed in 2016 and recorded in the tracking system.

The HomeWarming guidelines indicate that refrigerators eligible for a replacement through the program component must be manufactured in 1990 or earlier. Therefore, the tracked savings value is based on the average annual per-cubic-foot consumption for refrigerators older than 25 years old presented in the 2015 ARet report, i.e., 70.9 kWh/cu. ft. This consumption value was multiplied by the average size of the old refrigerators retired through HomeWarming in 2016 (rounded up to 16 cu. ft.) and the occupant adjustment factor of 1.12. It is assumed that all the refrigerators retired through HomeWarming were primary refrigerators since it was a program component criterion and therefore no part-use factor was applied. As a result, ENS has established that old refrigerators consume on average 1,270 kWh per year. As for the energy consumption of new refrigerators, no occupant adjustment factor was applied because the UEC rating of new ENERGY STAR certified refrigerators already account for this occupancy adjustment. Therefore, the UEC of new refrigerators was established at 332 kWh.

By applying the average consumption values established for the old and new refrigerators, the tracked unitary savings were established at 938 kWh per year.

Revised Savings

The Evaluator used the average annual consumption value of 58.9 kWh/cu.ft. obtained from the 2017 ARet metering data for refrigerators of the oldest age category (see section 3.3.1). This consumption value was multiplied by the average size of the old refrigerators retired through HomeWarming in 2017 (rounded to 16.0 cu.ft.) and the occupant adjustment factor of 1.12. All the refrigerators are considered primary refrigerators since it was a program component criterion; hence, no part-use factor was applied. As a result, the Evaluator established that old refrigerators consumed on average 1,055 kWh per year.

By applying the average annual per-cubic-foot consumption value of ENERGY STAR certified refrigerators installed in 2017 only, the Evaluator established the new refrigerators' UEC at 350 kWh. No occupant adjustment factor was applied because the UEC ratings of new ENERGY STAR certified refrigerators already account for this occupancy adjustment.

Based on the ENERGY STAR certified refrigerators' average annual consumption value, replacing an old refrigerator with a new model results in unitary savings of 705 kWh per year, as shown by the following equation.

$$\text{Revised Unitary Savings} = \left(58.9 \frac{\text{kWh}}{\text{cu. ft.}} \times 16.0 \text{ cu. ft.} \times 1.12 \right) - 350 \text{ kWh} = 705 \text{ kWh}$$

The main difference between the tracked and revised unitary savings for refrigerators is the value obtained from this year's metering activities, which has established the average consumption of the units manufactured in 1994 and earlier at 58.9 kWh/cu.ft, in comparison to the value of 70.9 kWh/cu.ft used in 2016, which was the average consumption level for retired refrigerators manufactured before 1990.

3.8.2 Freezer Replacement

Tracked Savings

As for the replacement of freezers, ENS uses a unitary savings value of 492 kWh per year. This value is based on the metered consumption of old appliances retired through ARet in 2015 and the UEC of new efficient freezers installed in 2016.

The HomeWarming guidelines indicate that freezers eligible for a replacement must be manufactured in 1990 or earlier. The tracked savings value is based on the average annual per-cubic-foot consumption of the older than 30-year-old category of freezers presented in the 2015 ARet report, i.e., 60.0 kWh/cu. ft. Using the average size of the retired freezers in the 2016 tracking system (11 cu. ft.) and the occupant adjustment factor of 1.12, the average consumption of a retired freezer was established at 739 kWh per year.

Using the information collected in the 2016 tracking system, the average consumption of the replacement freezers installed in 2016 was established at 247 kWh. Therefore, replacing an old freezer with a new efficient model results in tracked unitary savings of 492 kWh per year.

Revised Savings

The Evaluator used the average annual consumption value of 117.8 kWh/cu.ft. obtained from the 2017 ARet metering data for freezers (see section 3.4.1). By applying the average size of the retired freezers in 2017 (12.6 cu. ft.) and the occupant adjustment factor of 1.12 (but not the part-use factor), the average consumption of the retired freezers was established at 1,662 kWh per year.

In 2017, less than a quarter of the new freezers installed were ENERGY STAR certified models (20%). As in 2016, there were still only a limited number of ENERGY STAR certified freezers of a size comparable to the most commonly replaced freezers in HomeWarming (e.g., 11-15 cu.ft. upright freezers and smaller chest freezers). The DA continues to stock the most energy-efficient models available in the Canadian market for inclusion in this program component. Where an ENERGY STAR certified model is not available, the freezers installed through HomeWarming have, on average, a consumption level higher than the ENERGY STAR standards by 45 kWh/yr.

The Evaluator established a weighted average energy consumption value at 263 kWh/cu. ft for the new efficient freezers installed through HomeWarming based on the energy consumption of each model in the NRCan's list of compliant models²³ and each model's total number of installed appliances in the tracking sheet. Given the average consumption of 263 kWh per year for new freezers, replacing an old freezer with a new model results in unitary savings of 1,399 kWh per year, as shown in the following equation.

²³ Natural Resources Canada, *Energy Efficiency Ratings: Search – Freezers*, <http://oee.nrcan.gc.ca/pml-imp/index.cfm?action=app.download-telecharger&appliance=FREEZERS> (Last accessed January 19, 2018)

$$\text{Revised Unitary Savings} = \left(117.8 \frac{\text{kWh}}{\text{cu. ft.}} \times 12.6 \text{ cu. ft.} \times 1.12 \right) - 263 \text{ kWh} = 1,399 \text{ kWh}$$

The main difference between the tracked and revised unitary savings for freezers is the value obtained from this year's metering activities, which has allowed for establishing the average consumption of the retired units older than 25 years at 117.8 kWh/cu.ft., in comparison to the value of 60.0 kWh/cu.ft. used in 2016.

3.8.3 Dehumidifier Replacement

Tracked Savings

ENS promotes the replacement of old dehumidifiers with more efficient models through HomeWarming.

For the replacement of existing dehumidifiers, ENS used a unitary savings value of 633 kWh per year for each installed product based on the 2016 ARet evaluation report.

Revised Savings

The Evaluator reviewed the tracked unitary savings value used by ENS for dehumidifiers. The unitary savings value is calculated using the following algorithm:

$$\text{Unitary savings} \left[\frac{\text{kWh}}{\text{year}} \right] = \left(\text{Average water removal capacity} \left[\frac{\text{L}}{\text{day}} \right] \times \right. \\ \left. \text{Average operating days} \left[\frac{\text{days}}{\text{year}} \right] \right) \times \left(\frac{1}{\text{Energy Factor old dehumidifier}} - \right. \\ \left. \frac{1}{\text{Energy factor ENERGY STAR dehumidifier}} \right) \left[\frac{\text{kWh}}{\text{L}} \right]$$

The Evaluator conducted a literature review to compare other jurisdictions' assumptions and ensure this methodology is the most accurate. This review revealed that most jurisdictions (IESO, Maine, Connecticut, Massachusetts, Vermont, Illinois, Mid-Atlantic, Minnesota and New York) that rebate dehumidifiers use a similar algorithm adapted for unit consistency.

The ENERGY STAR Program Requirements for Dehumidifiers²⁴ were updated in October 2016. The certified dehumidifiers in the Canadian market with a water removal capacity of less than 35 L/day now need to have an Energy Factor of 2.00 L/kWh or higher. This new value was therefore used by the Evaluator to revise the unitary savings of dehumidifiers installed through HomeWarming in 2017.

²⁴ ENERGY STAR Program Requirements for Dehumidifiers Eligibility Criteria V4.0, Partner Commitments, October 2016.

For the old units, the assumptions are based on the 2011 Ontario Power Authority Prescriptive Measures and Assumptions report.²⁵ An average water removal capacity of 3.87 L/day and an average of 168 operating days per year were applied. In the same report, the Energy Factor of old units was established at 0.66 L/kWh. These values were used again this year to determine the unitary savings as they were determined from the information collected and metered in the field, which should be considered more accurate than more recent studies based on theoretical values only.

Therefore, replacing an old dehumidifier with a new model results in unitary savings of 660 kWh per year.

3.9 Summary of Unitary Savings Values

Table 34 presents the tracked and revised savings values for each type of product retired through ARet and the pilot, and replaced under HomeWarming in 2017.

Table 34: Tracked and Revised Unitary Savings by Appliance Type

	Tracked Unitary Savings (kWh/yr)		Revised Unitary Savings (kWh/yr)	
	Gross	Net	Gross	Net
Refrigerator (ARet)	745	406	751	410
Freezer (ARet)	756	398	863	465
Room Air Conditioner (ARet)	251	77	215	66
Small Refrigerator (ARet)	194	95	209	103
Small Freezer (ARet)	296	145	327	162
Refrigerator (Pilot)	745	406	814	814
Freezer (Pilot)	756	398	674	674
Small Refrigerator (Pilot)	194	95	295	295
Refrigerator (HomeWarming)	938	938	705	705
Freezer (HomeWarming)	492	492	1,399	1,399
Dehumidifier (HomeWarming)	633	633	660	660

3.10 Peak Demand Savings

The peak demand savings correspond to the demand savings that coincide (in time) with the peak demand of the electricity system. The projected electricity-demand peak period in Nova Scotia is between 5 p.m. and 7 p.m. in the months of December to February, on a non-holiday weekday.

²⁵ Ontario Power Authority (OPA). *2011 Prescriptive Measures and Assumptions*, Release Version 1, March 2011.

For ARet, the peak demand savings were calculated using the on-peak demand-to-energy ratios developed by Navigant in the 2016-2018 DSM Plan. These ratios were established for various measure categories, based on modelled system-coincident peak demand savings and energy savings for a projected deployment of measures. Navigant used local data to establish the ratios for 2017. The Evaluator considers that the approach used by Navigant to establish the on-peak demand-to-energy ratios is valid and therefore these ratios were used to estimate the peak demand savings for ARet. This year, the Evaluator decided to use the value used by Navigant for dehumidifiers rather than relying on an estimated value of 0.000, since a certain level of dehumidification is possible in winter due to indoor moisture sources. For air conditioners, for which no ratio was calculated in Navigant's model, the Evaluator assumed a ratio of zero since it is very unlikely for this type of appliance to operate during the peak demand period.

For the pilot, the Evaluator has assumed that the residential peak-demand-to-energy ratios established by Navigant are applicable to refrigerators and freezers located in schools because the same types of appliances are used in both cases. Although usage patterns are somehow different (appliances in schools would be opened more often during the day than in the evening), those patterns have a limited impact on peak demand savings, since compressors cycle even when no doors are opened. The Evaluator therefore considered it acceptable to use the same peak-demand-to-energy ratios.

Table 35 presents the on-peak demand-to-energy ratios established for each appliance type.

Table 35: Peak-demand-to-energy Ratios by Appliance Type

Type of Appliance	Peak-demand-to-energy Ratio	Peak-demand-to-energy Ratio Category
Refrigerator	0.138	RES-Appliance-Fridge
Freezer	0.138	RES-Appliance-Fridge
Air conditioner	0.000	Calculated by the Evaluator
Dehumidifier	0.335	RES-Appliance-Dehumidifier

3.11 Interactive Effects

Interactive effects occur in a conditioned space when an implemented energy-efficiency measure has an impact on the energy consumption of other elements in the system, such as heating and cooling equipment. In the case of ARet, retirement of old appliances causes an increase in the heating load in the winter, and a decrease in the cooling load in the summer, since the compressor of the old appliance releases significantly more waste heat than a newer, more efficient model. If an inefficient appliance is retired without being replaced, these interactive effects are greater.

The heating load period in Nova Scotia lasts about eight months, while the cooling load period is relatively short, lasting approximately two months. The annual total interactive effects due to the retirement or replacement of old appliances are therefore expected to be negative, pushing the savings generated by such retirement or replacement downward.

A number of other factors can also affect the interactive effects of the program component:

- › The focus of this ARet evaluation is on electricity savings. In Nova Scotia, fewer than 30 percent of households use electricity as their primary heating source.²⁶ Therefore, the negative interactive effects on the heating load only affect approximately one third of the participating households.
- › Additionally, in Nova Scotia, air conditioning is used by an even smaller proportion of households (only 28%²⁷), where positive interactive effects occur during the cooling period. Moreover, this cooling period is much shorter than the heating season, lasting only two months.²⁸
- › A significant number of appliances retired through the program component, such as refrigerators and freezers, are built into or leaned against an exterior wall. Rather than contributing to the loads, this results in more heat loss through the building envelope and reduces their interactive effects.

After carefully considering all these factors, the Evaluator concluded that the interactive effects of ARet are negligible, and so set the interactive effects factor at 0 percent.

3.12 Effective Useful Life

As part of the 2017 evaluation, the Evaluator reviewed the EUL values used by ENS in the calculation of lifetime energy savings.

For ARet, the lifetime energy savings and equivalent EUL of a unit are influenced by the remaining useful life (RUL) of old units, which corresponds to the time during which the old appliance would still have been used. Therefore, the EUL and RUL values of all the measures eligible for the program component were reviewed based on the findings of a literature review. When establishing the EUL and RUL for a given measure, the Evaluator considered the most common values found in the technical reference manuals, evaluation reports or relevant studies. Those sources that based their EUL and RUL estimates on measured data or other reliable methods were favoured, where available.

The Evaluator used different approaches to determine the lifetime energy savings of appliances retired through ARet and appliances replaced through HomeWarming.

²⁶ Statistics Canada, *Table 153-0145, Households and the environment survey, primary heating system*, <http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=1530145&&pattern=&stByVal=1&p1=1&p2=31&tabMode=dataTable&csid=> (Last accessed January 18, 2018).

²⁷ Statistics Canada, *Table 153-0147 - Households and the Environment Survey, air conditioners, Canada, provinces and census metropolitan areas, 2013*, CANSIM, March 10, 2015.

²⁸ RETScreen, Climatic Data for Halifax International Airport.

Appliances Retired Through ARet

The equivalent EUL of ARet savings corresponds to the RUL of the retired appliances, because the savings correspond to the removal from the electrical grid of an appliance, which would have continued to be used in the absence of the program component.

Table 36 below lists the tracked EUL and revised equivalent EUL values by measure category. Those values are also applicable to small-size appliances and appliances retired through the pilot.

Table 36: Summary of Effective Useful Life Values by Measure Category for Appliances Retired through ARet

Measure	ENS Tracked EUL	Revised Equivalent EUL	Reference
Refrigerator Retirement	8	8	KEMA, Residential Refrigerator Recycling Ninth Year Retention Study, value for refrigerators ²⁹
Freezer Retirement	8	8	KEMA, Residential Refrigerator Recycling Ninth Year Retention Study, value for freezers
Air Conditioner Retirement	3	3	DEER 2014 table, value for room air conditioner recycling

For refrigerator and freezer retirement measures, an EUL (or RUL) value of eight years is used by most TRMs, based on a measure persistence study conducted by KEMA. For air conditioner retirement, the tracked EUL value of three years was taken from the Database for Energy Efficiency Resources (DEER), which was specifically established for the retirement of a room air conditioner.³⁰

Appliances Replaced through HomeWarming

For appliances replaced through HomeWarming, the Evaluator has concluded, based on the literature review findings, that the EUL values used by ENS are appropriate to represent the equipment life of new appliances. The values tracked by ENS were taken from the Savings Calculator for ENERGY STAR Qualified Appliances,³¹ which quotes EPA research findings for refrigerators and dehumidifiers, and Appliance Magazine research findings for refrigerators. However, the equipment life of new appliances is not the same as the equivalent EUL of the appliance replacement measure. The difference is that first-year savings (based on the difference between the replaced appliance and the new efficient appliance) will not persist in full over the entire equipment life of the new refrigerator.

²⁹ KEMA Inc., *Residential Refrigerator Recycling Ninth Year Retention Study*, Study ID Nos. 546B, 563, Prepared for Southern California Edison Company, June 22, 2004.

³⁰ Database for Energy Efficiency Resources (DEER), *DEER2014 EUL Table*, May 2014.

³¹ U.S. EPA and DOE, *Savings Calculator for ENERGY STAR Qualified Appliances*, October 2016.

Therefore, for appliances replaced through HomeWarming, their equivalent EUL was calculated by taking into account different energy savings values during the RUL and the rest of the equipment life. Indeed, the savings occurring during the RUL correspond to the difference in consumption between the old and the new appliances, while the savings occurring during the rest of the equipment life correspond to the difference in energy consumption between the new efficient appliance installed through Home Warming and what would have been installed by the participant when the old appliance would have failed. Considering that appliance replacement is only offered to low-income participants, the Evaluator assumed that these participants would have bought appliances meeting the current minimum requirements at the end of the RUL of the old appliance. Therefore, the savings generated during the last eight years are the difference in energy consumption between a unit complying with the regulations and the new efficient unit installed through HomeWarming. The consumption values for new standard refrigerator and freezer units were taken respectively from Section 3.3.1 and 3.4.1, while the new standard dehumidifier's consumption value comes from Instant Savings.

The Evaluator used an RUL of four years for all appliances replaced through HomeWarming, assuming that the RUL represents one-third of the EUL. This is a common assumption that the Evaluator has found in many TRMs. The Evaluator considers it reasonable to use a smaller RUL for appliances replaced through HomeWarming than those retired through ARet, since appliances eligible for HomeWarming must be over 25 years old, while appliances eligible for ARet must be only over 10 years old. Table 37 summarizes the equipment life and RUL values used by the Evaluator.

**Table 37: Summary of Effective Useful Life Values by Measure Category
for Appliances Replaced through HomeWarming**

Appliance	ENS Tracked Values	Revised Values		Reference
	EUL	New Appliance Equipment Life	Retired Appliance RUL ³²	
Refrigerator Replacement	12	12	4	ENERGY STAR Calculator, Appliance Magazine Market Research Report, value for refrigerators
Freezer Replacement	12	12	4	ENERGY STAR Calculator, EPA Research, value for freezers
Dehumidifier Replacement	12	12	4	ENERGY STAR Calculator, EPA Research, value for dehumidifiers

The equivalent EUL value that the Evaluator calculated for every appliance type eligible for replacement through HomeWarming is listed in Table 38.

³² RUL values are assumed to be about one-third of the EUL values based on a common assumption used in several TRMs.

Table 38: Equivalent Effective Useful Life Calculations for Appliances Replaced through HomeWarming

Appliance	Energy Consumption (kWh/year)						Lifetime Savings (kWh)	Equivalent EUL (year)
	First 4 Years			Following 8 Years				
	Old Unit	New Unit	Savings	New Std. Unit	New Eff. Unit	Savings		
Refrigerator Replacement	1,055	350	705	406	350	56	3,268	5
Freezer Replacement	1,662	263	1,399	309	263	46	5,964	4
Dehumidifier Retirement	985	325	660	406	325	81	3,288	5

Summary

Table 39 summarizes the revised equivalent EUL values used by the Evaluator to calculate lifetime energy savings.

Table 39: Revised Equivalent Effective Useful Life Values

Appliance	Revised Equivalent EUL (Years)	Lifetime Gross Energy Savings per Unit (kWh)
Refrigerator Retirement – ARet	8	6,008
Freezer Retirement – ARet	8	6,904
Air Conditioner Retirement – ARet	3	645
Small Refrigerator Retirement – ARet	8	1,672
Small Freezer Retirement – ARet	8	3,718
Refrigerator Retirement – Pilot	8	6,512
Freezer Retirement – Pilot	8	5,392
Small Refrigerator Retirement – Pilot	8	2,360
Refrigerator Replacement – HomeWarming	5	3,268
Freezer Replacement – HomeWarming	4	5,964
Dehumidifier Replacement – HomeWarming	5	3,288

3.13 Overall Gross Savings

The gross energy and peak demand savings resulting from the retirement of old appliances and small appliances through ARet and the pilot, and the appliance replacements through HomeWarming are listed in Table 40. Overall, the total gross energy and peak demand savings amounted to 5.266 GWh and 0.740 MW respectively at the generator. Based on the average equivalent EUL of 7.7 years, the gross lifetime energy savings at the generator were established at 40.321 GWh.

For the appliances retired through ARet, the line-loss factor applied was 1.099, which represents the average line-loss factors associated with the rate code of each of the participants (who have a residential rate code in 97% of the cases). For appliances retired through HomeWarming, a line-loss factor of 1.100 was applied since all the participants have residential rate codes. For those appliances retired through the pilot, a line-loss factor of 1.071 was applied. The line-loss values were provided by Nova Scotia Power and the proportion of residential participants versus that of commercial participants was calculated with the data in the tracking report.

Table 40: Revised Gross Energy and Peak Demand Savings by Appliance Type

	Appliance Retirement				
	Refrigerators	Freezers	Room Air Conditioners	Small Refrigerators	Small Freezers
Energy Savings					
Number of Units Retired	3,847	1,659	124	78	31
Unitary Savings (kWh)	751	863	251	209	327
Gross Energy Savings – at the Meter (GWh)	2.889	1.432	0.027	0.016	0.010
Line Loss Factor	1.099	1.099	1.099	1.099	1.099
Gross Energy Savings – at the Generator (GWh)	3.175	1.573	0.029	0.018	0.011
Equivalent Effective Useful Life (years)	8	8	3	8	8
Gross Lifetime Energy Savings – at the Generator (GWh)	25.401	12.588	0.088	0.143	0.089
Peak Demand Savings					
Energy-to-demand Ratio	0.138	0.138	0.000	0.138	0.138
Gross Peak Demand Savings – at the Meter (MW)	0.399	0.198	0.000	0.002	0.001
Line Loss Factor	1.099	1.099	1.099	1.099	1.099
Gross Peak Demand Savings – at the Generator (MW)	0.438	0.217	0.000	0.002	0.002

Revised Gross Energy and Peak Demand Savings by Appliance Type (Continued)

	Pilot			HomeWarming			Total
	Refrigerators	Freezers	Small Refrigerators	Refrigerators	Freezers	Dehumidifiers	
Energy Savings							
Number of Units Retired	10	2	1	59	203	124	6,138
Unitary Savings (kWh)	814	674	295	705	1,399	660	-
Gross Energy Savings – at the Meter (GWh)	0.008	0.001	0.000	0.042	0.284	0.082	4.791
Line Loss Factor	1.071	1.071	1.071	1.100	1.100	1.100	-
Gross Energy Savings – at the Generator (GWh)	0.009	0.001	0.000	0.046	0.312	0.090	5.266
Equivalent Effective Useful Life (years)	8	8	8	5	4	5	-
Gross Lifetime Energy Savings – at the Generator (GWh)	0.070	0.012	0.003	0.229	1.250	0.450	40.321
Peak Demand Savings							
Energy-to-demand Ratio	0.138	0.138	0.138	0.138	0.138	0.335	-
Gross Peak Demand Savings – at the Meter (MW)	0.001	0.000	0.000	0.006	0.039	0.027	0.674
Line Loss Factor	1.071	1.071	1.071	1.100	1.100	1.100	-
Gross Peak Demand Savings – at the Generator (MW)	0.001	0.000	0.000	0.006	0.043	0.030	0.740

3.14 Internal Spillover

For ARet, internal spillover can occur when participants decide to retire or replace other appliances on their own following their participation in the program component and due to its influence. The Evaluator relied on the spillover level established in the 2016 evaluation, which was 1 percent, since no participant survey was conducted this year.

For the ARet Pilot, an internal spillover factor of 0 percent was applied since the HRSB representative interviewed mentioned that no additional appliance was retired without using the ARet services.

3.15 NTGR Calculation

Because of the methodology used to obtain the net savings, the net-to-gross ratio could not be calculated as a sum of the percentages of all the effects values. As required by the UMP calculation methodology, the savings associated with each possible “with ARet” and “without ARet” scenario was calculated, and then a weighted average was calculated to obtain the average net savings per unit. Consequently, the savings deducted from the gross savings for each kind of effect depend on not only the percentage of the participants affected, but also the difference in savings associated with each scenario. This methodology was followed to establish the net unitary savings, as described in previous sections of the report.

To obtain an equivalent NTGR that takes into account both the effects that were applied to the unitary savings and the spillover applied to the overall gross savings of the program component, the following equation was used:

$$NTGR_{equiv} = \frac{Net\ Unitary\ Savings}{Gross\ Unitary\ Savings} + Spillover\%$$

The detailed calculation results are shown in Table 41 below.

Table 41: Effects and Equivalent NTGR

Appliance Type	Number of Units	Gross Savings	Effects			Net Unitary Savings (kWh)	Internal Spillover	Equival. NTGR
		Consump. of Retired Appliances (kWh)	Free-ridership (kWh)	Secondary Market Impact (kWh)	Induced Consump. (kWh)			
Refrigerators	3,847	751	278	53	10	410	1%	0.55
Freezers	1,659	863	345	44	9	465		0.55
Air Conditioners	124	215	129	20	0	66		0.32
Small Refrigerators	78	209	92	14	0	103		0.50
Small Freezers	31	327	144	21	0	162		0.50

As for the appliances replaced through HomeWarming, an NTGR of 1 is assumed, considering the nature of the program component (direct replacement) and the participant demographic. Similarly, an NTGR of 1 is assumed for the appliances retired through the pilot.

3.16 Overall Net Savings

The net energy savings were estimated by multiplying the gross savings by the NTGR, as shown in the equation below.

$$\text{Net Energy Savings} = \text{Gross Energy Savings} \times \text{NTGR}_{\text{equiv}}$$

Overall, the total net energy and net peak demand savings for ARet amounted to 3.094 GWh and 0.443 MW at the generator respectively. Using Nova Scotia's specific factor³³ for GHG emissions generated by electricity production, 0.6531 kg CO₂ eq/kWh, it was estimated that the net energy savings resulted in 2,021 tonnes of avoided CO₂ eq annually. Based on the average equivalent EUL of 7.4 years, the net lifetime energy savings at the generator were established at 23.050 GWh.

The detailed savings results are shown in Table 42 below.

³³ When the Evaluator was drafting this evaluation report, the 2017 data was not yet available. The Nova Scotia-specific factor was obtained from Nova Scotia Power's 2016 total system emissions data (7,079,268 CO₂ eq tonnes) and total electricity generation (10,839 GWh), from the following two sources:

Nova Scotia Power, *Total System Emissions*, <http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx>, (Last accessed December 17, 2017).

Emera Inc., *Management's Discussion & Analysis As at February 10, 2017*, <http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693>, (Last accessed December 17, 2017).

Table 42: Evaluated Net Energy and Peak Demand Savings by Appliance Type

	Appliance Retirement				
	Refrigerators	Freezers	Room Air Conditioners	Small Refrigerators	Small Freezers
Energy Savings					
Revised Gross Energy Savings – at the Meter (GWh)	2.889	1.432	0.027	0.016	0.010
NTGR	0.55	0.55	0.32	0.50	0.50
Net Energy Savings – at the Meter (GWh)	1.589	0.787	0.009	0.008	0.005
Line Loss Factor	1.099	1.099	1.099	1.099	1.099
Net Energy Savings – at the Generator (GWh)	1.746	0.865	0.009	0.009	0.006
Equivalent Effective Useful Life (years)	8	8	3	8	8
Net Lifetime Energy Savings – at the Generator (GWh)	13.971	6.923	0.028	0.072	0.045
Peak Demand Savings					
Total Gross Peak Demand Savings – at the Meter (MW)	0.399	0.198	0.000	0.002	0.001
NTGR	0.55	0.55	0.32	0.50	0.50
Total Net Peak Demand Savings – at the Meter (MW)	0.219	0.109	0.000	0.001	0.001
Line Loss Factor	1.099	1.099	1.099	1.099	1.099
Total Net Peak Demand Savings – at the Generator (MW)	0.241	0.119	0.000	0.001	0.001

Evaluated Net Energy and Peak Demand Savings by Appliance Type (Continued)

	Pilot			HomeWarming			Total
	Refrigerators	Freezers	Small Refrigerator	Refrigerators	Freezers	Dehumidifiers	
Energy Savings							
Revised Gross Energy Savings – at the Meter (GWh)	0.008	0.001	0.000	0.042	0.284	0.082	4.791
NTGR	1.00	1.00	1.00	1.00	1.00	1.00	-
Net Energy Savings – at the Meter (GWh)	0.008	0.001	0.000	0.042	0.284	0.082	2.815
Line Loss Factor	1.071	1.071	1.071	1.100	1.100	1.100	-
Net Energy Savings – at the Generator (GWh)	0.009	0.001	0.000	0.046	0.312	0.090	3.094
Equivalent Effective Useful Life (years)	8	8	8	5	4	5	-
Net Lifetime Energy Savings – at the Generator (GWh)	0.070	0.012	0.003	0.229	1.250	0.450	23.050
Peak Demand Savings							
Total Gross Peak Demand Savings – at the Meter (MW)	0.001	0.000	0.000	0.006	0.039	0.027	0.674
NTGR	1.00	1.00	1.00	1.00	1.00	1.00	-
Total Net Peak Demand Savings – at the Meter (MW)	0.001	0.000	0.000	0.006	0.039	0.027	0.403
Line Loss Factor	1.071	1.071	1.071	1.100	1.100	1.100	-
Total Net Peak Demand Savings – at the Generator (MW)	0.001	0.000	0.000	0.006	0.043	0.030	0.443

Table 43 below compares the tracked and evaluated savings at the generator.

Table 43: Comparison of Tracked and Evaluated Savings at the Generator

	Initial Gross Savings	Revised Gross Savings	NTGR*	Net Savings
Energy Savings				
ENS Tracked Savings	4.852 GWh	4.852 GWh	0.57	2.761 GWh
Evaluation Results	5.266 GWh	5.266 GWh	0.59	3.094 GWh
Peak Demand Savings				
ENS Tracked Savings	0.653 MW	0.653 MW	0.56	0.368 MW
Evaluation Results	0.740 MW	0.740 MW	0.60	0.443 MW

*NTGRs varied for each type of appliance. The NTGRs presented in this table correspond to the rounded averages obtained by dividing net savings by gross savings.

The overall evaluated net energy savings are 12 percent higher than those tracked by ENS. This difference is mainly due to the increase in freezers' unitary savings values for both ARet and HomeWarming. This increase has resulted from an increase in the retired freezers' average energy consumption values established based on the metering activities in 2017.

The evaluated net peak demand savings are 21 percent higher than the tracked net peak demand savings, which is attributable to the higher revised energy savings and the increase in the peak-demand-to-energy ratio for dehumidifiers (from 0.000 to 0.335).

4 INSTANT SAVINGS OVERVIEW

The following sections present the Instant Savings evaluation results.

This section describes the Instant Savings program component, follows up on 2016 evaluation recommendations and presents participation history.

4.1 Description

Instant Savings offers instant cash rebates to consumers when purchasing eligible energy-efficient products. Instant Savings is carried out with the help of one DA and 28 participating retailers who offer eligible products at over 230 locations across Nova Scotia.

In 2017, rebates on eligible products were offered during two campaigns that took place in the spring from March 30 to May 14, 2017, and in the fall from September 29 to October 29, 2017. Similarly to 2016, rebates on appliances were offered throughout 2017.

During the fall 2017 campaign, ENS tested out new products related to indoor air quality to assess retailer and consumer responses to them. The following products were offered through this pilot project:

- › ENERGY STAR certified room air purifiers
- › ENERGY STAR certified dehumidifiers
- › ENERGY STAR certified bathroom fans

ENERGY STAR certified kitchen range hood fans were also included in the pilot, but no retailer elected to include this product in their Instant Savings offerings in 2017.

In the fall 2017, ENS also added multipacks (three or more) of ENERGY STAR certified Solid State Light Emitting Diode (LED) recessed downlight fixtures to the list of eligible products. As shown in Table 44 below, a rebate of \$20 was offered for this product.

Table 44 summarizes the energy-efficient products featured by Instant Savings and their respective rebate amounts.

Table 44: List of Rebates by Product

Products	Spring Rebate	Fall Rebate
ENERGY STAR certified LED A-type Lamps (1-2 packs/packs of 3 or more)	\$2/\$5	\$2/\$5
ENERGY STAR certified LED Non-A-type Lamps (1-2 packs/packs of 3 or more)	\$3/\$7	\$3/\$7
ENERGY STAR certified Recessed Downlight Fixtures (1-2 packs/packs of 3 or more)	\$8	\$8/\$20
ENERGY STAR certified LED Fixtures	\$10	\$10
Dimmer Switches (single packs/packs of 2 or more)	\$3/\$6	\$3/\$6
Indoor and Outdoor Motion Sensors	\$5	\$5
Power Bars with Integrated Timers	\$5	\$5
Load Sensing Power Bars (smart strips)	\$10	\$10
Heavy Duty Outdoor Timers (plug-in)	\$8	\$8
Programmable Thermostats for Electric Baseboard Heaters (1-2 packs/packs of 3 or more)	\$12/\$36	\$12/\$36
Outdoor Clothesline Kits and Outdoor Drying Racks	\$5	\$5
Refrigerators (qualifying models use 20 kWh per cubic foot of adjusted volume or less)	\$75	\$75
Clothes Washers (qualifying models are on the ENERGY STAR Most Efficient 2016 list)	\$75	\$75
ENERGY STAR certified Room Air Purifiers	N/A	\$40
ENERGY STAR certified Dehumidifiers	N/A	\$30
ENERGY STAR certified Bathroom Fans (without a light)	N/A	\$15

In an effort to manage sales and avoid excessively low prices as a result of rebates, ENS implemented a price floor on eligible products in 2017. The price floor is the lowest amount for which a retailer may advertise and sell a product if they want to be reimbursed for the associated rebate. ENS set the price floor for each eligible product such that the rebate itself never exceeds 50 percent of the pre-tax cost consumers pay for a product.

In 2017, Instant Savings was advertised through point-of-purchase materials and signage, training for efficiency ambassadors, the ENS website and other media including radio remotes, television commercials, social media as well as print and online advertising. As in previous years, consumer engagement events were held in participating retail stores during the campaign periods to both provide information about Instant Savings and cross-promote other ENS programs and services.

Instant Savings aimed to achieve 20.0 GWh in net electricity savings and 3.3 MW in net peak demand savings at the generator for 2017.

4.2 Follow-up on 2016 Evaluation Report Recommendations

Instant Savings was evaluated in 2016 and improvement recommendations were made by the Evaluator. Table 45 below provides a brief summary of the implementation status of each recommendation presented in the Executive Summary section of the 2016 Evaluation Report.

Table 45: Implementation Status of Recommendations in the 2016 Executive Summary

2016 Recommendations	Status
2016 Instant-R1. Continue monitoring key market indicators to adapt program component offerings when needed.	Implemented
2016 Instant-R2. Closely monitor the evolution of the refrigerator and clothes washer markets.	Implemented

Recommendation 2016 Instant-R1 involves monitoring various key market indicators that include product sales and prices. To implement this recommendation, ENS asked the Evaluator to conduct a market evolution assessment by analyzing key indicators gathered through the retailer interviews, intercept survey and database. The results of this analysis are presented in Section 8. Additionally, in 2017 ENS asked retailers to submit their annual lighting product sales data (including non-rebated sales outside the campaigns) so the impact of the campaigns on product sales could be assessed. Some retailers provided their January to June sales data which informed program component design for the Fall Campaign, whereas others opted to share their uplift data only once at the end of the year. Moving forward, the 2018 ENS retailer contract will require retailers to provide their sales data, including both sales during and outside campaigns, semi-annually in June and December.

A new Canadian energy efficiency regulation became effective on June 28, 2017.³⁴ This regulation has impacted the energy efficiency levels of refrigerators and clothes washers, among other energy-consuming products. Recommendation 2016 Instant-R2 was meant to assess the impact of this regulation on the appliances sold by retailers through Instant Savings. In June 2017, ENS provided the Evaluator with a list of the appliances sold by eight of the participating retailers. The Evaluator analyzed the list to determine whether the regulation had already affected the baseline energy consumption and thus, the unitary savings value of appliances sold through Instant Savings. The results of this analysis are presented in the Impact Evaluation section further below.

³⁴ Natural Resources Canada, *Notice – Publication of Energy Efficiency Regulation, 2016- Amendment 13*. December 2016, <http://www.nrcan.gc.ca/energy/regulations-codes-standards/18419> (Last accessed February 5, 2018)

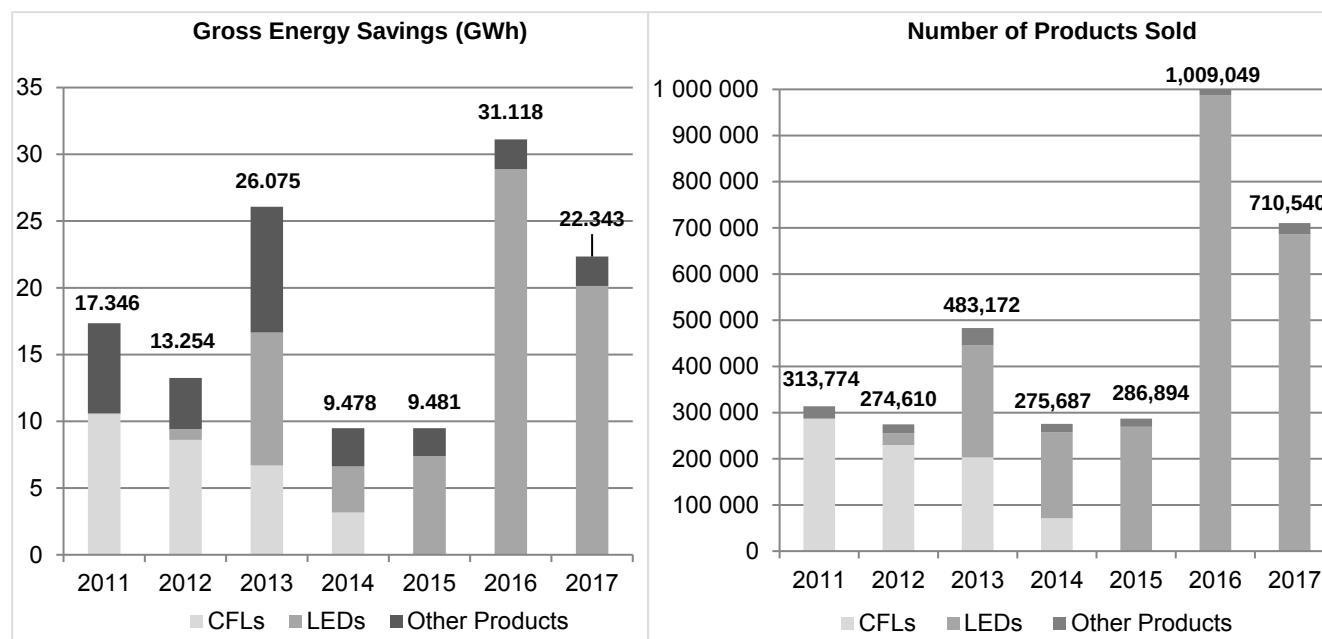
4.3 Participation History

In 2017, a total of 710,540 eligible products were sold in participating stores across Nova Scotia, as shown in Figure 7. Among these products, 651,968 were LED lamps which included 512,096 A-type and 139,872 Non-A-type LED lamps. Although lower than 2016, 2017 participation remains high compared to 2014 and 2015 levels. The 2016 Evaluation found that the very high volume of LED lamp sales in 2016 was primarily due to unusually low promotional prices offered by one retailer during the fall campaign. This retailer offered LED lamps at rebated prices between \$1 and \$3, which resulted in this retailer selling more LED lamps than any other participating retailer. This resulted in other retailers to offer LED lamps at similar prices, but the effect on these retailers' sales was less significant. This situation is not expected to occur again because ENS has established floor prices for all Instant Savings products and no product can be sold at a price below the value of the rebate.

Instant Savings achieved 22.343 GWh in gross energy savings and 2.993 MW in gross peak demand savings in 2017, which represents a decrease of 28 percent compared to 2016 levels. These lower savings were expected due to the new price floor policy.

While the number of rebated LED lamps sold decreased in 2017, other rebated products less affected by the price floor, on average, sold more in 2017 than 2016. Notably, the number of LED fixtures sold increased by 23 percent, while the number of all other sold products increased on average by 10 percent.

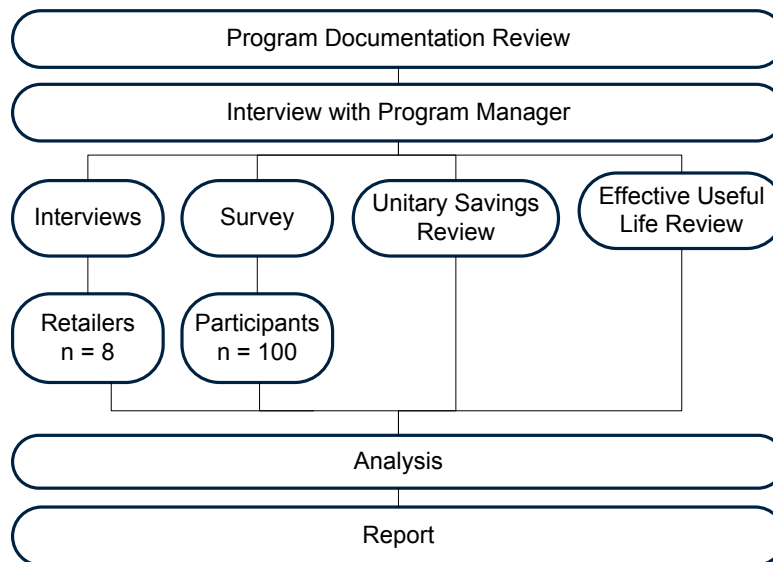
Figure 7: Summary of Participation in Instant Savings, 2011-2017



5 INSTANT SAVINGS EVALUATION METHODOLOGY

This section presents the methodology used and the activities carried out for the 2017 Instant Savings evaluation. As shown in Figure 8, various data-collection activities were used throughout the evaluation.

Figure 8: Methodological Model



The Evaluator reviewed the program component documentation and then met the program manager in August 2017 to verify the implementation status of previous evaluation recommendations and learn about primary program component changes. Based on the information obtained from this meeting, a list of questions and topics to be included in the data-collection instruments was prepared.

Once these activities were completed, specific evaluation activities were undertaken, as described in the following subsections.

For evaluation activities that yield quantitative results based on a sample, the Evaluator aimed to achieve a maximum margin of error of 10 percent, at a confidence level of 90 percent. This means that if measurement was conducted many times with different samples, the data would be within 10 percentage points above or below the percentage reported 90 percent of the time. Thus, the margin of error indicates the relative level of precision of the measurement, while its associated confidence level indicates the probability of a measure falling within this margin of error.

As part of this evaluation, the Evaluator calculated the margin of error for survey samples and free-ridership rates where applicable. The margins of error are presented alongside the results in the applicable sections. Examples of calculations used to establish margins of error can be found in Appendix II of the 2017 DSM Programs Evaluation Executive Summary.

Interviews with Retailers

In the fall of 2017, CRA conducted in-depth interviews with eight retailers representing nine retail chains (one respondent answered for two retail chains). These interviews were used to: (1) measure spillover in the form of market effects for ENERGY STAR certified LED Lamps; (2) understand the process retailers underwent as part of their participation; and (3) determine their perceptions of and satisfaction with Instant Savings.

The guide used for the interviews with retailers is presented in Appendix IV. Note that all appendices are presented in the Residential Efficient Product Rebates Program – Appendices.

Participant Survey

A participant intercept survey was conducted by CRA staff in Halifax with a total of 100 participants who purchased qualifying LED lamps during the fall campaign. The in-store interviews were conducted throughout the fall campaign at five participating retail banners. The average survey length was 10 minutes. The questionnaire and complete participant survey results are presented in Appendices V and VI respectively.

The intercept participant survey generated feedback on the following aspects of Instant Savings:

- › LED lamp purchases and expected uses
- › Awareness about Instant Savings
- › Awareness about ENS
- › Free-ridership
- › Awareness about rebated products
- › Demographics

The intercept survey sample of 100 participants yields a margin of error of ± 8.2 percent at a 90 percent confidence level.

Unitary Savings Review

For 2017, the Evaluator reviewed only the unitary savings of LED lamps and fixtures, which are the products generating by far the most savings for the program component, as well as clothes washers and refrigerators whose baseline changed as a result of new federal regulations. For other products, the Evaluator relied on 2016 values since the unitary savings of these products have remained stable over the last years. The Evaluator also established unitary savings values for the four new products offered under the pilot.

For the target products, the Evaluator conducted a literature review and performed engineering calculations to assess the unitary savings values used in the tracking sheet. Technical reference manuals and public evaluation reports of jurisdictions similar to ENS were consulted with focus on the most recent and accurate sources.

Effective Useful Life Review

As part of the 2017 evaluation, to examine the EUL values used by ENS to calculate lifetime energy savings, the Evaluator conducted a thorough literature review by consulting TRMs, evaluation reports and relevant studies.

Comparison with 2016 Evaluation Scope

The market evaluation for Instant Savings was reduced in 2017 because no mystery shopper visit was conducted and the intercept survey took place only in the fall campaign rather than during both campaigns. Instant Savings impact evaluation had a reduced scope because of the unitary savings of some products that were not reviewed. The rationale behind those choices is based on analysis of 2017 evaluation objectives, key results of the previous evaluations and recent changes made to each program. Further explanation can be found Section 1 of the DSM Programs Evaluation Executive Summary.

6 INSTANT SAVINGS MARKET EVALUATION

This section presents the partner and participant perspectives on Instant Savings.

6.1 Partner Perspectives

As part of the Instant Savings evaluation, eight interviews were conducted with nationwide retailers in October and November 2017. These interviews were conducted before both the retailers and ENS had the fall campaign sales results.

Satisfaction with Instant Savings, Marketing and Advertising

Overall satisfaction with Instant Savings varies between retailers when assessed on a 10-point scale (where 1 indicates “not at all satisfied” and 10 indicates “completely satisfied”). While five retailers were somewhat or completely satisfied with Instant Savings, offering ratings between 7 and 10, three retailers rated their satisfaction at 2 or 5. As a result, the overall satisfaction rating averages 7 on a 10-point scale. Retailers expressed frustration with the product price floor, an approach that, according to the retailers, resulted in retail prices at levels that no longer render those products attractive to consumers. Some retailers even chose to offer some LED models with no rebate so they could sell them cheaper on their own. It was mentioned that LED technology is now more prevalent and accessible to consumers and that the introduction of the LED product category in discount stores has led to a consumer expectation of a lower price point.

At the same time, retailers continue to request more advance notice from ENS of the products covered in the upcoming campaign, which would thus allow them to more adequately fulfill product orders to meet consumer demand during campaign periods. Being notified six months in advance is preferred. As in previous years, the list of eligible product categories and rebate amounts was sent to the retailers at least 90 days before the campaigns. The 90-day period meets ENS’s need to assess results from previous campaigns prior to confirming product and rebate amounts for the next campaign period.

With the exception of one retailer, satisfaction with the marketing and advertising activities conducted by ENS is fairly high with an overall satisfaction rating of 7.2 on a 10-point scale. The retailer who was less satisfied provided a rating of 2, indicating that ENS did not establish a campaign schedule that provides retailers enough time to advertise rebated products in their flyers. Two retailers did not rate Instant Savings marketing and advertising because they are unfamiliar with ENS initiatives given that they are located outside of Nova Scotia.

Selection of Products and Rebate Amounts

Retailers are generally satisfied with the selection of products included in Instant Savings, with an average satisfaction rating of 8.3 on a 10-point scale. Four retailers provided a rating of 9 or 10, three retailers rated a 7 or 8, and one retailer rated a 5. The latter believes that products with low sales uptake, including dimmers, clothes lines, and timers, should be removed from Instant Savings to simplify the stock keeping unit (SKU) list approval and reporting process. Conversely, retailers who are satisfied with the products covered by Instant Savings recommended that categories be expanded beyond lighting products. This was seen as an important consideration to continue motivating consumers to choose energy-efficient products as the market penetration of LED lighting increases. Additionally, one retailer mentioned being satisfied with the addition of dehumidifiers as a pilot product.

Mixed opinions were offered with respect to the rebate amounts, with an overall average of 6.8 on a 10-point scale. Specifically, four retailers rated this aspect an 8 or 9, two retailers rated a 7, and two displeased retailers rated a 1 and 5. One retailer is concerned that some consumers choose smaller packages to obtain the overall best price after rebate. Among retailers satisfied with the rebate amounts, it should again be noted that a few are displeased with the price floor required by Instant Savings.

SKU List Approval and Rebate Processing and Tracking

Satisfaction with the SKU list approval process is moderate, with retailers providing an average rating of 6.6 on a 10-point scale. The length of time and associated resources required to review and prepare the SKU list is considered cumbersome by many retailers, regardless of their satisfaction level with the overall SKU list approval process. In addition, one retailer noted that the delay in products being certified as meeting ENERGY STAR performance levels adds a level of complexity because retailers need to keep abreast of product certification if they wish to include those on the list.

Retailers offer a somewhat favourable opinion regarding the rebate processing, tracking and reporting processes, with an average satisfaction rating of 7.4 on a 10-point scale. The administrative burden and time required for these activities are the main reasons for dissatisfaction, in addition to being required to report sales figures twice during each campaign (at campaign mid-point and at the end). Inconsistent formats between the retailer and ENS internal tracking systems as well as the need to revise incorrect data also cause dissatisfaction. Although these requirements can be cumbersome for some retailers, they are essential for ENS in managing Instant Savings and the campaigns.

Relationship with the DA

Retailers continue to have good relationships with the DA, providing an average rating of 8.1 on a 10-point scale. They are generally pleased with DA helpfulness, responsiveness, support, reliability, and the thorough information provided on the campaigns. Seven of the eight retailers appreciate their relationship with the DA. The one retailer who is less satisfied with the DA mentioned preferring dealing with the program administrator directly for this type of program component, which ensures a more timely review and approval process.

Satisfaction with the campaign preparation process is moderate, with retailers providing an average rating of 6.3 on a 10-point scale. Dissatisfaction arose because campaign materials were not provided well in advance, with a preference expressed for having material at least two weeks before the campaign begins.

Satisfaction with DA timeliness for providing information about Instant Savings is moderately low, averaging 5.3 on a 10-point scale. While three retailers rated 8 to 10, two retailers rated a 6, and three retailers rated a 1 or 2. The main point of dissatisfaction is the insufficient advance notice of the campaign and rebated products to allow retailers sufficient time to order products.

Table 46 below summarizes the satisfaction ratings provided by the interviewed retailers. Most mean satisfaction ratings in the table below are lower than 2016. It should be noted that compared to 2016, greater variability in the range of individual responses provided by retailers in 2017 was observed.

Table 46: Retailer Satisfaction with Aspects of Instant Savings (10-point scale)

Aspects of Instant Savings (10-point scale)	2015		2016		2017	
	Mean	Sample Size	Mean	Sample Size	Mean	Sample Size
Overall program component	7.4	9	8.5	8	7.0	8
Products covered by the program component	8.3	9	8.4	8	8.3	8
Overall relationship with the DA	-	-	9.3	8	8.1	8
Rebate processing, tracking, and reporting	7.8	9	7.8	8	7.4	8
Program component marketing and advertising	7.4	9	8.7	7	7.2	6
Rebate amounts	7.4	9	7.6	8	6.8	8
SKU list approval process	-	-	6.1	8	6.6	8
Campaign preparation process	7.7	9	7.6	8	6.3	8
Timeliness providing program component information	8.2	9	7.4	8	5.3	8

Influence of Instant Savings

Retailers were asked to assess the influence of Instant Savings on a variety of factors. Overall, Instant Savings is seen as having some influence on the quantity of ENERGY STAR certified LED lamps stocked by retailers during the campaign period (average influence rating of 7.1 on a 10-point scale where 0 means “No influence at all” and 10 means “A great deal of influence”). Specifically, two retailers rated this aspect a 10 and two rated a 9, while one retailer rated an 8. The three remaining retailers rated a 5, 4 and 2. Two of the three retailers who gave an influence rating of less than 5 indicated that the minimum retail price established this year drove them to reduce their inventory since they anticipated lower sales than in 2016. It should be noted that the price floor did not affect all eligible products and that it mostly impacted the packs of 1 or 2 LED lamps. That said, there are mixed opinions regarding the influence of Instant Savings on the variety of ENERGY STAR certified LED lamps stocked by retailers. While one retailer provided an influence rating of 10, two retailers provided an 8 while another a 7. One retailer gave a rating of 4 and the other three retailers rated the influence of Instant Savings as a 0 on a 0-10 scale.

In terms of influencing knowledge of ENERGY STAR certified LED lamps and technology, six retailers believe that Instant Savings elevates staff knowledge, while two retailers consider that internal training is more impactful, resulting in a total average influence rating of 6.1 out of 10. It is noteworthy that for the first time in 2017, ENS sent some of its Instant Savings materials electronically to the retailers so that they could include these in their internal training if desired. The fact that consumers ask about rebated products in-store encourages staff to stay informed about the products and technology. Likewise, the same six retailers believe that Instant Savings has influenced consumer knowledge of ENERGY STAR certified LED lamps and technology, while two retailers disagree, resulting in a total average influence rating of 6.3 out of 10. The six retailers who see Instant Savings as influencing consumer knowledge believe that the promotion and education activities under Instant Savings lead consumers to ask store staff about LEDs and their benefits. The two retailers who disagree with this consider that consumers are more interested in the rebate than the technology (n=1), or that consumers focus on aspects such as bulb colour and temperature when making a purchase (n=1) rather than savings and other technical qualities of LEDs. Table 47 below provides an overview of average ratings on each assessed influence factor.

Table 47: Influence of Instant Savings

Influence Factors	Mean*
Quantity of ENERGY STAR certified LED lamps stocked in store (n=8)	7.1
Staff knowledge of ENERGY STAR certified LED lamps and technology (n=8)	6.1
Consumer knowledge of ENERGY STAR certified LED lamps and technology (n=8)	6.3
Variety of ENERGY STAR certified LED lamps stocked in store (n=8)	4.6

* Scale: 0 = Not at all influential; 10 = Very influential

Barriers and Recommendations

When asked to identify what prevents consumers from purchasing energy-efficient products, retailers identified both price and a lack of understanding of the energy savings achieved from energy-efficient products such as ENERGY STAR certified LED lamps. Five retailers identified cost as the main barrier, while three retailers believe that insufficient knowledge now trumps price as the key barrier to LED adoption.

Retailers offered few specific recommendations as to what actions could encourage consumers to participate in Instant Savings. For the most part, removing the price floor requirement on rebated products and increasing public awareness of LED technology and energy efficiency in general through sustained education was mentioned as a way of reaching those consumers who have not yet switched to energy efficiency. One retailer also suggested extending the campaign year-round, while another retailer suggested expanding the variety of rebated products to include more light fixtures. Along the same line, two retailers believe that participation in Instant Savings depends mostly on which products are made eligible and how well the program component monitors market saturation and trends.

6.2 Participant Perspectives

An intercept participant survey was conducted as part of the Instant Savings evaluation. A total of 100 interviews were completed with LED purchasers during the 2017 fall campaign.

Among interviewed LED purchasers, 90 percent already had LED lamps installed in their home. Similar to 2016, over six in ten respondents had heard of Instant Savings, primarily through in-store promotions (32%), TV ads (16%), the ENS website (13%) or word-of-mouth (13%). Awareness about ENS has remained very high, with 92 percent of respondents mentioning that they had heard of ENS prior to the survey. Additionally, four in ten respondents were aware of other energy-efficient products rebated by ENS (40%), with heat pumps mentioned most often (48%), followed by programmable thermostats (44%) and refrigerators (24%).

Over nine in ten (94%) respondents knew about the rebates offered on LED lamps prior to paying at the register. Again for 2017, in-store promotions were effective in educating respondents about the Instant Savings rebates with nearly eight in ten (78%) indicating this was how they became aware of the LED rebates. Store personnel were also effective at communicating information about the rebate offered through the program component (16%). Over nine in ten respondents saw stickers, shelf signs or posters in the lightbulb section of the store (94%).

If the rebate had not been offered, over one-half of respondents would not have bought any lamps (55%), results similar to 2016 (59%).

7 INSTANT SAVINGS IMPACT EVALUATION

The objective of the 2017 Instant Savings impact evaluation is to determine the gross and net electrical energy and peak demand savings.

7.1 Gross Savings

This section presents the tracked gross unitary savings used by ENS in the tracking system, as well as the revised gross unitary savings used by the Evaluator to accurately establish the savings associated with the products sold through Instant Savings in 2017.

For 2017, the Evaluator reviewed only the unitary savings of LED lamps and fixtures, which are the products generating by far the most savings for the program component, as well as clothes washers and refrigerators whose baseline changed as a result of new federal regulations. This section also presents the methodology used by the Evaluator to establish the unitary savings values of the three new products offered under the pilot.

For other products, the Evaluator relied on 2016 values since the unitary savings of these products have remained fairly stable over the last years. The unitary savings details for these products are presented in Appendix VII.

7.1.1 LED Lamps

Tracked Savings

In 2017, ENS used distinct unitary savings values for LED A-type and Non-A-type lamps sold through Instant Savings, which were 26.4 kWh and 46.7 kWh respectively. These values are based on the 2016 evaluation and were determined with the use of the following general lighting equation:

$$\text{Annual Unitary Savings} \left[\frac{\text{kWh}}{\text{yr}} \right] = \frac{\text{Displaced Wattage} [W] \times \text{HOU} \left[\frac{h}{\text{day}} \right] \times 365 \left[\frac{\text{day}}{\text{yr}} \right]}{1000 \left[\frac{W}{kW} \right]}$$

ENS uses displaced wattages of 24.9 W and 44.1 W respectively for LED A-type and Non-A-type lamps. Displaced wattage represents the difference between the old and new wattages. The new wattages were determined using the LED wattage values found in the 2016 tracking sheet for the 10 most popular products. Two types of baselines were defined to establish the baseline wattage: early replacement and replace on burn-out baselines. This approach uses the 2016 intercept survey results to determine the proportion for each baseline. The early replacement baseline was defined using the weighted average wattage of the applicable type of lamps (i.e. incandescent, halogen or CFL [compact fluorescent lamp]) replaced by the surveyed participants, while the replace on burn-out baseline was defined using the wattage of the equivalent minimal efficiency lamp for each of the 10 most popular products.

The value for the daily hours of operation used by ENS for the calculations is based on an average value of 2.9 hours per day, a value drawn from the NERHOU Study³⁵ on efficient lamps.

Revised Savings

Starting in 2016, ENS tracks LED A-type and Non-A-type lamps separately, based on the fact that non-A-types primarily include reflector lamps for which the baseline would be halogen lamps only, whereas A-types are available in incandescent, halogen, and CFL technologies. In addition this year, the Evaluator differentiated non-A-type lamps in two subcategories. The first category includes all R, BR and decorative lamps and the second all other non-A-type lamps. This change intends to take into account the difference in energy savings for the LED non-A-type lamps replacing halogen lamps and those replacing incandescent lamps. Therefore, three unitary savings values were calculated for LED lamps. To do so, the Evaluator analyzed the displaced wattage calculations for both LED A-type and Non-A-type lamps and reviewed the hours of operation.

To more accurately establish energy savings generated by LED lamps sold through Instant Savings, ENS should consider using these three lamp categories in future years.

Displaced Wattage

To establish the average displaced wattage for both LED A-type and Non-A-type lamps, the Evaluator used the methodology developed for the 2015 evaluation. This methodology takes into consideration the principles of the Uniform Methods Project (UMP).³⁶

Questions were included in the intercept survey to collect the following information:

- › Do participants mostly replace lamps that are still in a working condition (early replacement) or do they replace burned out lamps (replace on burn-out)?
- › When participants replace lamps that are still in a working condition, what types of lamps are replaced?

These two questions are essential to establishing the baseline because it corresponds to the least efficient lamp that would have been used if the program component had not been in place.

These questions were included in the fall campaign intercept survey, and answers obtained are summarized in Table 48 below.

³⁵ NMR Group Inc. and DNV GL, *Northeast Residential Lighting Hours-of-Use Study*, May 5, 2014, p. 69.

³⁶ National Renewable Energy Laboratory, *Uniform Methods Protocol Chapter 6: Residential Lighting Evaluation Protocol*, February 2014, pp. 6-20.

Table 48: Results of the Intercept Survey for Establishing the LED Lamp Baseline

Question	Number of Respondents	Number of Lamps	Percentage of Lamps
Do you plan on installing these LED bulbs...³⁷			
To replace bulbs once they burn out?	33	161	30%
To replace bulbs that are still working?	55	374	70%
For respondents who are replacing working bulbs: How many, if any, of these LED bulbs will be used to replace...			
LED lamps	8	49	13%
CFLs	34	194	52%
Halogen lamps	2	10	3%
Incandescent lamps	21	121	32%

In light of these findings, two types of baseline were defined.

Early Replacement Baseline: The survey revealed that 70 percent of LED lamps purchased by participants replaced working lamps. Because those lamps were assumed to have an average remaining useful life of at least one year, the baseline wattage was considered that of replaced working lamps and calculated based on the following two elements:

- › The proportion of every type of lamp being replaced, based on the results of the intercept survey.
- › The average wattage of LED lamps purchased, which was converted to an equivalent CFL, halogen and incandescent wattage, as applicable, according to the type of lamp being replaced.

The Evaluator consulted the tracking sheet to determine which types of lamps were sold under the Non-A-type LED category for 2017. It was found that most lamp types (such as GU, PAR and MR) were reflector lamps, with the exception of some R, BR, and decorative (e.g. B or globe) lamp types which comprised the third lamp category since they are used to replace mainly incandescent lamps.

³⁷ Four respondents, or 4 percent of total respondents, answered "Don't know." They were excluded from the calculation of the percentage of lamps for each option.

The equivalent halogen, incandescent and CFL wattage values were obtained by researching the recommended equivalencies for the 10 most popular products for each categories of LED lamps. As in last year's evaluation, the Evaluator applied a conversion factor to the equivalent incandescent wattage to obtain the equivalent wattage of CFLs. In addition, the wattage for LED lamps replacing other LED lamps was considered to be the same wattage as the average wattage of the lamps sold through Instant Savings. The Evaluator assumed that the LED lamps replacing other LED lamps were A-type lamps since it is unlikely that non-A-type lamps reached the end of their life considering their recent appearance on the market. In addition, no other technology than incandescent and LED are available to replace R, BR and decorative lamps, so it was assumed that all LED lamps replaced incandescent lamps for this product category. Since other non-A-type lamps are only available in halogen and LED, it was also assumed that all LED lamps replaced halogen lamps for this product category. Therefore, the 3 percent of lamps that replaced halogens (as per survey results) was attributed to non-A-type lamps (excluding R, BR and decorative) and the percentages of incandescent lamps, CFLs and LED lamps were assigned to A-type lamps and redistributed to obtain a total of 100 percent.

The wattage calculation details are presented in Table 49 below.

Table 49: Wattage Calculations for the Early Replacement Baseline

Purchased LED lamps		Replaced Lamps							
LED Product Category	Average Wattage	Incandescent		CFL		Halogen		LED	
		Average Wattage	%	Average Wattage	%	Average Wattage	%	Average Wattage	%
LED A-type lamps	9.8	61.5	33%	13.3	53%	-	-	9.8	14%
LED Non-A-type lamps (R, BR and Decorative)	5.7	44.7	100%	-	-	-	-	-	-
LED Non-A-type lamps (excluding R, BR and Decorative)	6.6	-	-	-	-	51.9	100%	-	-

Based on the above calculations, the baseline wattage for the early replacement scenario was established at 28.7 W for LED A-type, 44.7 W for R, BR and decorative lamps, and 51.9 W for the other LED non-A-type lamps.

Replace On Burn-out Baseline: For the 30 percent of LED lamps that replaced burned out lamps, it was assumed that the participant would have purchased lamps meeting the current federal energy performance regulation. Again, for all three product categories, the 10 most popular LED lamp models were used for savings calculations. For each of these models, the wattage of the minimal efficiency lamp was defined, which in turn allowed for the calculation of the weighted average equivalent wattage for each lamp category.

To determine the wattage of the equivalent minimal efficiency lamps, the Evaluator considered the latest federal regulation on general service lamps.³⁸ Currently, this regulation does not cover LED non-A-type lamps, which caused the displaced wattages of both scenarios to be equal for these lamps.

The replace on burn-out baseline was therefore defined as follows in Table 50.

Table 50: Replace On Burn-out Baseline by LED Lamp Type

LED Lamp Type	Baseline Technology
A	Efficient incandescent as per Natural Resources Canada Regulations on General Service Lamps
GU	Standard Halogen
PAR	Standard Halogen
R and BR	Incandescent
Decorative	Incandescent

The resulting replace on burn-out baseline wattage, based on the weighted average of the equivalent wattage for each of the 10 most popular LED lamp models, was established at 44.1 W for A-type lamps, 44.7 W for R, BR and decorative lamps, and 51.9 W for other non-A-type lamps.

Table 51 below outlines the overall displaced wattages for both categories of LED lamps.

³⁸ Natural Resources Canada, *General Service Lamps*, <http://www.nrcan.gc.ca/energy/regulations-codes-standards/products/6869> (Last accessed January 9, 2018).

Table 51: Calculations for Displaced Wattages

	Proportion	Baseline Wattage (W)	LED Lamp Wattage (W)	Displaced Wattage (W)
LED A-type Lamps				
Early Replacement Scenario	70%	28.7	9.8	18.9
Replace On Burn-out Scenario	30%	44.1	9.8	34.3
Total LED A-type Lamps	100%	33.3	9.8	23.5
LED Non-A-type Lamps (R, BR and Decorative)				
Early Replacement Scenario	70%	44.7	5.7	39.0
Replace On Burn-out Scenario	30%	44.7	5.7	39.0
Total LED Non-A-type Lamps (R, BR and Decorative)	100%	44.7	5.7	39.0
LED Non-A-type Lamps (excluding R, BR and Decorative)				
Early Replacement Scenario	70%	51.9	6.6	45.3
Replace On Burn-out Scenario	30%	51.9	6.6	45.3
Total LED Non-A-type Lamps (excluding R, BR and Decorative)	100%	51.9	6.6	45.3

As shown in Table 51, the overall displaced wattage for LED A-type lamps, LED R, BR and decorative lamps and other LED non-A-type lamps was established at 23.5 W, 39.0 W and 45.3 W respectively.

Hours of Operation

The Residential Lighting Evaluation Protocol of the Uniform Methods Project³⁹ recommends that each jurisdiction conduct a metering study to determine their specific hours of use (HOU). In 2016 and 2017, the Evaluator conducted a metering study among 75 households to assess the daily hours of operation. The overall average daily HOU was established at 2.48 hours/day with a margin of error of ± 0.24 hours/day. The detailed methodology and results of this metering study are presented in the 2017 Residential Lighting Study report, in Appendix XX of the Existing Residential Program 2017 DSM Evaluation report. Since the NERHOU study was conducted on a much larger scale with 848 households and its data and findings fall within the Evaluator's metering study's margin of error, the Evaluator has decided that the values established by NERHOU are still the most appropriate values for the LED lamps installed through Instant Savings. Again for 2017, the Evaluator used the average hours of operation value for efficient lamps without the snapback value, which is 2.9 hours per day.

In-service Rate

For upstream programs like Instant Savings, the UMP has made the following recommendation:

"In-service rates should be calculated through an in-home audit. Since program bulbs cannot be easily identified, the in-service rate can be calculated as the number of bulbs purchased in a recent 12-month period that are installed divided by the total number of bulbs purchased in the same 12-month period. If the sample size of homes with bulbs purchased in the recent 12-month period is insufficient to provide the necessary levels of confidence and precision, a long term in-service rate can be used using all bulbs regardless of the time of purchase." ⁴⁰

As in the past three years, the Evaluator decided to claim all savings in the year during which the lamps were purchased and not use an in-service rate. Based on the results of the fall campaign intercept survey, 70 percent of the participants purchased LED lamps to replace existing lamps still in working condition. Since most of the participants do not wait until old lamps burn out to install their purchased LED lamps, this might result in only a small number of LED lamps left in storage.

However, the Evaluator noticed that the majority (84%) of LED lamps purchased through Instant Savings in 2017 was in packs of two or more, while these packs only represented 28 percent of 2016 Instant Savings sales. With multipack sales now exceeding individual pack sales, participants are more likely to store some of their LED lamps. Furthermore, the percentage of participants who purchase LED lamps to replace lamps as they burn out (and might therefore wait longer to install all purchased lamps) increased again this year, going from 19 percent in 2015 to 23 percent in 2016 and 30 percent in 2017. Consequently, ENS should consider including an in-service rate for LED lamps in 2018.

³⁹ National Renewable Energy Laboratory, *Uniform Methods Protocol Chapter 6: Residential Lighting Evaluation Protocol*, February 2014, pp. 6-20.

⁴⁰ National Renewable Energy Laboratory. 4.1.2. *In-service Rates*. <http://ump.pnnl.gov/showthread.php/4839-4.12-In-Service-Rate> (Last accessed February 16, 2014).

Unitary Savings

The unitary savings values were revised according to the displaced wattage of 23.5 W for LED A-type lamps, 39.0 W for R, BR and decorative lamps, and 45.3 W for other LED Non-A-type lamps. The estimated hours of operation remained at 2.9 hours per day. Using the general lighting equation, the unitary savings values for LED A-type and Non-A-type lamps are 24.9 kWh, 41.3 kWh and 48.0 kWh respectively.

7.1.2 LED Recessed Downlight Fixtures

Tracked Savings

ENS uses a unitary savings value of 54.8 kWh per year for recessed downlight fixtures sold through Instant Savings. This value is drawn from the 2016 evaluation and was determined by using the abovementioned general lighting equation.

ENS uses a displaced wattage of 51.8 W, which represents the difference between the old wattage of 61.3 W and the new wattage of 9.5 W. The new wattage was determined using the LED wattage values in the 2016 tracking sheet for the 10 most popular products. The baseline wattage was determined as the weighted averages of equivalent incandescent or halogen lamp wattages specified by the manufacturer. Also, ENS uses a daily hours of operation value of 2.9 based on the NERHOU study.⁴¹

Revised Savings

The Evaluator reviewed the unitary savings value associated with LED recessed downlight fixtures.

Displaced Wattage

To establish the displaced wattage of each category of lighting fixture in Instant Savings, the 10 best-selling models in the 2017 tracking sheet were identified. Wattage value data of these models was then gathered on the participating retailers' websites and their incandescent or halogen wattage equivalent (as recommended by the manufacturers). This value was then converted into a wattage value that meets the current energy efficiency regulation requirements for general service lamps.

The 10 best-selling models of LED recessed downlight fixtures represent over 73 percent of all recessed LED lamps sold. Most fixtures house reflector lamps for which the baseline is a halogen lamp. Some LED downlight fixtures house BR type lamps; since this type is not included in the relevant federal regulation, the baseline used was the recommended equivalent incandescent wattage.

The analysis indicated that the average wattage value for these fixtures is 9.3 W and the average equivalent wattage for the replaced halogen and incandescent lamps is 54.5 W. As a result, the displaced wattage is established at 45.2 W.

⁴¹ NMR Group Inc. and DNV GL, *Northeast Residential Lighting Hours-of-Use Study*, May 5, 2014, p. 69.

Hours of Operation

Similar to LED lamps, the Evaluator concluded that the hours of operation value of LED lamps from the 2014 NERHOU Study (2.9 h/day) is still valid for LED recessed downlight fixtures and all other types of LED fixtures sold through Instant Savings, with the exception of those equipped with motion sensors.

Unitary Savings

The unitary savings value was revised according to the displaced wattage of 45.2 W. The estimated hours of operation remained at 2.9 hours per day. Using the general lighting equation, a new unitary savings value was established at 47.8 kWh per year for all the LED recessed downlight fixtures sold through Instant Savings.

7.1.3 ENERGY STAR Certified LED Fixtures Without a Motion Sensor

Tracked Savings

For ENERGY STAR certified LED fixtures without a motion sensor, ENS uses a unitary savings value of 82.2 kWh per year based on the 2016 evaluation. This value was determined by using a displaced wattage of 77.7 W, which represents the difference between the old wattage of 103.6 W and the new wattage of 25.9 W. The new wattage was established by using the wattage values of the 10 best-selling models of ENERGY STAR certified LED fixtures without a motion sensor. The baseline wattage was determined as the weighted averages of equivalent incandescent lamp wattages specified by the manufacturer and converted by using the current energy efficiency regulation requirements for general service lamps. ENS uses a daily hours of operation value of 2.9 based on the NERHOU study.⁴²

Revised Savings

The Evaluator reviewed the unitary savings value associated with ENERGY STAR certified LED fixtures without a motion sensor.

Displaced Wattage

The Evaluator selected the 10 most popular models, which represent 77 percent of all 2017 ENERGY STAR certified LED fixture sales. Some of those fixtures were used to replace fluorescent lamps. In these cases, a ballast factor of 0.88 was applied to the fluorescent wattage equivalent found on participating retailers' websites. The other selected fixtures replaced general-use lamps. For some fixtures, information concerning the equivalent wattage was not available, so the Evaluator used the light output measured in lumens found on manufacturers' websites and used a table from the ENERGY STAR website to establish the equivalent incandescent wattage (see Table 52 below). Then, the equivalent incandescent wattage was converted by using the current energy efficiency regulation requirements for general service lamps.

⁴² NMR Group Inc. and DNV GL, *Northeast Residential Lighting Hours-of-Use Study*, May 5, 2014, p. 69.

Table 52: ENERGY STAR® Certified Lamp Light Output Equivalency to Incandescent Lamp Wattage⁴³

Old Incandescent Lamps (W)	ENERGY STAR Certified Lamp Light Output (Lumens)
40	450
60	800
75	1,100
100	1,600
150	2,600

This analysis indicates that for replaced lamps the average wattage value is 21.4 W and the average equivalent wattage is 102.0 W. Thus, the displaced wattage was established at 80.6 W.

Unitary Savings

Using the displaced wattage and hours of use of 2.9 h/day, the unitary savings value for ENERGY STAR certified LED fixtures not equipped with a motion sensor was revised at 85.3 kWh per year.

7.1.4 ENERGY STAR Certified LED Fixtures Equipped With a Motion Sensor

Tracked Savings

For ENERGY STAR certified LED fixtures equipped with a motion sensor, ENS uses a unitary savings value of 273 kWh per year based on the 2016 evaluation.

ENS uses an old wattage of 179.7 W and a new wattage of 36 W, resulting in a displaced wattage of 143.7 W. These values were established by using the wattage values and the equivalent halogen lamp wattages of all four models of ENERGY STAR certified LED fixtures equipped with a motion sensor and sold through Instant Savings in 2016. The old and new hours of operation values used by ENS are 4.75 and 2.95 hours per day respectively, as defined in the Ontario Power Authority (OPA) 2011 Prescriptive Measures and Assumptions.⁴⁴

Revised Savings

The Evaluator reviewed the unitary savings value associated with ENERGY STAR certified LED fixtures equipped with a motion sensor.

⁴³ ENERGY STAR, *Learn About Brightness*, https://www.energystar.gov/products/lighting_fans/light_bulbs/learn_about_brightness (Last accessed January 04, 2018).

⁴⁴ Ontario Power Authority (OPA), *2011 Prescriptive Measures and Assumptions Version 1*, March 2011.

Displaced Wattage

The Evaluator analyzed four of the five models⁴⁵ of ENERGY STAR certified LED fixtures equipped with a motion sensor sold through Instant Savings (accounting for 97% of all products sold in this category) and found that more than 99 percent of these fixtures housed LED lamps that replaced halogen lamps.

This analysis indicates that the average wattage value for the new LED fixtures is 35.9 W and the average equivalent wattage is 179.7 W. Using these values, the displaced wattage was established at 143.8 W.

Hours of Operation

The Evaluator did not identify any reliable metering study that reported the hours of use associated with motion sensors in residential settings. Since the large majority of the ENERGY STAR certified LED fixtures equipped with a motion sensor are installed outdoors, as was the case in 2016, the old operating time of 4.75 hours per day and a new operating time of 2.95 hours per day remain adequate. Further information about outdoor motion sensors is discussed in Appendix VII.

Unitary Savings

Using the aforementioned displaced wattage and hours of use values, the unitary savings for ENERGY STAR certified LED fixtures equipped with a motion sensor was revised to 273 kWh per year.

7.1.5 Efficient Refrigerators

Tracked Savings

ENS used a unitary savings value of 104 kWh per year for efficient refrigerators sold through Instant Savings before June, and updated this value to 44 kWh per year for the second half of the year as a result of applying the new regulation as the baseline starting in June 2017. The value of 104 kWh per year corresponds to the 2016 evaluation results for ENERGY STAR certified refrigerators, which were based on the following parameters:

- › An average annual energy consumption of 401 kWh for ENERGY STAR certified refrigerators, obtained from the ENERGY STAR website⁴⁶ for the ten most popular models sold through Instant Savings in 2016.

⁴⁵ One model was excluded from the analysis since no information was available on this product.

⁴⁶ ENERGY STAR, *ENERGY STAR Certified Residential Refrigerators*, <https://www.energystar.gov/productfinder/product/certified-residential-refrigerators/> (Last accessed December 1, 2016).

- › An average annual energy consumption for standard refrigerators estimated at 505 kWh, which is based on the Canadian Energy Efficiency Standard in effect until June 2017.⁴⁷ It corresponds to the average maximum annual energy consumption based on the type of refrigerator and adjusted volume calculated for the top 10 most popular models sold in 2016.

The value of 44 kWh was obtained with the same methodology, but the new regulation was used to establish the average annual energy consumption for standard refrigerators.

Revised Savings

Because a new regulation came into effect in June 2017, the Evaluator analyzed all available models sold by participating retailers as of early June 2017 and concluded that an energy consumption value based on the new regulation should be applied to obtain the unitary savings for refrigerators sold after June 1, 2017. Therefore, the Evaluator used two revised unitary savings values for efficient refrigerators; one was applied to appliances sold before June 1, 2017, and the other to those sold thereafter.

The Evaluator reviewed the average consumption of both standard and ENERGY STAR certified refrigerators to validate the unitary savings value for efficient refrigerators. The 10 most popular models of refrigerators sold through Instant Savings for 2017 were analyzed; these models constitute 77 percent of all 2017 Instant Savings refrigerator sales. The annual energy consumption value of each model was retrieved from the ENERGY STAR website.⁴⁸ Using this data, the weighted average energy consumption of efficient refrigerators was established at 418 kWh. The Evaluator used a single energy consumption value of efficient refrigerators (418 kWh) for all refrigerators sold through Instant Savings since a difference of less than 1 percent was observed between the consumption values before and after June 1, 2017.

The revised standard refrigerator energy consumption was established at 518 kWh per year for the period before June 1, 2017, and at 467 kWh per year thereafter. Both values correspond to the average maximum annual energy consumption based on the type of refrigerator and the adjusted volume calculated for the 10 most popular models.

The unitary savings values before and after the application of the new regulation were respectively estimated at 100 and 49 kWh per year as presented in Table 53.

⁴⁷ Natural Resources Canada, *Refrigerators, Combined Refrigerator-Freezers and Freezers | Energy Efficiency Regulations*, <https://www.nrcan.gc.ca/energy/regulations-codes-standards/6965> (Last accessed December 1, 2016).

⁴⁸ ENERGY STAR, *ENERGY STAR Certified Residential Refrigerators*, <https://www.energystar.gov/productfinder/product/certified-residential-refrigerators/>. (Last accessed January 8, 2018).

Table 53: Revised Unitary Savings Value for Efficient Refrigerators

Parameters	Before June 2017	After June 2017
Base Annual Consumption – Standard Refrigerator	518	467
New Annual Consumption – Efficient Refrigerator	418	418
Annual Unitary Savings	100	49

7.1.6 Efficient Clothes Washers

Tracked Savings

In 2017, ENS used a unitary savings value of 171 kWh per year for efficient clothes washers sold through Instant Savings before June and updated this value to 135 kWh per year for the second half of the year as a result of applying the new regulation as the baseline starting in June 2017. The value of 171 kWh corresponds to the 2016 evaluation results for ENERGY STAR Most Efficient 2016 clothes washers, which were based on the following parameters:

- › The Modified Energy Factor (MEF) and average capacity, which allowed the Evaluator to estimate the baseline and efficient annual energy consumption for all three components of the washing process, namely water heating, clothes washer drum, and clothes dryer.
- › Adjustments to energy consumption values made to take into account the percentage of clothes washer water that is heated electrically and the cold water washing habits of participants.

Using this methodology, the annual consumption of standard clothes washers before and after the new regulation were established at 541 and 504 kWh respectively, while the consumption of efficient clothes washers was set at 370 kWh for both scenarios, which led to unitary savings values of 171 and 135 kWh/year respectively.

Revised Savings

The Evaluator used the same general methodology as in previous evaluations to revise the savings generated by efficient clothes washers. Since the new regulation became the baseline for clothes washers starting in June 2017, the Evaluator planned to use two different unitary savings values for this product. However, the Evaluator analyzed the average efficiency, which is expressed by the Integrated Modified Energy Factor (IMEF)⁴⁹, for models not meeting the ENERGY STAR Most Efficient 2016 criteria but that are in the list of compliant models from the Natural Resources Canada Energy Efficiency Ratings directory, at two point in time, namely January 2017 (average MEF of 56.0) and January 2018 (average IMEF of 55.1), and concluded that the variation is not significant enough to apply different unitary savings for the period before and after the new regulation. Therefore, a single unitary savings value was applied to efficient clothes washers sold through Instant Savings in 2017 based on the Natural Resources Canada list of compliant models obtained in January 2018.

⁴⁹ The new Canadian regulations now use IMEF as a measure of energy efficiency instead of MEF.

The 10 most popular models sold through Instant Savings were identified based on the data in the tracking sheet. These models constitute 88 percent of all 2017 Instant Savings clothes washer sales. The Evaluator consulted the ENERGY STAR Certified Residential Clothes Washers database⁵⁰ to establish the IMEF and capacity for each model. To determine the annual energy use of clothes washers, the following equation was used:

$$\text{Clothes washer consumption} = \frac{\frac{\text{Loads}}{\text{Year}} * \text{Capacity}}{\text{IMEF}}$$

In this equation, capacity is the volume of clothes washers in litres, and the number of loads per year is assumed to be 290 which was the value used in the 2016 evaluation based on a survey conducted to evaluate the Hydro-Québec ENERGY STAR certified appliances program. For efficient washers, the weighted average based on the frequency of each model yielded an IMEF value of 81.9 L/kWh/cycle and a capacity of 125 L. Therefore, the annual consumption value for efficient models was established at 443 kWh.

To estimate the baseline consumption of standard clothes washers, the Evaluator used the same capacity as for efficient clothes washers and established the average IMEF values of non-ENERGY STAR Most Efficient 2016 clothes washers (excluding compact models) using the Natural Resources Canada Energy Efficiency Ratings directory from January 2018, as aforementioned.⁵¹ Using the IMEF value of 55.1, the number of loads per year of 290 and the capacity of 125 L, the annual consumption for standard clothes washers was established at 658 kWh.

The same algorithm used in previous years was applied to establish electricity savings. First, the energy consumption of both efficient and standard clothes washers was broken down for each stage of the washing process, as presented in Table 54, in order to apply correction factors separately to each stage.

⁵⁰ ENERGY STAR, *ENERGY STAR Certified Residential Clothes Washers*, <https://www.energystar.gov/productfinder/product/certified-clothes-washers/> (Last accessed January 8, 2018).

⁵¹ Natural Resources Canada, *Search: Clothes Washers | Energy Efficiency Ratings*, <http://oee.nrcan.gc.ca/pml-imp/index.cfm?action=app.search-recherche&appliance=CLOTHESWASHERS>. (Last accessed January 8, 2018).

Table 54: Energy Consumption Breakdown for Standard and Efficient Clothes Washers

Energy Consumption Breakdown for Clothes Washers	Proportion of Overall Consumption ⁵²	Standard Clothes Washer Electricity Consumption (kWh)	Efficient Clothes Washer Electricity Consumption (kWh)
Water Heating System	24.8%	163	110
Clothes Dryer	68.1%	448	302
Clothes Washer Drum	7.1%	47	31
Total	100.0%	658	443

To estimate the savings attributable to water-heating system energy consumption, the Evaluator calculated the percentage of electrically heated water as presented in Table 55. First, the percentage of non-ENERGY STAR Most Efficient 2016 clothes washers with an internal electric heater was obtained from the Energy Efficiency Ratings directory. This same percentage was applied to efficient clothes washers. Where an internal heater was present, it was assumed that 100 percent of the water heating savings were to be claimed.

For clothes washers using a domestic hot water (DHW) tank as heating source, the proportion of electrical DHW tanks in Nova Scotia was used to calculate the overall proportion of electrically heated water for both standard and efficient clothes washers. The Evaluator reviewed the proportions of electrical DHW tanks used in 2016 since discrepancies were found between the values provided on the Natural Resource Canada website and the proportion of participants with electrical DWH tanks observed in other ENS programs; the percentage of electrical water heaters in Nova Scotia provided by Natural Resource Canada was significantly lower than the value obtained from Efficient Product Installation (EPI) participants for instance, which is of approximately 70 percent. Natural Resource Canada provided more recent data (not yet published) which are closer to what is observed in the other ENS programs. Therefore, these values were updated, increasing both the energy consumption of the standard and efficient clothes washers, and thus the energy savings as well.

Table 55: Water Heating Sources for Clothes Washers

Source of Hot Water for Clothes Washers	Clothes Washer Water Heating	DHW Tank Type	Proportion	Clothes Washer Energy Source
Internal Electrical Heater	25%	-	-	25.0%
DHW Tank	75%	Electrical	67%	50.3%
		Non-electrical	33%	24.7%

⁵² Ad Hoc Recherche, *Rapport d'évaluation, Programme : Produits Mieux Consommer – Électroménagers Energy Star (Années 2008 et 2009)*, p. 18.

By adding the proportion of internal electrical heaters to the proportion of electrical DHW tanks, the proportion of electrical water heating was established at 75.3 percent of total water-heating energy consumption by clothes washers.

For water-heating consumption, an adjustment factor for cold water washing was applied, as in the 2016 calculation. Thus, to account for the usage of cold water for washing, the water-heating energy consumption value was multiplied by a factor of 0.67 (1-33% = 67%).

Table 56 and Table 57 present the calculations of the total electricity consumption for both standard and efficient clothes washers.

Table 56: Electricity Consumption for Standard Clothes Washers

Energy Consumption Component	Energy Consumption	Electricity Consumption (kWh)	Adjustment Factor	Adjusted Electricity Consumption (kWh)
Water-heating System	163	123	0.67	82
Internal Clothes Dryer	448	448	-	448
Washing Machine Drum	47	47	-	47
Total	658	618	-	577

Table 57: Electricity Consumption for Efficient Clothes Washers

Energy Consumption Component	Energy Consumption (kWh)	Electricity Consumption (kWh)	Adjustment Factor	Adjusted Electricity Consumption (kWh)
Water-heating System	110	83	0.67	56
Internal Clothes Dryer	302	302	-	302
Washing Machine Drum	31	31	-	31
Total	443	416	-	389

Therefore, the average electricity consumption value was established at 577 kWh for a standard clothes washer and 389 kWh for an efficient clothes washer. As a result, the unitary savings were established at 188 kWh.

7.1.7 ENERGY STAR Certified Room Air Purifiers

This measure consists of the purchase and installation of a room air purifier, also called a room air cleaner, that meets ENERGY STAR specifications instead of a non-ENERGY STAR qualified model. This is a new measure this year and is part of the pilot. ENS tracked a unitary savings of 372 kWh per year based on an early estimate by the Evaluator.

The minimum requirements for an ENERGY STAR certified room air cleaner are:

- › Produce a minimum Clean Air Delivery Rate (CADR) of 50
- › Minimum performance requirement of 2.0 CADR per W
- › Standby power requirement of 2.0 W

Evaluated Savings

The literature review conducted by the Evaluator revealed that most jurisdictions (Massachusetts,⁵³ Illinois,⁵⁴ Mid-Atlantic,⁵⁵ Rhode Island⁵⁶ and Maine⁵⁷) use the following algorithm to calculate the unitary savings of room air purifiers.⁵⁸

This algorithm is based on the Savings Calculator for ENERGY STAR Qualified Appliances.

$$\begin{aligned}
 \text{Unitary Savings } \left[\frac{kWh}{\text{year}} \right] &= \left[\text{CADR} \left[\text{CADR} \right] \times \left(\frac{1}{EF_{\text{base}}} - \frac{1}{EF_{\text{eff}}} \right) \left[\frac{W}{\text{CADR}} \right] \times \text{Hours} \left[\frac{\text{hours}}{\text{year}} \right] + (SBP_{\text{base}} - SBP_{\text{eff}}) [W] \right. \\
 &\quad \left. \times (8,760 - \text{Hours}) \left[\frac{\text{hours}}{\text{year}} \right] \right] \times \frac{1 \text{ kW}}{1,000 \text{ W}}
 \end{aligned}$$

Where:

- › CADR: Clean Air Delivery Rate (CADR)⁵⁹
- › EFbase: Efficiency for baseline unit (CADR/W)
- › EFeff: Efficiency for efficient unit (CADR/W)
- › Hours: Annual operating hours (hours/year)
- › SBPbase: Standby power for baseline unit (W)
- › SBPeff: Standby power for efficient unit (W)

⁵³ Massachusetts Electric and Gas Energy Efficiency Program Administrators, *Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures, 2016-2018 Program Years – Plan Version*, October 2015, p.160.

⁵⁴ Illinois Energy Efficiency Stakeholder Advisory Group, *Illinois Statewide Technical Reference Manual for Energy Efficiency Version 6.0, Volume 3*, February 2017, p.5.

⁵⁵ Northeast Energy Efficiency Partnerships, *Mid-Atlantic Technical Reference Manual Version 7.0*, May 2017.

⁵⁶ National Grid, *Rhode Island Technical Reference Manual for Estimating Savings from Energy Efficiency Measures – 2016 Program Year*, October 2015, p.207.

⁵⁷ Efficiency Maine, *Retail/Residential Technical Reference Manual Version 2018.1*, July 2017, p.41.

⁵⁸ Environmental Protection Agency. *Savings Calculator for Energy Star Qualified Appliances (2014)*, http://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx (Last accessed November 8, 2017).

⁵⁹ CADR is a widely used measure for room air purifier performance. This metric was developed by the Association of Home Appliance Manufacturers (AHAM) and is measured according to the ANSI/AHAM AC-1 test protocol. It is the rate of particulate contaminant reduction in the test chamber when the room air purifier is turned on, minus the rate of natural decay when the unit is not running, times the volume of the test chamber.

Since climate does not affect room air purifier usage and no study was available on the subject, the Evaluator used the Savings Calculator for ENERGY STAR Qualified Appliances value of 5,840 hours per year (16 hours per day all year long) for annual operating hours.

Currently, the Canadian government has no minimum requirements for room air purifiers. Additionally, retailers and manufacturers rarely provide the efficiency of room air purifiers, which prevented the Evaluator from identifying reliable baseline efficiency and standby power values. Therefore, the Evaluator used baseline efficiency and standby power values of 1 CADR per watt and 1 watt respectively, values based on the Savings Calculator for ENERGY STAR Qualified Appliances which is commonly referred to in other jurisdiction TRMs.

Using the ENERGY STAR list of compliant models⁶⁰ (which provides the energy data of these products) and the tracking sheet, the Evaluator calculated a weighted-average clear air delivery rate (CADR), efficiency and standby power for air purifiers purchased through Instant Savings based on all models sold. The efficient case average CADR, efficiency, and standby power were established at 125 CADR, 2.9 CADR per watt, and 0.6 W respectively. With annual operating hours of 5,480 hours per year, the annual consumption of an ENERGY STAR certified air purifier was established at 253 kWh.

Using a 125 CADR, an efficiency of 1 CADR per watt, a standby power of 1 watt and annual operating hours of 5,840 hours per year, the annual consumption of a standard air purifier was established at 733 kWh.

The Evaluator therefore used unitary savings of 480 kWh per year for the room air purifiers sold.

7.1.8 ENERGY STAR Certified Dehumidifiers

This measure consists of the purchase and installation of a new ENERGY STAR certified dehumidifier instead of a new code-compliant or standard efficiency dehumidifier. This is a new measure this year and is part of the pilot. ENS tracked a unitary savings of 217 kWh per year based on an early estimate by the Evaluator.

The ENERGY STAR specifications require a minimum energy factor of 2.0 litres per kWh for dehumidifiers with capacities measuring less than or equal to 35.5 litres per day and a minimum energy factor of 2.8 litres per kWh for dehumidifiers with daily water-removal capacities up to 87.5 litres per day.⁶¹

⁶⁰ ENERGY STAR, *Certified Products – Find and Compare Products – Room Air Cleaners*, <https://www.energystar.gov/productfinder/product/certified-room-air-cleaners/> (Last accessed August 11, 2017).

⁶¹ ENERGY STAR, *ENERGY STAR® Program Requirements Product Specification for Dehumidifiers – Eligibility Criteria 4.0*, [https://www.energystar.gov/sites/default/files/ENERGY%20STAR Dehumidifiers V4%20 Specification Final 1.pdf](https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Dehumidifiers%20V4%20Specification%20Final%201.pdf) (Last accessed August 2017).

Evaluated Savings

Since the ARet program component, through HomeWarming, provides incentives for dehumidifier replacements, the same methodology was used to calculate savings for this product through Instant Savings. However, the baseline scenarios of Instant Savings and ARet differ; the ARet baseline scenario is the old unit replaced, while the Instant Savings baseline scenario is a new standard unit. Therefore, the algorithm was adjusted to factor in the appropriate baseline.

$$\text{Unitary savings } \left[\frac{\text{kWh}}{\text{year}} \right] = \left(\text{Average water removal volume } \left[\frac{\text{L}}{\text{day}} \right] \times \right. \\ \left. \text{Average operating days } \left[\frac{\text{days}}{\text{year}} \right] \right) \times \left(\frac{1}{\text{Energy Factor standard dehumidifier}} - \right. \\ \left. \frac{1}{\text{Energy factor ENERGY STAR dehumidifier}} \right) \left[\frac{\text{kWh}}{\text{L}} \right]$$

The Evaluator used an average water removal volume of 3.87 L/day and an average of 168 operating days per year, based on the 2011 Ontario Power Authority Prescriptive Measures and Assumptions report.⁶² These parameters are considered more accurate than parameters based on theoretical studies since they are based on field activities such as metering.

Using the tracking sheet and the list of products displaying the ENERGY STAR symbol⁶³ (which provides the energy factor of these products), the Evaluator established a weighted average water removal capacity⁶⁴ of 25.5 L/day for the dehumidifiers purchased through Instant Savings.

Since October 2012, the Canadian regulations⁶⁵ have required a minimum energy factor of 1.6 L/kWh for dehumidifiers with a rated water removal capacity between 21.3 and 25.5 L/day. Therefore, the Evaluator used 1.6 L/kWh for the standard unit energy factor.

ENERGY STAR certified dehumidifiers on the Canadian market with a water removal capacity of less than 35.5 L/day has an energy factor of 2.00 L/kWh or higher as indicated in the ENERGY STAR guidelines for dehumidifiers.⁶⁶ All the models sold through Instant Savings had an energy factor of 2.00 L/kWh. Therefore, the Evaluator used 2.00 L/kWh for the efficient unit energy factor.

Hence, the Evaluator used a unitary savings of 81.3 kWh per year for the purchase of an efficient dehumidifier.

⁶² Ontario Power Authority (OPA). 2011 *Prescriptive Measures and Assumptions*, Release Version 1, March 2011.

⁶³ ENERGY STAR, *Certified Products – Find and Compare Products – Dehumidifiers*, <https://www.energystar.gov/productfinder/product/certified-dehumidifiers/> (Last accessed August 11, 2017).

⁶⁴ The average water removal capacity refers to the amount of water that can be removed from the air during a day if a dehumidifier worked at full capacity with infinite water available in the air, while the average water removal volume is the actual amount of water removed during an average day which was obtained from metering activities conducted for the Ontario Power Authority.

⁶⁵ Natural Resources Canada, *Regulations and Standards – Dehumidifiers*, <http://www.nrcan.gc.ca/energy/regulations-codes-standards/products/6889> (Last accessed August 3, 2017).

⁶⁶ ENERGY STAR, *ENERGY STAR® Program Requirements Product Specification for Dehumidifiers – Eligibility Criteria 4.0*, [https://www.energystar.gov/sites/default/files/ENERGY%20STAR Dehumidifiers V4%20 Specification Final 1.pdf](https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Dehumidifiers%20V4%20Specification%20Final%201.pdf) (Last accessed August 2017).

7.1.9 ENERGY STAR Certified Bathroom Fans (without a light)

This measure is the purchase and installation of a new ENERGY STAR certified bathroom fan without a light instead of a new standard efficiency fan. It is a new measure this year and is part of the pilot. ENS tracked a unitary savings of 13 kWh per year based on an early estimate by the Evaluator.

The ENERGY STAR specifications require that, for bathroom fans with an airflow rate less than 90 CFM, the minimum efficiency is 2.8 CFM/W, while a minimum efficiency of 3.5 CFM/W applies to units with rated airflow between 90 and 200 CFM.

Evaluated Savings

The Evaluator used the following algorithm to calculate fan unitary savings. This algorithm is based on the ENERGY STAR Simple Savings Calculator⁶⁷ for ventilating fans without lighting and is used in multiple TRMs such as Vermont,⁶⁸ Illinois⁶⁹ and Mid-Atlantic.⁷⁰

$$\begin{aligned}
 \text{Unitary savings } \left[\frac{kWh}{\text{year}} \right] &= CFM \left[\frac{ft^3}{min} \right] \times \left(\frac{1}{\text{Efficiency}_{\text{baseline}}} - \frac{1}{\text{Efficiency}_{\text{efficient}}} \right) \left[\frac{W}{\frac{ft^3}{min}} \right] \times \text{Hours} \left[\frac{\text{hours}}{\text{year}} \right] \\
 &\times \frac{1 \text{ kW}}{1000 \text{ W}}
 \end{aligned}$$

Where:

- › CFM: Nominal capacity of the exhaust fan (CFM or ft³/min)
- › Efficiency_{baseline}: Average efficiency of the baseline fan (CFM/W)
- › Efficiency_{efficient}: Average efficiency of the efficient fan (CFM/W)
- › Hours: Annual operating hours (hours/year)

The Evaluator assumed annual operating hours of 360 hours per year based on the Electric Usage Chart Tool of Efficiency Vermont.⁷¹ These operating hours represent one hour of daily usage, which the Evaluator considered realistic.

⁶⁷ Natural Resources Canada, *CANADA'S ENERGY STAR Simple Savings Calculator (v11.3)*, February 2017, <http://oee.nrcan.gc.ca/residential/business/energystar/procurement/calculator.cfm> (Last accessed November 29, 2017).

⁶⁸ Efficiency Vermont, *Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions*, March 2015, p.52.

⁶⁹ Illinois Energy Efficiency Stakeholder Advisory Group, *Illinois Statewide Technical Reference Manual for Energy Efficiency Version 6.0, Volume 3*, February 2017, p.123.

⁷⁰ Northeast Energy Efficiency Partnerships, *Mid-Atlantic Technical Reference Manual Version 7.0*, May 2017, p.136.

⁷¹ Efficiency Vermont, *Electric Usage Chart Tool*, www.efficiencyvermont.com/tips-tools/tools/electric-usage-chart-tool (Last accessed August 11, 2017).

Using the ENERGY STAR list of compliant models⁷² and the tracking sheet, the Evaluator calculated a weighted average efficiency level and a nominal exhaust fan capacity based on all efficient fan models sold through Instant Savings, which resulted in 4.66 CFM/W and 99.1 CFM respectively.

To determine the average standard fan efficiency, the Evaluator applied a reduction factor of 50 percent to the average efficient fan efficiency, based on the information provided on the ENERGY STAR website. ENERGY STAR estimates that an ENERGY STAR certified ventilating fan uses on average 50 percent less energy than a standard unit.⁷³ Therefore, the efficiency of standard fans was established at 2.33 CFM/W.

Using the parameters presented above, the annual consumption of a standard and efficient bathroom fan were established at 15.5 and 7.65 kWh per year respectively. Therefore, unitary savings of 7.85 kWh per year were used by the Evaluator for the purchase of an efficient bathroom fan.

7.1.10 Summary of Unitary Savings

Table 58 summarizes the tracked and revised savings values for each product category rebated through Instant Savings.

⁷² ENERGY STAR, *Certified Products – Find and Compare Products – Ventilating Fans* <https://www.energystar.gov/productfinder/product/certified-ventilating-fans/> (Last accessed January 8, 2018)

⁷³ ENERGY STAR, *Ventilating Fans*, <http://www.nrcan.gc.ca/energy/products/categories/cooling-ventilating/ventilating/fans/16201> (Last accessed November 28, 2017).

Table 58: Summary of Tracked and Revised Unitary Savings Values

Product	Tracked Savings (kWh/yr)	Revised Savings (kWh/yr)
LED A-type Lamps	26.4	24.9
LED Non A-type Lamps (R, BR and Decorative)	46.7	41.3
LED Non A-type Lamps (excluding R, BR and Decorative)	46.7	48.0
LED Recessed Downlight Fixtures	54.8	47.8
ENERGY STAR Certified LED Fixtures	82.2	85.3
ENERGY STAR Certified LED Fixtures with Motion Sensors	273	273
Dimmer Switches	17.0	17.0
Indoor Motion Sensors	45.8	45.8
Indoor Motion Sensors with Dimmer Switches	53.6	53.6
Outdoor Motion Sensors	159	159
Power Bars with Integrated Timers	53.7	53.7
Load Sensing Power Bars (Smart Strips)	53.8	53.8
Heavy-duty Outdoor Timers	122	122
Programmable Thermostats	221	221
Clotheslines and Outdoor Drying Racks	150	150
Efficient Refrigerators (before June)	104	100
Efficient Refrigerators (after June)	44.0	49.0
Efficient Clothes Washers (before June)	171	188.0
Efficient Clothes Washers (after June)	135	188.0
ENERGY STAR Certified Room Air Purifiers	372	480
ENERGY STAR Certified Dehumidifiers	217	81.3
ENERGY STAR Certified Bathroom Fans (without a light)	13	7.85

7.1.11 Peak Demand Savings

The peak demand savings correspond to the demand savings that coincide in time with the peak demand of the electricity system. The projected electricity peak demand period in Nova Scotia is between 5 p.m. and 7 p.m. from December to February on a non-holiday weekday.

For Instant Savings, the peak demand savings were calculated using the on-peak demand-to-energy ratios developed by Navigant in the 2016-2018 DSM Plan. These ratios were established for various measure categories, based on modelled system-coincident peak demand savings and energy savings for a projected deployment of measures. Navigant used local data to establish the ratios for 2017. The Evaluator considers that the approach used by Navigant to establish the on-peak demand-to-energy ratios is valid. Therefore, these ratios were used to estimate peak demand savings for Instant Savings, except for the following: lighting products for which measured data obtained from the 2017 EPI Residential Lighting Metering Study was compared to values found in the literature; outdoor motion sensors, clotheslines and drying racks; as well as some of the pilot products for which no ratios were calculated in the Navigant model.

The metering study analyzed the HOU values specifically for the peak demand period of the electricity system for each room type. The results revealed that the peak demand-to-energy ratio previously used for residential lighting (0.249 W/kWh) was higher than the average value established at 0.161 W/kWh $\pm$ 0.016 W/kWh in 2017. The Evaluator compared these results with those from the NERHOU study which obtained a result corresponding to a peak-demand-to-energy ratio of 0.162 W/kWh (with a peak coincidence factor of 16% and 2.7 hours of use per day⁷⁴). The Evaluator recommends using this result as it is very close to the 0.161 W/kWh obtained in the Residential Lighting Metering Study. In addition, the margin of error in the NERHOU study was 1 percent, which is lower than the 10 percent obtained in the Residential Metering study. Furthermore, the sample also includes outdoor lamps thus eliminating the need to make assumptions for calculating their specific peak-demand-to-energy ratio. Therefore, the Evaluator recommends applying the NERHOU study result of 0.162 W/kWh to all indoor and outdoor lamps.

The Evaluator assumed a ratio of zero for clotheslines and outdoor drying racks since these products are not likely used during winter. In the case of outdoor motion sensors, it is assumed that most movement around the house occurred around the peak demand period. Therefore, the peak demand savings during this period are minimal because the lights are turned on most of the time with or without the motion sensor. Consequently, the on-peak demand-to-energy ratio is set at zero.

The Evaluator also calculated the on-peak demand-to-energy ratios of the new pilot products. For room air purifiers, which run approximately 16 hours per day, the Evaluator assumed that this product runs during the peak period. Therefore, an on-peak demand-to-energy ratio of 0.171 was established based on annual operating hours of 5,840. For bathroom fans, which operate one hour per day on average, the Evaluator assumed that those fans run in the morning and the evening. A peak coincident factor of 10 percent was established for bathroom fans, leading to an on-peak demand-to-energy ratio of 0.278 with an annual runtime of 360 hours.

⁷⁴ The peak coincidence factor in the NERHOU study are only available for all lamps, and not specifically for efficient lamps. Therefore the Evaluator relied on this value even though the HOU value is slightly lower than that used for Instant Savings lamps and fixtures.

Table 59 presents the on-peak demand-to-energy ratios established for each product category.

Table 59: Peak Demand-to-energy Ratios by Product Type

Type of Product	Peak Demand-to-energy Ratio	Peak Demand-to-energy Ratio Category
Lighting Products (LED Lamps, LED Recessed Downlight Fixtures, ENERGY STAR Certified LED Fixtures With or Without Motion Sensors, and Dimmer Switches)	0.162	Northeast Residential Lighting Hours-of-Use Study
Indoor Motion Sensors	0.000	RES-Lighting-Controls-OccSensors
Indoor Motion Sensors with Dimmer Switches	0.000	RES-Lighting-Controls-OccSensors
Outdoor Motion Sensors	0.000	Calculated by the Evaluator
Power Bars with Integrated Timers	0.000	RES-Plug Load-Controls
Load Sensing Power Bars (Smart Strips)	0.000	RES-Plug Load-Controls
Heavy-duty Outdoor Timers	0.000	RES-Plug Load-Controls
Clotheslines and Outdoor Drying Racks	0.000	Calculated by the Evaluator
Programmable Thermostats	-0.399	RES-HVAC-Controls
Efficient Refrigerators	0.138	RES-Appliance-Fridge
Efficient Clothes Washers	0.138	RES-Appliance-CW
ENERGY STAR Certified Room Air Purifiers	0.171	Calculated by the Evaluator
ENERGY STAR Certified Dehumidifiers	0.335	RES-Appliance-Dehumidifier
ENERGY STAR Certified Bathroom Fans (without a light)	0.278	Calculated by the Evaluator

7.1.12 Interactive Effects

In a home, interactive effects occur when the implementation of energy efficiency measures has an impact on the energy consumption of other elements such as heating and cooling. In the case of Instant Savings, replacing incandescent lighting products with LED lamps causes an increase in the heating load in the winter and a decrease in the cooling load in the summer.

In 2015, the Evaluator performed a literature review of the interactive effects calculation methodology. The objective was to update the methodology to include the latest studies and improve precision by taking into consideration additional variables. The literature review revealed that no reliable interactive effects study other than the one currently used by ENS was available. The literature review also indicated that most jurisdictions use separate interactive effects factors for energy savings and peak demand savings. As of 2016, ENS applied different interactive effects factors to the peak demand savings and energy savings.

The interactive effects factors used by ENS for energy savings are based on a methodology developed by the Evaluator in 2015 and are still valid for 2017. As for peak demand savings, the Evaluator changed the methodology to not apply an interactive effects factor for products to which a peak demand-to-energy ratio is applied that already accounts for interactive effects. This change reflects the fact that the peak demand-to-energy ratios developed by Navigant are ratios of peak demand and energy savings values that both account for interactive effects since these were obtained through whole-building energy modelling. Therefore, the interactive effects factors specific to peak demand savings were only applied for products for which peak demand-to-energy ratios were not obtained through whole-building modelling, namely LED lamps, LED recessed downlight fixtures, ENERGY STAR certified LED fixtures, dimmer switches, outdoor motion sensors, clotheslines, outdoor drying racks, room air purifiers, and bathroom fans. The peak demand-to-energy ratios for those products were adjusted so that they can be applied to gross energy savings with interactive effects and result in calculated peak demand savings including interactive effects. The adjusted peak demand-to-energy ratios for those products are presented in Table 62 further below after the presentation of interactive effects calculation results.

The Evaluator updated the percentage of homes electrically heated and air conditioned since more recent data were available from Statistics Canada.

Table 60 lists the interactive effects factors used for lighting products.

Table 60: Interactive Effects Calculation for Lighting Products

Parameter	% of Homes ^{75,76}	Energy Interactive Effects Factor ⁷⁷	Peak Demand Interactive Effects Factor
Electrical Heating With Air Conditioning	$33\% \times 32\% = 11\%$	-54.4%	-90.0%
Electrical Heating Without Air Conditioning	$33\% \times 68\% = 22\%$	-58.0%	-90.0%
No Electrical Heating With Air Conditioning	$67\% \times 32\% = 21\%$	3.6%	0.0%
Neither Electrical Heating Nor Air Conditioning	$67\% \times 68\% = 46\%$	0.0%	0.0%
Weighted Interactive Effects Factor	100%	-18.0%	-29.7%

⁷⁵ The proportions of homes that are air conditioned are drawn from Statistics Canada, *Table 153-0147 - Households and the Environment Survey, Air-conditioners, Canada, Provinces and Census Metropolitan Areas, 2015*, CANSIM, November 13, 2017.

⁷⁶ The proportion of homes that are electrically heated is drawn from Statistics Canada, *Table 153-0145 - Households and the Environment Survey, Primary Heating System, Canada, Provinces and Census Metropolitan Areas, 2015*, CANSIM, November 13, 2017.

⁷⁷ ADS ASSOCIÉS, *Évaluations des effets énergétiques combinés des mesures d'économies d'énergie – résidence unifamiliale*, Report presented to Hydro-Québec, 1992.

These interactive effects occur only when products are installed inside the house. Since LED lamps and ENERGY STAR certified LED fixtures installed through the program component are also used for outdoor lighting, the interactive effects factors for these products were adjusted to take this into account. The proportions of LED lamps installed inside houses and on outdoor sockets were used, as reported in the 2016 Socket Study⁷⁸ in which 1,008 Nova Scotia residents completed the survey. The proportions of ENERGY STAR certified LED fixtures installed indoors and outdoors were determined using the information provided in the tracking sheet, based on whether those products were designed for indoor or outdoor use. As for LED recessed downlight fixtures, the interactive effects factor remains -18.0 percent for energy savings and -29.7 percent for peak demand savings since the Evaluator assumed they are all installed indoors.

Devices controlling lights sold through the program component, i.e. dimmer switches and indoor motion sensors, also cause interactive effects similar to efficient lamps and were therefore considered. The Evaluator used the same interactive effects factor as lighting products.

Table 61 presents the interactive effects factors for LED products.

Table 61: Interactive Effects Factors for LED Lamps and Fixtures and Other Indoor Devices

Category of Product	Indoor %	Outdoor %	Energy Interactive Effects Factor	Peak Demand Interactive Effects Factor
LED Lamps	92%	8%	$92\% \times -18.0\% + 8\% \times 0\%$ = -16.6%	$92\% \times -29.7\% + 8\% \times 0\%$ = -27.3%
LED Recessed Downlight Fixtures	100%	0%	-18.0%	-29.7%
ENERGY STAR Certified LED Fixtures Without Motion Sensors	86%	14%	$86\% \times -18.0\% + 14\% \times 0\%$ = -15.5%	$86\% \times -29.7\% + 14\% \times 0\%$ = -25.5%
ENERGY STAR Certified LED Fixtures With Motion Sensors	3%	97%	$3\% \times -18.0\% + 97\% \times 0\%$ = -0.5%	$3\% \times -29.7\% + 97\% \times 0\%$ = -0.9%
Dimmer Switches	100%	0%	-18.0%	-29.7%
Indoor Motion Sensors	100%	0%	-18.0%	-29.7%
Indoor Motion Sensors with Dimmers	100%	0%	-18.0%	-29.7%

The interactive effects factors were then integrated to the peak demand-to-energy ratios for lighting products as shown in Table 62 below.⁷⁹

⁷⁸ Corporate Research Associates Inc., *2016 Socket Study*, Final Report Prepared for Efficiency Nova Scotia, December 2016.

⁷⁹ Adjusted peak demand-to-energy ratio = peak demand-to-energy ratio $\times$ (1 + interactive effects factor for peak demand savings) / (1 + interactive effects factor for energy savings).

Table 62: Adjusted Peak Demand-to-energy Ratios by Lighting Product Type

Type of Product	Peak Demand-to-energy Ratio	Interactive Effects Factor for Energy Savings	Interactive Effects Factor for Peak Demand Savings	Adjusted Peak Demand-to-energy Ratio
LED Lamps	0.162	-16.6%	-27.3%	0.141
LED Recessed Downlight Fixtures	0.162	-18.0%	-29.7%	0.139
ENERGY STAR Certified LED Fixtures Without Motion Sensors	0.162	-15.5%	-25.5%	0.143
ENERGY STAR Certified LED Fixtures With Motion Sensors	0.162	-0.5%	-0.9%	0.161
Dimmer Switches	0.162	-18.0%	-29.7%	0.139

No interactive effects factors were calculated for power bars and outdoor devices sold through the program component, i.e. LED fixtures with motion sensors, outdoor motion sensors, and heavy duty timers.

For refrigerators, since the compressor in this appliance releases heat, replacing an old refrigerator with a more efficient unit has the effect of releasing less heat. However, this effect is reduced when the refrigerator is built-in or positioned against an exterior wall. Given that these elements reduce the interactive effects of refrigerator replacements and that only 33 percent of homes in Nova Scotia are electrically heated, the interactive effects associated with the purchase of efficient refrigerators were not integrated into the program component net savings calculations.

For all other products, interactive effects were also considered negligible. Therefore, the other peak demand-to-energy ratios not obtained through whole-building modelling (ENERGY STAR certified LED fixtures with motion sensors, outdoor motion sensors, clotheslines, outdoor drying racks, room air purifiers, and bathroom fans) did not need to be adjusted to account for interactive effects.

7.1.13 Effective Useful Life

As part of the 2017 evaluation, the Evaluator reviewed the EUL values used by ENS in the calculations of energy savings that are expected to persist over time.

The EUL values of all the measures eligible under the program component were reviewed based on the findings of the literature review. When establishing the EUL for a given measure, the Evaluator considered the most common values found in technical reference manuals, evaluation reports or relevant studies.

The EUL obtained from the literature was then adjusted to account for increased baselines throughout the EUL of the measure. This equivalent EUL therefore corresponds to the number of years by which the first-year savings estimate is multiplied to obtain lifetime energy savings.

Table 63 below lists the tracked and the revised equivalent EUL values by measure category.

Table 63: Summary of Effective Useful Life Values by Measure Category

Measure	ENS Tracked EUL	Revised Equivalent EUL	Reference
LED Lamps A-Type	16.7	9	Analysis of EE regulations (see the explanation below)
LED Lamps Non-A-Type (R, BR and Decorative)	16.7	8	Analysis of EE regulations (see the explanation below)
LED Lamps Non-A-Type (Excluding R, BR and Decorative)	16.7	9	Analysis of EE regulations (see the explanation below)
LED Recessed Downlight Fixtures	20	9	Analysis of EE regulations (see the explanation below)
LED Fixtures Without Motion Sensors	20	10	Analysis of EE regulations (see the explanation below)
LED Fixtures With Motion Sensors	20	9	Analysis of EE regulations (see the explanation below)
Dimmer Switches	10	10	IESO PMA List ⁸⁰
Indoor Motion Sensors	8	10	GDS Measure Life Report, Table 1; value for occupancy sensor ⁸¹
Indoor Motion Sensor With Dimmer Switches	8	10	Motion Sensor and Dimmer Switch EUL
Outdoor Motion Sensors	10	10	IESO PMA List
Power Bars With Integrated Timers	4	4	Power Smart Engineering ⁸²
Load Sensing Power Bars (Smart Strips)	4	4	Power Smart Engineering
Heavy-duty Outdoor Timers	10	10	IESO PMA List
Clotheslines and Outdoor Drying Racks	10	10	IESO PMA List
Programmable Thermostats	10	10	GDS Measure Life Report, Table 1; value for residential programmable thermostats
Efficient Refrigerators	12	12	ENERGY STAR Calculator, EPA Research, value for refrigerators ⁸³
Efficient Clothes Washers	14	14	DOE Life-Cycle Cost and Payback Period tool ⁸⁴

⁸⁰ Independent Electricity System Operator, *IESO Prescriptive Measures and Assumptions List*, October 2015.

⁸¹ GDS Associates, Inc., *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*, Report prepared for the England State Program Working Group, June 2007, Table 1, pp. 1-3.

⁸² David Rogers, PowerSmart Engineering, *Smart Strip Electric Savings Usability*, October 2008, p. 22.

⁸³ U.S. EPA and DOE, *Savings Calculator for ENERGY STAR Qualified Appliances (2016)*, https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx (Last accessed December 4, 2017).

⁸⁴ U.S. Department of Energy, *DOE Life-Cycle Cost and Payback Period tool*, www1.eere.energy.gov/buildings/appliance_standards/residential/clothes_washers_support_stakeholder_negotiations.html (Last accessed May 2017).

Measure	ENS Tracked EUL	Revised Equivalent EUL	Reference
Efficient Room Air Purifiers	9	9	ENERGY STAR Calculator, EPA Research, value for Air Purifier
Efficient Dehumidifiers	12	12	ENERGY STAR Calculator, EPA Research, value for dehumidifiers
Efficient Bathroom Fans (without a light)	N/A	19	GDS Measure Life Report, Table 1; value for thermostatically-controlled attic fans

Based on the literature review findings, the Evaluator concluded that the following measure EUL values tracked by ENS are accurate since these values are used by most of the TRMs consulted or are based on more reliable sources:

- › Dimmer Switches
- › Power Bars with Integrated Timers
- › Load Sensing Power Bars (Smart Strips)
- › Heavy-duty Outdoor Timers
- › Clotheslines and Outdoor Drying Racks
- › Programmable thermostats
- › Efficient Refrigerators
- › Efficient Clothes Washers
- › Efficient Room Air Purifiers
- › Efficient Dehumidifiers

For LED lamps, the Evaluator first calculated the equipment life for each type of lamps as presented in Table 64 below. The equipment life was calculated as the ratio between the manufacturers' rated lifetime hours for the most popular models of lamps installed under Instant Savings and the annual HOU value used to calculate unitary savings values.

Table 64: Equipment Life Value per LED Lighting Product

LED Lighting Product	Average Rated Lifetime Hours (Hours) ⁸⁵	Annual HOU (Hours/Year) ⁸⁶	Equipment Life (Years)
LED Lamps A-Type	18,916	1,059	18
LED Lamps Non-A-Type (R, BR and Decorative)	16,861	1,059	16
LED Lamps Non-A-Type (excluding R, BR and Decorative)	25,000	1,059	24
LED Recessed Downlight Fixtures	39,906	1,059	38
LED Fixtures Without Motion Sensors	35,010	1,059	33
LED Fixtures With Motion Sensors	43,555	1,077	40

The LED lamps market is evolving rapidly and driven by government regulations. LED lamps installed today are likely to become the baseline before the end of their rated life, since LED technologies are developing quickly and prices are falling. Some jurisdictions have already applied a reduced equivalent EUL to their residential lighting savings by adopting a higher baseline to represent savings in future years. In other words, their baseline increases over the lifetime of the product, which in turns reduces the equivalent EUL that is applied to first-year savings to obtain lifetime energy savings. That is the case for Illinois, where savings for LED lamps are considered nil after 10 years, and baselines are adjusted throughout the lifetime to match changes in regulations: for instance, a 60 W incandescent baseline is raised to a 43 W halogen incandescent after the end of the incandescent's remaining useful life and raised again to the minimum efficiency CFL level required by the Energy Independence and Security Act (EISA) 2020 effective in 2021.⁸⁷ Massachusetts also uses a similar methodology and has set the equivalent EUL value at eight to nine years for LED lamps, which takes into account baseline increases that will occur because of EISA 2020.⁸⁸

⁸⁵ Based on the manufacturers' specification sheets for the most popular models installed under Instant Savings.

⁸⁶ Based on the unitary savings review.

⁸⁷ Illinois Energy Efficiency Stakeholder Advisory Group, *Illinois Statewide Technical Reference Manual for Energy Efficiency Version 6.0, Volume 3*, February 2017, p. 258.

⁸⁸ Massachusetts Electric and Gas Energy Efficiency Program Administrators, *Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures, 2016-2018 Program Years – Plan Version*, October 2015, p. 151.

The Canadian market may change less quickly than the American market because Canadian regulations generally lag a few years behind the United States; so, limiting the EUL to 10 years, as done by Illinois, is too conservative. Consequently, the Evaluator used the equipment life of LED A-type lamps as the EUL, thereby avoiding capping since it is uncertain when LED lamps will become the baseline technology on the Canadian market. Like the approach used in Illinois and Massachusetts, the Evaluator applied a triple baseline for LED A-type lamps over their 18-year EUL to find their equivalent EUL that accounts for the following factors:

- › The replaced incandescent light lamps have an estimated remaining useful life of one year. Incandescent light lamps have a typical rated life expectancy of 1,000 to 2,000 hours.⁸⁹ The remaining useful life of replaced functional incandescent light lamps is assumed to be half the rated life expectancy. By applying a remaining useful life of 1,000 hours and 2.9 hours of use per day, the period over which savings can be calculated with an incandescent baseline has been established at one year.
- › The current Canadian regulation bans imports on 60 W, 75 W and 100 W light lamps, imposes a minimum efficiency to be achieved by efficient incandescent light lamps (also called halogen incandescent light lamps),⁹⁰ and reflects U.S. federal legislation (as outlined in the three tables further below). After the first year over which incandescent remain the baseline, the baseline is increased to halogen incandescent lamps.
- › The next anticipated federal regulation expected in the USA will impose an efficiency level of 45 lumens per watt in 2020,⁹¹ as outlined in the three tables further below. The U.S. EISA of 2007 mandates that general-service light lamps must achieve 45 lumens per watt as of January 1, 2020. Considering that Canada's residential lighting market is also evolving rapidly and closely follows trends in the U.S. market, the Evaluator considers it advisable to pay close attention to the anticipated U.S. legislation in establishing the baseline wattage. Natural Resources Canada intends to update the general service lamps minimum energy performance requirement in Amendment 16 which is planned for pre-consultation in 2019⁹² (and should therefore be applied within a few years after 2019). The intent is to align the Canadian regulations with the requirements in force or soon to be in force in the United States, EISA 2020 in the case of general service lighting. Since this regulation would effectively ban the import and fabrication of efficient incandescent light lamps, it is expected that these incandescent light lamps would still be available in retail outlets before stocks are depleted for up to two years after the legislation is implemented.

⁸⁹ Lighting Research Center - Rensselaer Polytechnic Institute, *Lighting Patterns for Homes. Light Bulb Features*, www.lrc.rpi.edu/patternbook/resources/lamp_features.asp (Last accessed January 19, 2018).

⁹⁰ Natural Resources Canada, *Energy Efficiency Regulations. General Service Lamps and Modified Spectrum Incandescent Lamps*, www.nrcan.gc.ca/energy/regulations-codes-standards/products/6869 (Last accessed January 19, 2018).

⁹¹ US EPA, *Summary of the Energy Independence and Security Act. Public Law 110-140 (2007)*, www.epa.gov/laws-regulations/summary-energy-independence-and-security-act (Last accessed January 19, 2018).

⁹² Natural Resources Canada, *Forward Regulatory Plan 2017-19*, <http://www.nrcan.gc.ca/energy/regulations-codes-standards/18318> (Last accessed January 19, 2018).

It should be noted that using the minimum efficiency levels of EISA 2020 starting in 2024 might be optimistic. Since LED lamps are rapidly gaining popularity while CFL market share is declining, it is possible that the baseline for covered lamps will be LED lamps by 2024.⁹³ In that case, savings would occur over a maximum of seven years. However, since it is difficult to determine this with certainty, the Evaluator preferred using the efficiency levels set in the proposed American legislation until the end of the EUL of A-type lamps.

The Evaluator established lifetime energy savings values for early replacement and replace-on-burn-out scenarios, as well as for the different types of lamps replaced. The displaced wattage values used to obtain the lifetime energy savings of each scenario are summarized in Table 65 and Table 66 below.

⁹³ Barclay, D., von Trapp, K. and Miziolek C.,
Party Like It's 2020: EISA Phase 2 – An Examination of DOE Rulemaking and Implications for Programs, Poster presented at the 2017 International Energy Program Evaluation Conference, Baltimore, MD, 2017.

Table 65: Equivalent Effective Useful Life Calculation Summary for LED A-Type Lamps Replaced Early

Type of Lamp Replaced	Incandescent Baseline		Halogen Incandescent Baseline – Canadian Legislation ^{94,95}		CFL Equivalent Baseline – American Legislation ⁹⁶		Lifetime Energy Savings (kWh)	% of Lamps Replaced	Average Lifetime Energy Savings (kWh)
	1 year (2017)		6 years (2018-2023)		11 years (2024-2034)				
	Baseline Wattage	Displaced Wattage	Baseline Wattage	Displaced Wattage	Baseline Wattage ⁹⁷	Displaced Wattage			
Incandescent	61.5 W	51.7 W	44.1 W	34.3 W	18.4 W	8.6 W	373	33%	156
CFL	13.3 W	3.5 W	13.3 W	3.5 W	13.3 W	3.5 W	62	53%	
LED	9.8 W	0 W	9.8 W	0 W	9.8 W	0 W	0	14%	

For replaced lamps that are already CFLs or LED lamps, the changing energy efficiency regulation has no impact on the baseline which remains the same throughout the entire EUL of the measure.

⁹⁴ Natural Resources Canada. “Energy Efficiency Regulations. General Service Lamps and Modified Spectrum Incandescent Lamps”. www.nrcan.gc.ca/energy/regulations-codes-standards/products/6869 (Last accessed January 20, 2018).

⁹⁵ Also equivalent to Incandescent Equivalent 1st Tier EISA 2007.

⁹⁶ As imposed by U.S. federal legislation. Incandescent Equivalent 2nd Tier EISA 2007.

⁹⁷ Baseline wattage values were established based on the minimum efficiency level of 45 lumen/watts dictated by the EISA regulation and on the assumed level of 829 lumens established from a weighted average of the 10 most popular models.

**Table 66: Equivalent Effective Useful Life Calculation Summary
for LED A-Type Lamps Replaced on Burn Out**

Halogen Incandescent Baseline – Canadian Legislation		CFL Equivalent Baseline – American Legislation		Lifetime Energy Savings (kWh)
7 years (2017-2023)		11 years (2024-2034)		
Baseline Wattage	Displaced Wattage	Baseline Wattage	Displaced Wattage	
44.1 W	34.3 W	18.4 W	8.6 W	354

The lifetime energy savings values in Table 65 and Table 66 were weighted by the proportion of each scenario (70% early replacement and 30% replaced on burn out) to obtain an average lifetime energy savings value for A-type lamps (215 kWh), which was then divided by the average first year energy savings for LED A-type lamps (24.9 kWh/yr) to obtain an equivalent EUL for LED A-type lamps of nine years.

A similar analysis was conducted for LED non-A-type lamps which mostly include reflector and decorative lamps (R, BR, GU, PAR, MR and decorative lamps). Reflector and decorative lamps are not impacted by the current Canadian regulation, but they will be affected by the requirements of EISA 2020. Starting in 2024, the baseline wattage is therefore increased to match the minimum efficiency level of 45 lumens/watt. As shown in Table 67, an equivalent EUL of eight years was established for R, BR and decorative lamps, while an equivalent EUL of nine years was established for the other LED non-A-types.

**Table 67: Equivalent Effective Useful Life Calculation Summary for LED Non-A-Types
(R, BR and Decorative Lamps)**

Average Replaced Lamp (W)	Average Wattage of Efficient Lamp (W)	Halogen Incandescent Baseline – Canadian Legislation 7 years (2017-2023)		CFL Equivalent Baseline – American Legislation ⁹⁸ 9 years (2024-2032)		Lifetime Energy Savings (kWh)	Equivalent EUL (years)
		Baseline Wattage	Displaced Wattage	Baseline Wattage ⁹⁹	Displaced Wattage		
44.7	5.7	44.7	39.0	9.5	3.8	325	8

⁹⁸ As imposed by U.S. federal legislation. Incandescent Equivalent 2nd Tier EISA 2007.

⁹⁹ Baseline wattage values were established based on the minimum efficiency level of 45 lumen/watts dictated by the EISA regulation and on the assumed level of 428 lumens established from a weighted average of the 10 most popular models.

**Table 68: Equivalent Effective Useful Life Calculation Summary for LED Non-A-Types
(Except R, BR and Decorative Lamps)**

Average Replaced Lamp (W)	Average Wattage of Efficient Lamp (W)	Halogen Incandescent Baseline – Canadian Legislation 7 years (2017-2023)		CFL Equivalent Baseline – American Legislation ¹⁰⁰ 17 years (2024-2040)		Lifetime Energy Savings (kWh)	Equivalent EUL (years)
		Baseline Wattage	Displaced Wattage	Baseline Wattage ¹⁰¹	Displaced Wattage		
51.9	6.6	51.9	45.3	10.7	4.1	409	9

For LED fixtures, the Evaluator considered that their equivalent EUL can be analyzed the same way as for replaced-on-burn-out lamps since the energy consumption of these fixtures is the consumption of the lamps provided with them. Therefore, the baseline is a fixture with lamps meeting current energy efficiency standards. However, the Evaluator decided to cap the EUL of LED fixtures at 25 years because it is very unlikely that these products produce savings throughout their entire equipment life considering factors such as early replacement.

The rated life of products sold under the LED Recessed Downlight Fixtures category was used to establish an equipment life of 38 years. However, for the same reason as for LED downlight fixtures, the EUL was capped at 25 years and the equivalent EUL for LED recessed downlight fixtures was set to 8 years as shown in Table 69.

**Table 69: Equivalent Effective Useful Life Calculation Summary
for LED Recessed Downlight Fixtures**

Average Replaced Lamp (W)	Average Wattage of Efficient Lamp (W)	Halogen Incandescent Baseline – Canadian Legislation 7 years (2017-2023)		CFL Equivalent Baseline – American Legislation ¹⁰² 18 years (2024-2041)		Lifetime Energy Savings (kWh)	Equivalent EUL (years)
		Baseline Wattage	Displaced Wattage	Baseline Wattage ¹⁰³	Displaced Wattage		
54.5	9.3	54.5	45.2	12.4	3.1	394	8

¹⁰⁰ As imposed by U.S. federal legislation. Incandescent Equivalent 2nd Tier EISA 2007.

¹⁰¹ Baseline wattage values were established based on the minimum efficiency level of 45 lumen/watts dictated by the EISA regulation and on the assumed level of 480 lumens established from a weighted average of the 10 most popular models.

¹⁰² As imposed by U.S. federal legislation. Incandescent Equivalent 2nd Tier EISA 2007.

¹⁰³ Baseline wattage values were established based on the minimum efficiency level of 45 lumen/watts dictated by the EISA regulation and on the assumed level of 558 lumens established from a weighted average of the 10 most popular models.

Table 65 For LED fixtures without motion sensors, the baseline for 98 percent of the 10 most popular models is mostly one, two or three general-service halogen incandescent lamps, with only one model replacing linear fluorescent lamps. Therefore, the same methodology as for A-type lamps was used, as presented in Table 70 below. The equivalent EUL for LED fixtures without motion sensors was thus established at ten years.

Table 70: Equivalent Effective Useful Life Calculation Summary for LED Fixtures Without Motion Sensors

Average Replaced Lamp (W)	Average Wattage of Efficient Lamp (W)	Halogen Incandescent Baseline – Canadian Legislation 7 years (2017-2023)		CFL Equivalent Baseline – American Legislation ¹⁰⁴ 18 years (2024-2041)		Lifetime Energy Savings (kWh)	Equivalent EUL (years)
		Baseline Wattage	Displaced Wattage	Baseline Wattage ¹⁰⁵	Displaced Wattage		
102.0	21.4	102.0	80.6	33.4	12.0	826	10

For LED fixtures with motion sensors, the baseline is reflector lamps for more than 95 percent of the units sold through Instant Savings. Therefore, the Evaluator applied the same methodology as for reflectors and established the equivalent EUL of LED fixtures with motion sensors at nine years as outlined in Table 71.

Table 71: Equivalent Effective Useful Life Calculation Summary for LED Fixtures With Motion Sensors

Average Replaced Lamp (W)	Average Wattage of Efficient Lamp (W)	Halogen Incandescent Baseline – Canadian Legislation 7 years (2017-2023)		CFL Equivalent Baseline – American Legislation ¹⁰⁶ 18 years (2024-2041)		Lifetime Energy Savings (kWh)	Equivalent EUL (years)
		Baseline Wattage	Displaced Wattage	Baseline Wattage ¹⁰⁷	Displaced Wattage		
179.7	35.9	179.7	143.8	55.5	19.6	1,464	9

¹⁰⁴ As imposed by U.S. federal legislation. Incandescent Equivalent 2nd Tier EISA 2007.

¹⁰⁵ Baseline wattage values were established based on the minimum efficiency level of 45 lumen/watts dictated by the EISA regulation and on the assumed level of 1,504 lumens established from a weighted average of the 10 most popular models.

¹⁰⁶ As imposed by U.S. federal legislation. Incandescent Equivalent 2nd Tier EISA 2007.

¹⁰⁷ Baseline wattage values were established based on the minimum efficiency level of 45 lumen/watts dictated by the EISA regulation and on the assumed level of 2,498 lumens established from a weighted average of the most popular models.

For indoor motion sensors, the Evaluator updated the EUL value to 10 years based on the GDS Measure Life Report¹⁰⁸ value for occupancy sensors, which is specific to lighting controls. This value was deemed more accurate for motion sensors sold through Instant Savings than the value of eight years appearing in the DEER since the DEER value is for plug control occupancy sensors or for the commercial sector.¹⁰⁹

For indoor motion sensors with dimmer switches, the EUL value was updated to 10 years since the values for indoor motion sensors and dimmer switches were both 10 years.

The EUL values for power bars with integrated timers and load sensing power bars were drawn from a report on smart strips made by PowerSmart Engineering,¹¹⁰ which is the most referenced source in the TRM addressing power bars.

For efficient bathroom fans, only the Mid Atlantic, Illinois and Vermont TRMs cover similar measures for which they all use an EUL value of 19 years based on the GDS Measure Life Report value for thermostatically-controlled attic fans. Although attic fans are used differently than bathroom and kitchen fans, the Evaluator deemed that a EUL of 19 years is a reasonable value for residential fan applications.

7.1.14 Revised Gross Savings

The annual gross savings were calculated by the Evaluator based on the revised unitary savings values established for each product sold in 2017. They are presented in Table 72 and Table 73 further below.

These tables also present the gross savings at the generator, estimated using a line-loss factor of 1.100 between the meter and the generator. This line-loss factor was provided by Nova Scotia Power and corresponds to the value used for residential consumers. As a result, the gross energy savings at the generator were established at 22.343 GWh, which translates into 203.959 GWh in lifetime energy savings based on a weighted average EUL value of 9.1 years. The total gross peak demand savings were established at 2.993 MW at the generator.

¹⁰⁸ GDS Associates, Inc., *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*, Report prepared for the England State Program Working Group, June 2007, pp. 1-3.

¹⁰⁹ Database for Energy Efficiency Resources (DEER), *DEER2014 EUL Table*, <http://www.deeresources.com/index.php/23-deer-versions/27-deer-2014>.

¹¹⁰ David Rogers, PowerSmart Engineering, *Smart Strip Electric Savings Usability*, October 2008, p. 22.

Table 72: Revised Gross Energy and Peak Demand Savings by Product Category

Product Category	LED A-type Lamp	LED Non A-type Lamp		LED Recessed Downlight	LED Energy Star Fixture	LED Energy Star Fixture With Motion Sensor	Dimmer Switch	Indoor Motion Sensor	Motion Sensor With Dimmer Switch	Outdoor Motion Sensor	Power Bar with Timer
		R, BR and Decorative	Others								
Number of Units											
Number of Units – Spring	209,215	22,678	33,365	5,340	7,227	917	4,870	133	15	455	385
Number of Units – Fall	302,881	36,570	47,259	7,532	12,945	706	5,886	222	3	750	220
Number of Units – Spring + Fall	512,096	59,248	80,624	12,872	20,172	1,623	10,756	355	18	1,205	605
Energy Savings											
Unitary Savings Value (kWh)	24.9	41.3	48.0	47.8	85.3	273	17.0	45.8	53.6	159	53.7
Interactive Effects Factor	-16.6%	-16.6%	-16.6%	-18.0%	-15.5%	-0.5%	-18.0%	-18.0%	-18.0%	0.0%	0.0%
Gross Energy Savings – at the Meter (GWh)	10.640	2.042	3.229	0.505	1.454	0.441	0.150	0.013	0.001	0.192	0.032
Line Loss Factor	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100
Gross Energy Savings – at the Generator (GWh)	11.704	2.246	3.552	0.555	1.599	0.485	0.165	0.015	0.001	0.211	0.036
Effective Useful Life (years)	9	8	9	9	10	9	10	10	10	10	4
Gross Lifetime Energy Savings – at the Generator (GWh)	105.332	17.967	31.968	4.995	15.994	4.365	1.649	0.147	0.009	2.108	0.143
Peak Demand Savings											
On-peak Demand-to-energy Ratio	0.141	0.141	0.141	0.139	0.143	0.161	0.139	0.000	0.000	0.000	0.000
Gross Peak Demand Savings – at the Meter	1.650	0.317	0.501	0.077	0.229	0.078	0.023	0.000	0.000	0.000	0.000
Line Loss Factor	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100
Gross Peak Demand Savings – at the Generator	1.815	0.348	0.551	0.085	0.252	0.086	0.025	0.000	0.000	0.000	0.000

Table 73: Revised Gross Energy and Peak Demand Savings by Product Category (Continued)

Product Category	Smart Power Bar	Heavy Duty Timer	Program-mable Thermostat	Clothes-line	Efficient Refrigerator		Efficient Clothes Washer		Room Air Purifier	Dehumi-difier	Bath-room Fan	Total for All Products
					Before June	After June	Before June	After June				
Number of Units												
Number of Units – Spring	56	408	689	1,242	295	-	789	-	-	-	-	265,401
Number of Units – Fall	34	2,049	1,957	228	34	273	107	601	133	1,309	762	385,891
Number of Units – Spring + Fall	90	2,457	2,646	1,470	329	273	896	601	133	1,309	762	710,540
Energy Savings												
Unitary Savings Value (kWh)	53.8	122	221	150	100	49.0	188.0	188.0	480	81.3	7.85	-
Interactive Effects Factor	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-
Gross Energy Savings – at the Meter (GWh)	0.005	0.300	0.585	0.221	0.033	0.013	0.168	0.113	0.064	0.106	0.006	20.312
Line Loss Factor	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	-
Gross Energy Savings – at the Generator (GWh)	0.005	0.330	0.643	0.243	0.036	0.015	0.185	0.124	0.070	0.117	0.007	22.343
Effective Useful Life (years)	4	10	10	10	12	12	14	14	9	12	19	-
Gross Lifetime Energy Savings – at the Generator (GWh)	0.021	3.297	6.432	2.426	0.434	0.177	2.594	1.740	0.632	1.405	0.125	203.959
Peak Demand Savings												
On-peak Demand-to-energy Ratio	0.000	0.000	-0.399	0.000	0.138	0.138	0.138	0.138	0.171	0.335	0.278	-
Gross Peak Demand Savings – at the Meter	0.000	0.000	-0.257	0.000	0.005	0.002	0.026	0.017	0.012	0.039	0.002	2.721
Line Loss Factor	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	-
Gross Peak Demand Savings – at the Generator	0.000	0.000	-0.282	0.000	0.005	0.002	0.028	0.019	0.013	0.043	0.002	2.993

7.2 Net-to-gross Ratio

The NTGR serves to determine net savings, i.e. the energy savings that can be reliably attributed to a program component. More precisely, the NTGR represents the positive or negative impacts of the free-ridership and spillover effects on gross savings. In the case of Instant Savings, free-ridership and spillover are considered for one specific product – LED lamps. This product was selected since it is the best-selling product category of the program component, accounting for 92 percent of total tracked gross savings.

7.2.1 Free-ridership

In the case of Instant Savings, the Evaluator assessed the free-ridership level at which LED lamps would still have been bought by participants in the absence of the program component. The free-ridership level was assessed using a self-reporting approach which involved asking participants who had purchased LED lamps a series of questions during the intercept survey.

The free-ridership level is calculated using an algorithm that assesses the likelihood for participants to have purchased LED lamps without the discount offered through Instant Savings. The algorithm considers all applicable variables of the decision-making process, including awareness of the discount, efficiency, cost, timing and quantity.

The intercept survey revealed a free-ridership level of 32 percent for LED lamps sold through Instant Savings in 2017 with a margin of error of 5.5 percent. This level is similar to the 33 percent obtained during the 2016 evaluation. This result indicates that the market is stabilizing. In addition, survey results revealed that 6 percent of surveyed participants were unaware of the rebate before paying at the cash register, while this proportion was 10 percent in 2016. This lower percentage of unaware participants demonstrates that the program component has a great visibility and can explain the small decrease in the free-ridership level since these participant answers have a significant impact on free-ridership because they are considered full free-riders.

The intercept survey questionnaire and the algorithm underlying free-ridership calculations are presented in Appendix V and Appendix VIII respectively.

7.2.2 Spillover

Outside of the spring and fall campaigns, sales of eligible products might have occurred due to program component influence even if no discount was offered. This influence can be due to better knowledge and awareness of energy efficient products and changes in retailer offerings. These sales should be attributable to the program component as a form of market effect.

The retailer interviews were used to estimate the level of spillover by measuring the market effects attributable to the program component associated with LED lamps, including A-type and non A-type LED lamps. The methodology used to calculate the level of spillover is presented in Appendix IX. It consists in identifying the number of LED lamps sold outside the campaigns and the proportion of those sales that can be attributed to Instant Savings.

The percentage of LED lamp sales occurring outside of the campaigns was established at 41 percent. The interview results demonstrate that retailers consider, on average, that 23 percent of their sales occurring outside of the two campaigns can be attributed to Instant Savings. The main influence factor cited by retailers is an increase in the quantity of ENERGY STAR certified LED lamps stocked in their stores, followed by the knowledge of sales people and consumers. Overall, LED lamp sales (both A-type and non-A-type) outside the 2017 campaigns that can be attributed to Instant Savings represent 16 percent of LED lamps sales during the campaigns.

The 2017 spillover level of 16 percent is considerably lower than in 2016 (47%). The variable that explains the majority of this decrease is the number of LED lamp sales outside the campaign. In 2017, the LED lamps sold during Instant Savings campaigns represented 59 percent of the LED lamps sold annually, while retailers had estimated it at only 39 percent in 2016; this difference resulted in spillover being 50 percent higher in 2016, independently of the changes in the influence level Instant Savings had on those sales.

In 2016, the number of LED lamps sold outside the campaigns was calculated based only on retailer estimates of annual sales. In 2017, retailers provided an estimate of their annual sales during their interview, but for the first time some retailers also provided annual LED lamp sales data on a voluntary basis after being encouraged to do so by ENS. The Evaluator used this data to identify the number of LED lamps sold outside the campaigns by these retailers, while the number of LED sold by other retailers was established based on their estimates provided during the interviews. Considering the very high number of LED lamp sales during the 2016 campaigns, it is unlikely that sales during the 2016 campaigns represented a lower percentage of the annual sales than in 2017. The Evaluator concluded that retailers responses on sales outside of the campaign in 2016 did not align with the new availability of sales data in 2017.. Since ENS has made it mandatory for the participating retailers to provide annual sales data as of 2018, the number of LED lamps sold outside the campaigns will be established with more accuracy and reliability.

In addition to the reduced percentage of sales outside campaigns, the average influence level of Instant Savings was lower in 2017 (23%) than in 2016 (28%). This might be explained by the general price decrease of LED products, a factor that has an important influence on the LED lamp sales outside the campaigns. This also partially explains why the spillover level is lower in 2017 since the 5 percent reduction of the influence level decreased the spillover level by 3 percent.

7.2.3 Net-to-gross Ratio Calculation

The NTGR is calculated using the following equation:

$$NTGR = (1 - \% \text{ free-ridership} + \% \text{ spillover})$$

Using this equation, the NTGR for LED lamps is estimated at 0.83. For all other products, a NTGR of 1.00 was used. The free-ridership and spillover levels for these non-LED products could not be assessed through this evaluation. Products such as dimmer switches, occupancy sensors and power bars with integrated timers are specialized products grouped into broader retail categories, which renders it difficult for retailers to estimate program component influence on their sales. Moreover, the buyer populations of these products are smaller, which renders it more difficult to reach them using an intercept or general population survey.

7.3 Net Savings

Net savings are defined as the changes in energy use that are attributable specifically to Instant Savings. Net program component impacts were estimated by applying the overall NTGR presented above to the gross savings, as shown in the following equation.

$$Net\ Savings = Gross\ Savings \times NTGR$$

This equation was used to calculate both peak demand savings and energy savings.

The net energy savings for Instant Savings in 2017 are established at 19.543 GWh at the generator, while the net peak demand savings are 2.558 MW at the generator. Using the Nova Scotia-specific factor¹¹¹ for GHG emissions generated by electricity production, 0.6531 CO₂ eq/kWh, it was determined that the net energy savings resulted in 12,764 tonnes of avoided CO₂ eq annually. Based on the average equivalent EUL of 9.2 years, the net lifetime energy savings were established at 179.116 GWh.

The detailed results are presented in Table 74 and Table 75 below.

¹¹¹ At the time of writing, 2017 data was not available. The Nova Scotia-specific factor was obtained from Nova Scotia Power's 2016 total system emissions data (7,079,268 CO₂ eq tons) and total electricity generation (10,839 GWh), from the following two sources:

Nova Scotia Power, *Total System Emissions*, <http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx>, (Last accessed December 17, 2017).

Emera inc., Management's Discussion & Analysis As at February 10, 2017, <http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693>, (Last accessed December 17, 2017).

Table 74: Evaluated Net Energy and Peak Demand Savings by Product Category

Product Category	LED A-type Lamp	LED Non A-type Lamp		LED Recessed Downlight	LED Energy Star Fixture	LED Energy Star Fixture With Motion Sensor	Dimmer Switch	Indoor Motion Sensor	Motion Sensor With Dimmer Switch	Outdoor Motion Sensor	Power Bar with Timer
		R, BR and Decorative	Others								
Energy Savings											
Revised Gross Energy Savings – at the Meter (GWh)	10.640	2.042	3.229	0.505	1.454	0.441	0.150	0.013	0.001	0.192	0.032
NTGR	0.84	0.84	0.84	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Net Energy Savings – at the Meter (GWh)	8.937	1.715	2.712	0.505	1.454	0.441	0.150	0.013	0.001	0.192	0.032
Line Loss Factor	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100
Net Energy Savings – at the Generator (GWh)	9.831	1.887	2.984	0.555	1.599	0.485	0.165	0.015	0.001	0.211	0.036
Effective Useful Life (years)	10	8	9	9	10	9	10	10	10	10	4
Net Lifetime Energy Savings – at the Generator (GWh)	88.479	15.092	26.853	4.995	15.994	4.365	1.649	0.147	0.009	2.108	0.143
Peak Demand Savings											
Revised Gross Peak Demand Savings – at the Meter (MW)	1.650	0.317	0.501	0.077	0.229	0.078	0.023	0.000	0.000	0.000	0.000
NTGR	0.84	0.84	0.84	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Net Peak Demand Savings – at the Meter (MW)	1.386	0.266	0.421	0.077	0.229	0.078	0.023	0.000	0.000	0.000	0.000
Line Loss Factor	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100
Net Peak Demand Savings – at the Generator (MW)	1.525	0.293	0.463	0.085	0.252	0.086	0.025	0.000	0.000	0.000	0.000

Evaluated Net Energy and Peak Demand Savings by Product Category (Continued)

Product Category	Smart Power Bar	Heavy Duty Timer	Program-mable Thermostat	Clothes-line	Efficient Refrigerator		Efficient Clothes Washer		Room Air Purifier	Dehumi-difier	Bath-room Fan	Total for All Products
					Before June	After June	Before June	After June				
Energy Savings												
Revised Gross Energy Savings – at the Meter (GWh)	0.005	0.300	0.585	0.221	0.033	0.013	0.168	0.113	0.064	0.106	0.006	20.312
NTGR	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-
Net Energy Savings – at the Meter (GWh)	0.005	0.300	0.585	0.221	0.033	0.013	0.168	0.113	0.064	0.106	0.006	17.766
Line Loss Factor	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	-
Net Energy Savings – at the Generator (GWh)	0.005	0.330	0.643	0.243	0.036	0.015	0.185	0.124	0.070	0.117	0.007	19.543
Effective Useful Life (years)	4	10	10	10	12	12	14	14	9	12	19	-
Net Lifetime Energy Savings – at the Generator (GWh)	0.021	3.297	6.432	2.426	0.434	0.177	2.594	1.740	0.632	1.405	0.125	179.116
Peak Demand Savings												
Revised Gross Peak Demand Savings – at the Meter (MW)	0.000	0.000	-0.257	0.000	0.005	0.002	0.026	0.017	0.012	0.039	0.002	2.721
NTGR	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-
Net Peak Demand Savings – at the Meter (MW)	0.000	0.000	-0.257	0.000	0.005	0.002	0.026	0.017	0.012	0.039	0.002	2.326
Line Loss Factor	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	-
Net Peak Demand Savings – at the Generator (MW)	0.000	0.000	-0.282	0.000	0.005	0.002	0.028	0.019	0.013	0.043	0.002	2.558

Table 75 compares the energy and peak demand savings established by this evaluation with the savings calculated in the 2017 tracking sheet.

Table 75: Comparison of Tracked and Evaluated Savings at the Generator

	Initial Gross Savings	Revised Gross Savings	NTGR*	Net Savings
Energy Savings				
ENS Tracked Savings	23.562 GWh	23.562 GWh	1.11	26.162 GWh
Evaluation Results	22.343 GWh	22.343 GWh	0.87	19.543 GWh
Peak Demand Savings				
ENS Tracked Savings	4.615 MW	4.615 MW	1.12	5.186 MW
Evaluation Results	2.993 MW	2.993 MW	0.85	2.558 MW

*NTGRs varied for each product category. The NTGRs presented in this table correspond to the rounded averages obtained by dividing net savings by installed gross savings (with interactive effects taken into account).

The evaluated net energy savings are 25 percent lower than the tracked energy savings. This difference is mainly due to two reasons: (1) the decrease in gross unitary savings associated with LED A-type lamps which were decreased by 6 percent and accounted for more than 50 percent of the total savings; and (2) the lower market effects established this year compared to those of 2016. Based on the 2017 participant survey, the LED unitary savings adjustment resulted mainly from the decreasing number of participants replacing incandescent lamp in favor of CFL and LED lamps.

The evaluated net peak demand savings are 51 percent lower than the tracked net peak demand savings. This difference is mainly due to the same reasons as for difference in the energy savings, but is further explained by the lower evaluated peak demand-to-energy ratios used for lighting products based on the findings of the EPI Residential Lighting Metering Study and the NERHOU study.

8 INSTANT SAVINGS MARKET EVOLUTION

ENS has been active in the LED lamp market since 2011 through Instant Savings. The 2016 Evaluation found indicators that market barriers for LED lamps, especially A-type LED lamps, had been reduced. These indicators include the number of LED lamps sold in 2016 and their declining prices. As a result of these findings, the 2016 Evaluation recommended that ENS continue monitoring key market indicators to recognize the moment that program component offerings should be adapted or removed. In the following section, we examine whether the significant changes observed in 2016 have persisted over time, and offer insights regarding LED market transformation in Nova Scotia. A technology diffusion curve illustrating the market adoption of LED lamps in Nova Scotia is presented at the end of the section in Figure 13

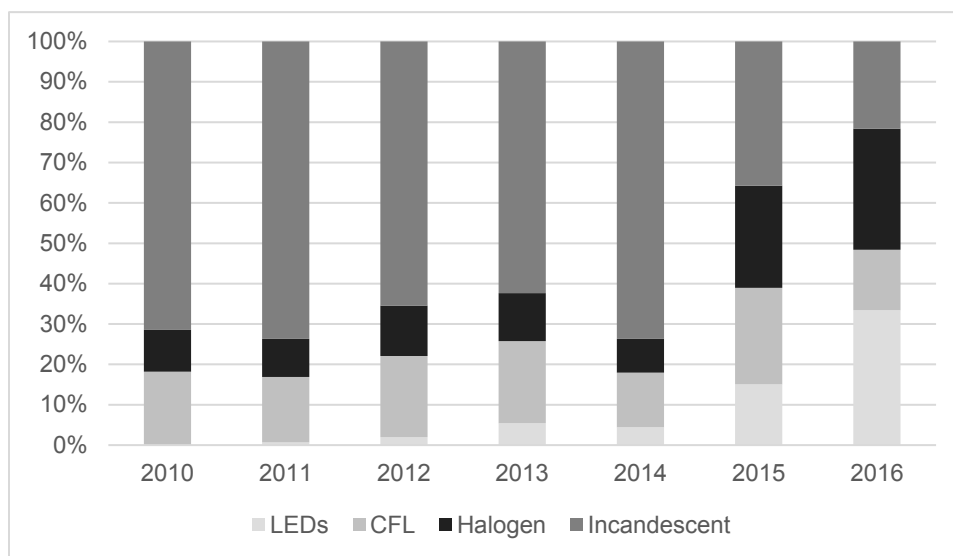
8.1 Market Indicators

The Evaluator analyzed a number of market indicators to understand the state of the LED market in Nova Scotia by looking at the market shares of lighting technologies, the number and types of LED lamps rebated by Instant Savings, socket saturation, LED lamp prices, customer intentions with LED lamps, and customer demographics.

8.1.1 Market Shares of Lighting Technologies

The residential lighting market is dominated by four main technologies: incandescents, halogens, CFLs and LED lamps. The Atlantic shipment data indicates that LED lamps are rapidly growing in popularity. In terms of market share, as shown in Figure 9 below, LED lamps grew from having no sales in 2010 to having the highest share of sales (33%) in 2016. The gains in LED lamp market share have largely been at the expense of incandescent lamps which went from having the largest share of sales in 2010 at 70 percent to just 22 percent share in 2016. CFLs also lost some market share, from 18 percent in 2010 to 15 percent in 2016. Like LED lamps, halogen lighting increased market share over this period, from 10 to 30 percent. Halogen lighting increased market share is partially explained by the fact that this lighting technology was primarily used as reflector lamps, but now an ever-increasing proportion of halogens is replacing incandescents.

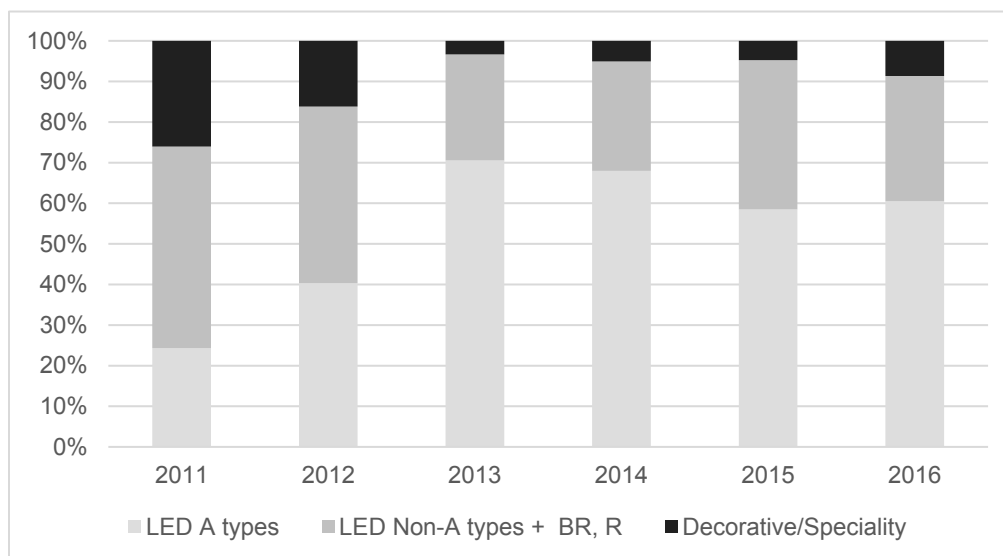
Figure 9: Atlantic Consumer Lighting Shipments by Type of Technology



Source: Electro-Federation Canada, *Lamp Data - Consumer Channel and C&I Channel 2004–2016*, March 2017.

Figure 10 below breaks down LED shipments in the Atlantic region by lamp type. From 2011 to 2014, A-type lamp market share grew compared to Non-A types and BR, R and decorative lamps. Non-A type lamps are typically reflector lamps and replace halogen reflector lamps; BR and R lamps are also reflector lamps, but primarily replace incandescent lamps. In 2015 and 2016, while the share of Non-A types lamps grew, A-types remained the dominant LED lamp type.

Figure 10: Atlantic Consumer LED Shipments by Lamp Type

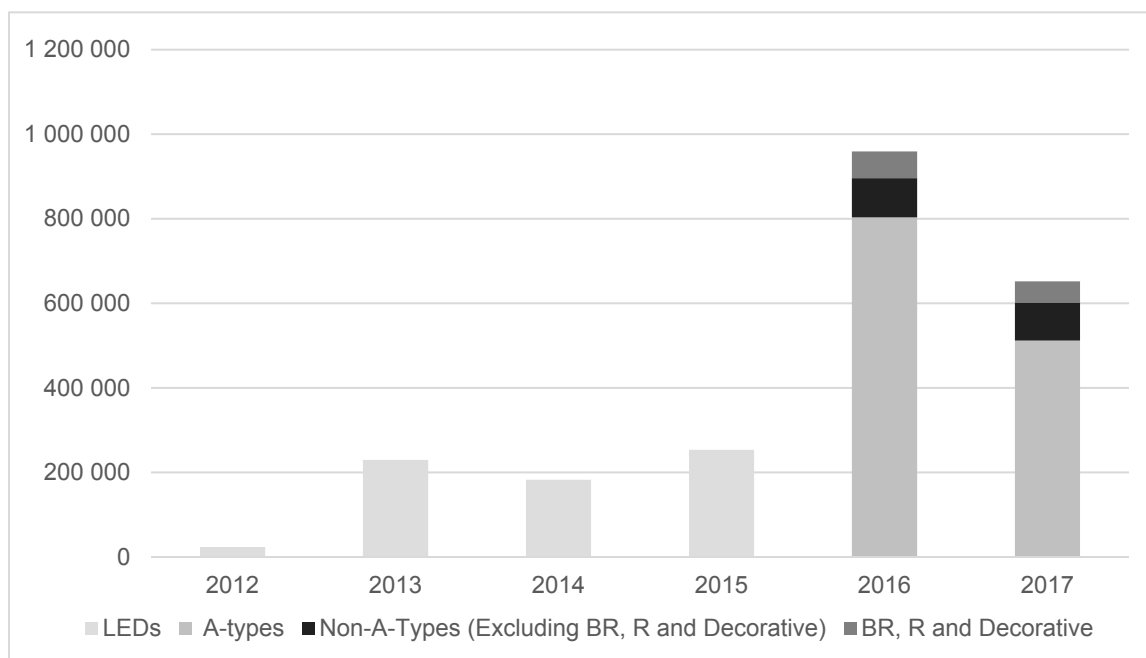


Source: Electro-Federation Canada, *Lamp Data - Consumer Channel and C&I Channel 2004–2016*, March 2017.

8.1.2 LED Lamps Rebated by Instant Savings

Figure 11 illustrates the number of LED lamps rebated by Instant Savings since 2012, broken down by lamp type where data is available. A-type lamps accounted for most of the LED lamps rebated by Instant Savings.

Figure 11: ENS Instant Savings Rebated LED Lamps



Source: 2012–2016 Evaluation Reports for Instant Savings and 2017 results

8.1.3 Socket Saturation

According to a socket study conducted in Nova Scotia in 2016,¹¹² the incidence of households with at least one LED lamp was 59 percent in 2016.

Table 76 below compares lamp socket saturation results for 2011 and 2016. LED socket saturation has increased significantly since 2011. LED lamps increased from accounting for only 4 percent of all permanent fixture lamps in homes to 24 percent in 2016 and from only 3 percent to 21 percent in plug-in lamps. However, CFLs and incandescents remained the dominant lamp types installed in Nova Scotian homes in 2016. While Figure 9 above demonstrates a significant increase in halogen shipments in Atlantic Canada, the socket study found that halogen lamps approximately comprised only 5 percent of the market share of all lamps in 2016. Interestingly, the two types of lamps are very difficult to distinguish from one another. This might explain the discrepancy between the survey results (presented in Table 76) and the halogen shipment data.

¹¹² Corporate Research Associates Inc., 2016 *Socket Study*, Final Report Prepared for Efficiency Nova Scotia, December 2016.

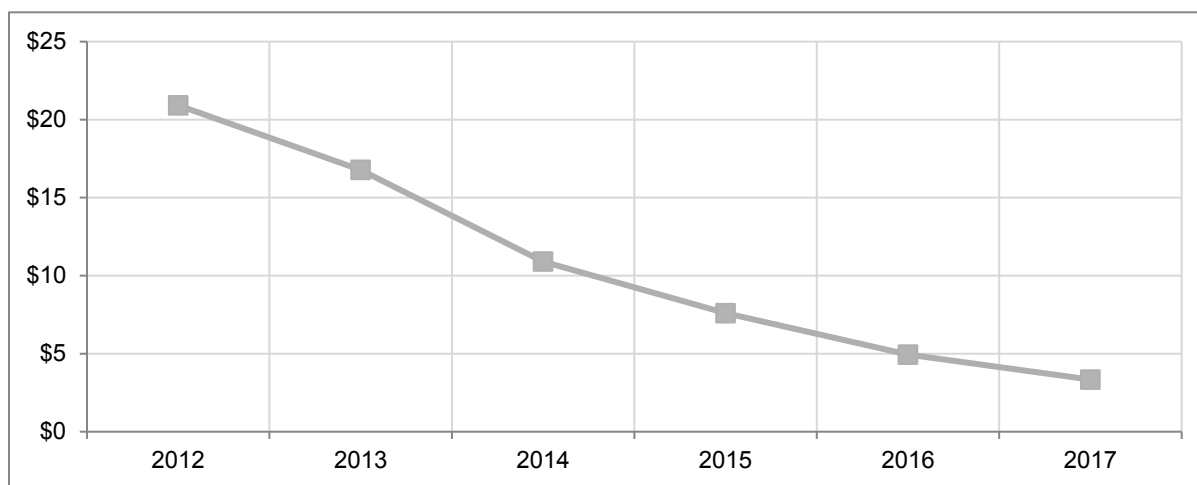
Table 76: Nova Scotia Lamp Socket Saturation

	Permanent		Plug-in	
	2011	2016	2011	2016
Incandescents	48%	29%	50%	33%
Halogens	0%	6%	0%	5%
CFLs	48%	42%	47%	42%
LED lamps	4%	24%	3%	21%

Source: 2011 Nova Scotia Socket Study, 2016 Nova Scotia Socket Study

8.1.4 LED Prices

LED prices have been decreasing. Figure 12 below illustrates the evolution of the price of LED lamps sold through Instant Rebates (before rebate). The average price decreased from just over \$20 in 2012 to about \$3.30 in 2017, making LED lamps much more cost competitive. It should be noted that LED lamps were only sold in single packs in 2012 while multipacks represent 84 percent of the 2017 Instant Savings LED lamp sales; this change explains a portion of the price decrease over time. As mentioned in the interviews conducted with nationwide retailers (summarized in Subsection 6.1), another factor causing the decrease in LED lamp prices was that the introduction of the LED product category in discount stores has caused consumers to expect lower prices.

Figure 12: Average LED Lamp Prices in Instant Rebates (All Lamp Types)


Source: 2012–2015 Evaluation Reports for Instant Savings, 2016–2017 Tracking Sheets for Instant Savings

As demonstrated in Table 77 below, the prices of all LED lamp types have decreased since 2016, with BR lamps having the biggest decrease from an average price of \$9.78 in 2016 to \$4.43 in 2017. R type lamps remain the most expensive LED lamps with an average price of \$5.59. The other lamp types all have an average price in the range of \$3.00 to \$4.60.

Table 77: Average LED Prices by Lamp Type

Lamp Type	2016 (\$)	2017 (\$)
A-type	5.26	3.04
Non A-type	7.55	4.60
BR	9.78	4.43
R	10.19	5.59
Decorative	7.81	4.12

The incentives provided by Instant Savings in 2017 were up to \$5 for A-type LED lamps and up to \$7 for non-A type lamps. The average incentive provided for LED A-type lamps in 2017 was \$1.32. The incentives bring the average price of A-type LED lamps down to about \$1.72 per lamp. In fact, as discussed in the Partner Perspectives section of this report, a portion of retailers believes that insufficient knowledge now trumps prices as the key barrier to LED adoption.

8.1.5 Customer Intentions and Demographics

Customer intention to replace at least one lamp with an LED lamp has grown stronger. Residents surveyed in the 2016 socket study were asked to indicate whether a set of behaviour descriptions applied to their households in terms of their intentions to replace non-efficient lamps in the following year with energy-efficient lamps. In 2011, residents were uncertain with respect to LED lamps, with 40 percent saying they did not know if they would replace at least one light fixture with an LED lamp. In 2016, 40 percent of residents were certain they would replace at least one lamp with an LED lamp (up from 26% in 2011).

The 2016 socket study found that homeowners are far more likely to use at least one LED lamp than renters.

8.1.6 Codes and Standards

The ultimate indicator of market transformation is the adoption of more stringent codes and standards. Currently, general service lamps¹¹³ are required to meet an efficiency level that corresponds to halogen incandescent lamps (for instance, a standard 60-watt incandescent lamp is no longer allowed and its equivalent is a 43-watt halogen incandescent lamp). This minimum energy performance standard has been enforced since early 2014 and early 2015, depending on lamp wattages. The latest amendment to the Canadian energy efficiency regulations (Amendment 13 published on December 28, 2016)¹¹⁴ did not have any significant impact on the efficiency of lamps rebated through Instant Savings. However, Natural Resources Canada has included an update of general service lamps minimum energy performance requirement in Amendment 16 which is planned for pre-consultation in 2019. This update will most likely align Canadian regulations with the next American EISA regulation update (planned for 2020), which will effectively ban the import and fabrication of halogen incandescent lamps as a result of the minimum acceptable efficiency level being higher than halogen incandescent technology efficiency.

8.2 Measured Free-ridership

The Evaluator looked at the free-ridership level to gain insights into the evolution of the LED residential market in Nova Scotia.

Given the reduction in market barriers to LED lamps and increased adoption thereof, careful attention should be paid to the free-ridership level of Instant Savings to ensure continued cost effectiveness. The 2017 evaluation intercept survey revealed a free-ridership level of 32 percent for LED lamps sold through Instant Savings. This level is similar to the 33 percent free-ridership level obtained in the 2016 evaluation, and lower than the 37 percent obtained in the 2015 evaluation. Although quite high, the free-ridership level for LED lamps was low enough to justify continuing to offer incentives to the many participants who would not have purchased LED lamps without Instant Savings.

8.3 Market Evolution Summary

Rosenburg and Hoefgen (2009) made recommendations on market transformation program planning and suggested analyzing certain factors, as outlined in Table 78 below, to identify whether program-based support should be withdrawn or reduced in light of changes observed in the market.¹¹⁵

¹¹³ The Energy Efficiency Regulation on general-service lamps covers most A-type lamps. Natural Resources Canada, *General Service Lamps and Modified Spectrum Incandescent Lamps*, <http://www.nrcan.gc.ca/energy/regulations-codes-standards/products/6869> (Last accessed January 26, 2018).

¹¹⁴ Natural Resources Canada, *Amendment 13, December 2016*, <http://www.nrcan.gc.ca/energy/regulations-codes-standards/18419> (Last accessed January 26, 2018).

¹¹⁵ Rosenburg M. and Hoefgen L, *Market Effects and Market Transformation: Their Role in Energy Efficiency Program Design and Evaluation*, Prepared for the California Institute of Energy and the Environment, 2009.

Table 78: Overview of Key Factors in Program Planning

Factor	Results
Market share of LED lamps	› LED lamp socket saturation was 21% in permanent fixture lamps and 24% in plug-in lamps in Nova Scotia in 2016. 59% of Nova Scotians have at least one LED lamp. › LED lamp shipments accounted for approximately one third of all lamps shipped in Atlantic Canada in 2017.
Recent trends in prices and availability	› LED lamp prices have declined significantly and, depending on the lamp types, the price gap between LED lamps and alternative lighting technologies is narrowing. › LED lamps are available at major retailers as well as at independent stores, as indicated by the various kinds of retailers participating in Instant Savings.
Likelihood of inclusion in a near-term code or standard	› Canada will update the general service lamp minimum energy performance requirement in Amendment 16 which is planned for pre-consultation in 2019. This update effectively bans halogen incandescent lamps from being manufactured or imported.
Market readiness of more efficient substitute technology	› No substitute more efficient than LED lamps has become available.

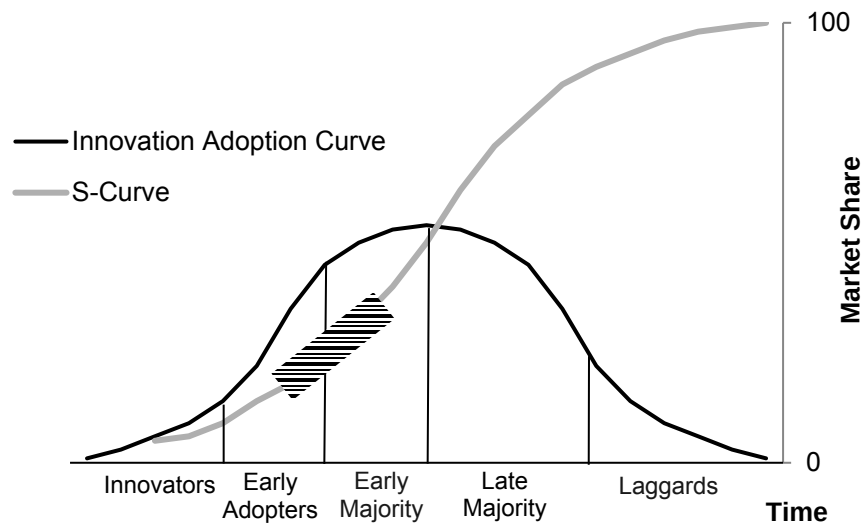
The market indicators listed above (namely LED lamp increased share in the lighting market, greater availability and price reductions) demonstrate that the barriers to LED lamp adoption continue to weaken. Furthermore, customers reported stronger intentions to replace lamps with LED lamps. There is likely a five-year window before LED lamps are included in Canadian regulations.

Figure 13 below provides an indication of the adoption stages of LED lamps in Nova Scotia. This figure illustrates how with successive groups of consumers adopting the new technology (as shown by the innovation adoption curve, in black),¹¹⁶ its market share (as shown by the S-curve, in grey) will eventually reach the saturation level.

The 2016 socket study found that LED lamps socket saturation was 21 percent in permanent fixture lamps and 24 percent in plug-in lamps in Nova Scotia. In addition, 59 percent of Nova Scotians have at least one LED lamp in their homes. This data, combined with other market indicators as discussed above, was used to provide an indication of the market phase of residential LEDs in Nova Scotia, as illustrated by the hatched area of the S- curve shown in Figure 13. The data suggests that the market for LED lamps is still in a growth phase and is approaching maturity as more and more residents adopt LED lamps.

¹¹⁶ Everett Rogers, *Diffusion of Innovations*, 1983.

Figure 13: Residential Market Evolution for LED Lamps



9 OVERALL SAVINGS OF THE RESIDENTIAL EFFICIENT PRODUCT PROGRAM

Table 79 summarizes the participation levels, as well as gross and net savings for each Residential Efficient Product Rebates program component and for the program as a whole.

Table 79: Overall Savings of the Residential Efficient Product Rebates Program

	Participation Level	Gross Savings	NTGR	Net Savings
ARet				
Energy Savings	6,138 appliances	5.266 GWh	0.59	3.094 GWh
Lifetime Energy Savings		40.321 GWh	0.57	23.050 GWh
Peak Demand Savings		0.740 MW	0.60	0.443 MW
Instant Savings				
Energy Savings	710,540 products sold	22.343 GWh	0.87	19.543 GWh
Lifetime Energy Savings		203.959 GWh	0.88	179.116 GWh
Peak Demand Savings		2.993 MW	0.85	2.558 MW
Total				
Energy Savings		27.609 GWh		22.637 GWh
Lifetime Energy Savings		244.280 GWh		202.166 GWh
Peak Demand Savings		3.733 MW		3.001 MW

CONCLUSION

The Residential Efficient Product Rebates program aimed to achieve net energy and peak demand savings of 22.6 GWh and 3.6 MW respectively in 2017. The program achieved 22.637 GWh in net energy savings and 3.001 MW in net peak demand savings at the generator in 2017, resulting in 14,785 tonnes of avoided CO₂ eq annually. The total net lifetime energy savings amount to 202.166 GWh. The program thus achieved the planned energy savings, but fell short of the planned peak demand savings. The main reason the planned peak demand savings was not achieved is the lower evaluated peak demand-to-energy ratios used for lighting products in the Instant Savings component. Since this component represented 86 percent of the whole program's total net energy and peak demand savings in 2017 and the lighting products represented 89 percent of Instant Savings' net energy savings, this adjustment had a great impact on the Residential Efficient Product Rebates program's overall performance.

The following subsections summarize the main findings for each of the two components comprising the Residential Efficient Product Rebates program.

Appliance Retirement

A total of 6,138 appliances were retired or replaced through ARet in 2017, generating 3.094 GWh in net energy savings and 0.443 MW in net peak demand savings.

The number of appliances retired through ARet in 2017 remained fairly stable compared to previous years with less than 2 percent more appliances retired than in 2016. The HRSB pilot was launched in 2017, and it only served to retire 13 appliances, but this number should increase in 2018 with the pilot already operating.

Again for 2017, the Evaluator conducted a metering activity to establish the average consumption of retired refrigerators and freezers. Although the metering protocol was improved, the margins of error remained high due to fewer usable data points than expected, but the results were deemed acceptable by the Evaluator. Based on these results and the tracking sheet data, the unitary savings of all measures were revised upward, except for air conditioner retirement and refrigerator replacement, which contributed to ARet exceeding its planned energy savings of 2.6 GWh and 0.3 MW in energy and peak demand savings respectively.

Instant Savings

Instant Savings aimed to achieve 20.0 GWh in net energy savings and 3.3 MW in net peak demand savings at the generator in 2017 and achieved 19.543 GWh in net energy savings and 2.558 MW in net peak demand savings.

Instant Savings therefore missed planned energy savings, which is mainly explained by the lower spillover level established for 2017. Indeed, the retailer interviews revealed a spillover level of 16 percent in 2017, while it was established at 47 percent in 2016. The much higher percentage in 2016 was calculated using retailers responses on sales outside of the campaign in 2016 did not align with the new availability of sales data in 2017. The improved sales data available in 2017 allowed for a more accurate estimate.

The number of products sold through Instant Savings in 2017 decreased by 30 percent compared to 2016, but still represented a great improvement compared to years prior to 2016. This reduction mainly resulted from the exceptional situation in 2016 when a very large number of LED lamps were sold at about one dollar each. A price floor was introduced in 2017 to avoid this situation, resulting in fewer LED lamps sold. Yet, sales of other products increased over 2016 levels. LED lamps nonetheless represented 92 percent of the 710,540 eligible products sold through participating stores across Nova Scotia in 2017.

In 2017, apart from the new price floor dissatisfying some retailers, retailers expressed a high level of satisfaction with Instant Savings, and they considered their relationship with the DA very good. While most retailers identified cost as the main barrier to LED adoption, some retailers identified insufficient knowledge as the key barrier, which is a first in the history of the program component.

As with previous years, the intercept participant survey indicated that ENS marketing was the most common way for participants to find out about Instant Savings, primarily through in store promotions (32%), TV ads (16%) or the ENS website (13%). Again this year, the evaluation results demonstrated that in-store signage was successful in informing participants about eligible Instant Savings products.

The market evolution analysis revealed that LED lamps are still in a growth phase, although they are approaching maturity. Indeed, more and more Nova Scotia residents adopt LED technology while the prices of LED lamps are rapidly dropping, notably for A-type lamps.

LIST OF APPENDICES

The following are presented in the Residential Efficient Product Rebates Program – Appendices.

Appliance Retirement

Appendix I - ARet: 2017 Recommendations

Appendix II - ARet: Interview Guide with Representative of the Halifax Regional School Board

Instant Savings

Appendix III - IS: 2017 Recommendations

Appendix IV - IS: Interview Guide with Retailer Partners

Appendix V - IS: Participant Intercept Survey Questionnaire

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Appendix VII - IS: Unitary Savings Calculations for Measures not Updated in 2017

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Appendix IX - IS: Internal Spillover Methodology



ECONOLER

RESIDENTIAL EFFICIENT PRODUCT REBATES PROGRAM

2017 DSM EVALUATION

EFFICIENCY NOVA SCOTIA

Appendix Report

March 15, 2018



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Appendix I

ARET: 2017 RECOMMENDATIONS

This appendix summarizes all the recommendations made by the Evaluator as part of the 2017 evaluation. There were no incomplete 2016 recommendations at the time of evaluation.

Sections	Recommendations
Executive Summary	1 Continue to perform the metering activity to increase sample sizes. This year, the Evaluator developed a new metering protocol, which greatly improved the quality of the metering data. Although the metering approach used in 2017 was improved, the sample sizes were not large enough to provide acceptable margins of error on gross energy consumption values. Therefore, the Evaluator recommends continuing the metering activity in 2018 using the same age categories and the same protocol as used in 2017 to increase the sample size of each age category. As for the metering activity to be performed next year, the Evaluator also suggests implementing some minor changes, such as using a better tool to measure the power factor of each appliance type and measuring old appliances' inside temperature at the time of pick-up, as recommended in the Metering Review section of this report.
	2 Improve the process for tracking appliances retired through the pilot. This year, the savings of those appliances retired through the AREt pilot were tracked using the same parameters and methodology as for full-sized residential appliances. After conducting an interview with a representative of HRSB schools, the Evaluator used different unitary gross and net savings values for the pilot. Going forward, the Evaluator recommends using the unitary savings values established in this year's evaluation for appliances retired through the pilot. The Evaluator also recommends improving the tracking process by clearly identifying the appliances retired through the pilot.
Metering Review	3 The Evaluator recommends that old appliances be plugged in on the evening before the pick-up to ensure that a reasonable temperature is reached if the appliance works.
	4 Another recommendation is to send the HOBO® data loggers back to the manufacturer every year at the end of the metering process to have the loggers recalibrated and get them ready for the upcoming year.

Appendix II

ARET: INTERVIEW GUIDE WITH REPRESENTATIVE OF THE HALIFAX REGIONAL SCHOOL BOARD

Introduction

- I1. The Halifax Regional School Board (HRSB) has participated in Efficiency Nova Scotia's Appliance Retirement Pilot, during which an audit of all the refrigeration appliances in HRSB schools was conducted. Then, school principals were asked to remove surplus or old appliances from their schools. Removal can take place within the Appliance Retirement Program which removes working refrigerators that are at least 10 years old for free and offers a \$30 incentive per appliance.

First a few questions about the partnership between the HRSB and Efficiency Nova Scotia:

- a) Who initiated the discussion about participating in the Appliance Retirement Pilot?
 - b) [IF HIMSELF] How did you learn about it?
 - c) Who suggested conducting an audit of all the refrigeration appliances in HRSB schools?
- I2. Can you tell me more about your role in the development and implementation of the Appliance Retirement Pilot with the HRSB?
- I3. What is the role of the school principals? [PROBE: Are the principals mainly involved in the scheduling of the disposal or they are also involved in the selection of appliances to be retired and replaced?]

Free-Ridership Section (FR Series)

I would like to ask you to consider which actions you would have taken in the absence of the Appliance Retirement Pilot. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is "Very Unlikely," and a 10 indicating that it is "Very Likely."

- FR1. Without the support of Efficiency Nova Scotia, how likely is it that you would have conduct an audit or identified the appliances to be retired by yourself?

___ Response ___98 Don't Know ___99 Refused

- FR2. Without the support of Efficiency Nova Scotia, how likely would you have asked the school principals to dispose of exactly the same number of appliances?

___ Response ___98 Don't Know ___99 Refused

- FR3. In your opinion, how likely are schools to retire appliances without the support of the Appliance Retirement Program?

___ Response ___98 Don't Know ___99 Refused

FR4a. Among the appliances retired so far, can you provide an estimate of the number of appliances that were unplugged at the time of the audit visit?

1. Yes, number: _____
 98. (Don't know)
 99. (Refused)

FR4b. Among the appliances retired so far, can you provide an estimate of the number of appliances that were replaced?

1. Yes, number: _____
 98. (Don't know)
 99. (Refused)

FR4c. To our knowledge, 12 appliances have been retired so far. Can you provide an estimate of the additional number of appliances that were retired without using Appliance Retirement Program services?

1. Yes, number: _____
 98. (Don't know)
 99. (Refused)

FR5. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to collaborate with Efficiency Nova Scotia to dispose of the old appliances in HRSB schools. Using a scale from 0 to 10, where 0 means "No influence" and 10 means "Great influence", please rate the influence of each of the following in your decision.

Factor (READ AND RANDOMIZE)	Responses – DO NOT ACCEPT A RANGE
a. ENS support in conducting the audit of all the refrigeration appliances in HRSB schools	___ Response ___ 98 Don't Know ___ 99 Refused
b. The cash incentive of the Appliance Retirement Program	___ Response ___ 98 Don't Know ___ 99 Refused
c. Convenience of the removal process of the Appliance Retirement Program	___ Response ___ 98 Don't Know ___ 99 Refused
d. Previous experience with ENS programs, including the Appliance Retirement Program	___ Response ___ 98 Don't Know ___ 99 Refused

Appendix III

IS: 2017 RECOMMENDATIONS

This appendix summarizes all the recommendations made by the Evaluator as part of the 2017 evaluation. There were no incomplete 2016 recommendations at the time of evaluation.

Sections	Recommendations
Executive Summary	1 Continue providing program component support to expand the share of LED bulbs in the Nova Scotia residential lighting market while beginning to plan an exit strategy for A-type bulbs. Given the high participation level in this program component, high purchase volume of A-type bulbs and reductions in LED prices, ENS should consider decreasing incentive levels for A-type bulbs. In addition, ENS should consider possible opportunities for shifting the focus of the program component, for example to bulb types with lower market adoption, to extend Instant Savings beyond the short-term.
	2 Continue monitoring market indicators and collect additional information to further characterize the LED market. Because the lighting market is in a period of change, the Evaluator recommends continuing to monitor market indicators such as market share of lighting technologies, socket saturation and LED prices. Also, to better characterize the current state of the lighting market, the Evaluator recommends collecting data about the following aspects: (1) Different LED and halogen bulb types installed in homes. This information could be collected during site visits in future socket studies; and (2) Customer knowledge of LEDs. This information could be collected using questions included in a periodic Omnibus survey. An Omnibus survey is a cost-effective method where data on a wide variety of subjects is collected during the same interview.
Peak Demand Savings	3 The Evaluator compared these results with those from the NERHOU study which obtained a result corresponding to a peak-demand-to-energy ratio of 0.162 W/kWh (with a peak coincidence factor of 16% and 2.7 hours of use per day¹). The Evaluator recommends using this result as it is very close to the 0.161 W/kWh obtained in the Residential Lighting Metering Study. Therefore, the Evaluator recommends applying the NERHOU study result of 0.162 W/kWh to all indoor and outdoor lamps.

¹ The peak coincidence factor in the NERHOU study are only available for all lamps, and not specifically for efficient lamps. Therefore the Evaluator relied on this value even though the HOU value is slightly lower than that used for Instant Savings lamps and fixtures.

Appendix IV

IS: INTERVIEW GUIDE WITH RETAILER PARTNERS

Hello, may I please speak with _____?

Introduction

Hello, my name is _____, from Corporate Research Associates. I am calling on behalf of Efficiency Nova Scotia for the Instant Savings Program.

Identification and Screening of Respondent

The records we received from Efficiency Nova Scotia show your company has participated in their Instant Savings program. Efficiency Nova Scotia has contracted with Corporate Research Associates and Econoler to evaluate this program. Can I please speak with the person most responsible for stocking and supplying the LED light bulbs that have received rebates through Efficiency Nova Scotia's Instant Savings program this year? Would that person be you?

- › Person responsible available [CONTINUE]
- › Person responsible currently unavailable [ARRANGE CALL BACK WITH THE RIGHT PERSON]
- › No person responsible for stocking or management of products [CONTINUE INTERVIEW WITH CORPORATE MANAGER - CONTINUE]
- › Don't know [CONTINUE INTERVIEW WITH CORPORATE MANAGER - CONTINUE]
- › Refused [THANK AND TERMINATE]

Confidentiality

Your responses are for research purposes only. We will not share your information with any party in a way that could identify you or your company.

Recording of the Interview

I would like to record our interview so that I make sure I capture everything you say accurately. Is that all right with you?

Context

Since the beginning of 2017, Efficiency Nova Scotia has held two promotional campaigns for the Instant Savings program, where customers can get rebates for products including LED bulbs. They ran a spring promotion from March 30 to May 14 and a fall promotion that started on September 29 and will end on October 29. In this interview, I will sometimes ask you to focus just on the promotional campaign periods and sometimes I will ask you to think about those other months when there weren't any campaigns.

Section V - Verification of Products from Database

V1. [To the interviewer] Using the database supplied, check below which products the retailer sold during each campaign. Then, validate the information with the interviewee.

Product	Spring Campaign (March 30-May 14)	Fall Campaign (September 29-October 29)
ENERGY STAR A-type LED bulbs		
ENERGY STAR non-A-type LED bulbs		

NOTE: IF NO LED BULBS SOLD DURING EITHER CAMPAIGN, SKIP TO SATISFACTION SECTION

V2. For the purpose of our discussion, I would like you to provide information on the A-type LED bulbs separately from the non-A-type LED bulbs. Do you have sales figures for both products separately or are they combined?

IF SEPARATE, ASK EACH RELEVANT SECTION

IF COMBINED, ASK ABOUT BOTH TYPES UNDER ONE SECTION

Section L - Energy Star A-Type Led Bulbs

L1. First, I would like to discuss the number of individual ENERGY STAR **A-type** LED bulbs – not packages of bulbs – your company will sell in 2017.

By A-type LED bulbs, we refer to standard LED bulbs which are only screw-in bulbs and have a pear-like shape. They also provide omnidirectional light.

A. According to our information, your company sold _____ ENERGY STAR A-type LED bulbs during the 2017 spring campaign? Is this correct? [NOTE: This represents the number of individual bulbs, not the number of packs.]

☐ Yes

☐ No - Record actual number of individual bulbs sold:

☐ No ENERGY STAR A-type LED bulbs sold during the spring campaign

B. Do you anticipate selling more, fewer or about the same number of ENERGY STAR A-type LED bulbs during the fall campaign as you did during the spring campaign earlier this year?

C. How many ENERGY STAR A-type LED bulbs do you anticipate selling during the fall campaign?

D. Is your answer based on a number of individual bulbs or a number of packs? [IF ANSWER IS A NUMBER OF PACKS, ASK HOW MANY LED BULBS ON AVERAGE ARE IN EACH PACK]

E. Of all the ENERGY STAR LED A-type bulbs you anticipate selling in 2017, roughly what percentage of bulbs will have been sold during the spring and fall campaign periods combined—that is from March 30 to May 14, and from September 29 to October 29 2017?

L2. Would sales of ENERGY STAR A-type LED bulbs during the spring and fall campaigns have been the same, lower or higher without the Instant Savings program?

- ☐ Same [SKIP TO NEXT SECTION]
☐ Lower [SKIP TO L2b]
☐ Higher [SKIP TO L2a]
☐ Don't know [SKIP TO NEXT SECTION]
☐ Refused [SKIP TO NEXT SECTION]

L2a. [IF HIGHER] Why do you think your sales would have been higher without the rebate program?

L2b. [IF LOWER] By what percentage do you estimate the number of ENERGY STAR LED A-type bulbs you sold this year would have been lower during the two campaign periods combined, without the Instant Savings program?

RECORD PERCENT DECREASE ____%

Section N - Energy Star Non-A-Type Led Bulbs

N1. Now, I would like to discuss the number of individual ENERGY STAR **non-A-type** LED bulbs – not packages of bulbs – your company will sell in 2017.

By non-A-type LED bulbs, we refer to those bulbs which do not have a pear-like shape. Non-A-type LED bulbs can either have a screw-in or pin base. They are often used to replace halogens, reflector lamps or incandescent lamps for recessed fixtures.

A. According to our information, your company sold _____ ENERGY STAR non-A-type LED bulbs during the spring campaign? Is this correct? [NOTE: This represents the number of individual bulbs, not the number of packs.]

- ☐ Yes
☐ No - Record actual number of individual bulbs sold:
☐ No ENERGY STAR LED non-A-type bulbs sold during the spring campaign

- B. Do you anticipate selling more, fewer or about the same number of ENERGY STAR non-A-type LED bulbs during the fall campaign as you did during the spring campaign earlier this year?
- C. How many ENERGY STAR non-A-type LED bulbs do you anticipate selling during the fall campaign?
- D. Is your answer based on a number of individual bulbs or a number of packs? [IF ANSWER IS A NUMBER OF PACKS, ASK HOW MANY LED BULBS ON AVERAGE ARE IN EACH PACK]
- E. Of all the ENERGY STAR LED non-A-type bulbs you anticipate selling in 2017, roughly what percentage of bulbs will have been sold during the spring and fall campaign periods combined—that is from March 30 to May 14, and from September 29 to October 29, 2017?
- N2. Would sales of ENERGY STAR non-A-type LED bulbs during the spring and fall campaigns have been the same, lower or higher without the Instant Savings program?
- ☐ Same [SKIP TO NEXT SECTION]
- ☐ Lower [SKIP TO N2b]
- ☐ Higher [SKIP TO N2a]
- ☐ Don't know [SKIP TO NEXT SECTION]
- ☐ Refused [SKIP TO NEXT SECTION]
- N2a. [IF HIGHER] Why do you think your sales would have been higher without the rebate program?
- N2b. [IF LOWER] By what percentage do you estimate the number of ENERGY STAR LED non-A-type bulbs you sold this year would have been lower during the two campaign periods combined, without the Instant Savings program?
- RECORD PERCENTAGE ____%

Section I - Instant Savings Program's Impact

11. For the next questions, please take in consideration both ENERGY STAR A-type and non-A-type LED bulbs.

I would like to understand the influence Instant Savings has had on staff and consumer knowledge, as well as product offerings. Using a 0-10 scale, where 0 means “not at all” and 10 means “a great deal”, to what extent has Instant Savings helped increase...

- a. The sales staff's knowledge of ENERGY STAR LED bulbs and their benefits

Scale:

Please explain your response:

- b. The consumers' knowledge of ENERGY STAR LED bulbs and their benefits

Scale:

Please explain your response:

- c. The variety of ENERGY STAR LED bulbs stocked in your stores

Scale:

Please explain your response:

- d. The quantity of ENERGY STAR LED bulbs stocked in your stores

Scale:

Please explain your response:

12. While the Instant Savings rebates are only offered during the spring and fall campaigns, Efficiency Nova Scotia promotes energy-efficient products including LED bulbs throughout the year, through other energy efficiency programs and services, its website and advertisement activities, such as home shows. It is likely that the discount has a direct impact on sales of LEDs, but Efficiency Nova Scotia's promotion of energy efficiency throughout the year may indirectly influence the sales of LEDs as well. For instance:

- › your sales people may have a better knowledge of LEDs, thus being more apt to recommend these products to customers outside of the campaigns; or perhaps
- › your offer of LEDs may change and be more diversified and attractive throughout the year due to program influence; or maybe
- › awareness of energy efficiency among customers may have increased due to Efficiency Nova Scotia's programs and general promotion of energy-efficiency.

With this in mind, approximately what percentage of the number of ENERGY STAR LED bulbs you sold outside of the two campaign periods can you directly or indirectly attribute to Efficiency Nova Scotia's programs and promotion – in essence, sales you would not have had during the months of January through March, mid-May through September, and November through December, if the program did not exist?

[SINCE THE FALL REBATE CAMPAIGN IS NOT OVER YET, ASK THE RESPONDENT TO ANSWER BASED ON A PROJECTION]

Enter %:

[If interviewee cannot provide an exact percentage, ask for a range (e.g. 0-10%, 10-20%, etc.)]

I2a. Please explain your answer:

Section S - Satisfaction

S0. On a scale of 1 to 10, where 1 is "not at all satisfied" and 10 is "completely satisfied", please rate your satisfaction in regard to the following aspects of the Instant Savings program.

Aspects of the program	Score 1 = not at all satisfied 10 = completely satisfied NA = Not applicable	Reason If less than 8, please share the reason(s) for your score.
S1. The overall program		
S2. The preparation process to the campaign		
S3. The program marketing and advertising		
S4. The products covered by the program		
S5. The rebate amounts		
S6. The rebate processing, tracking and reporting		
S7. The overall relationship with Summerhill		
S8. Timeliness of program information provided to you		
S9. The SKU list approval process		

Section Br - Barriers and Recommendations

The last questions will allow us to help ENS improve the Instant Savings program.

BR1. In your opinion, what prevents consumers from buying energy-efficient products? What is the single most important barrier? How if at all has that changed in the past year?

BR2. And finally, what suggestions do you have, if any, to increase participation in the program?

END: That concludes my questions. Thank you for your time and your collaboration.

Appendix V

IS: PARTICIPANT INTERCEPT SURVEY QUESTIONNAIRE

SELECT LOCATION:

Home Depot

Not Home Depot

INTRODUCTION AND ELIGIBILITY

Hello, my name is _____ and I am with Corporate Research Associates. Today we are conducting a short survey about energy efficiency. We are gathering information from customers who just purchased L-E-D energy efficient lights.

[NOTE FOR THE HOME DEPOT STORE LOCATIONS: Please know that this survey was commissioned by Efficiency Nova Scotia, not the Home Depot, but that the results will be shared with the Home Depot Canada in all confidentiality.]

I1. Did you purchase L-E-Ds today? [CODE ONE ONLY]

- 1. Yes
- 2. No [THANK AND TERMINATE].
- 98. (Don't Know) [ASK AGAIN. IF STILL DK, THANK AND TERMINATE].
- 99. (Refused) [THANK AND TERMINATE].

[NOTE FOR THE HOME DEPOT STORE LOCATIONS: SKIP TO I2, DO NOT ASK I1a]

I1a. Would you mind showing me the L-E-Ds you bought today? [CODE ONE ONLY]

[CONFIRM VISUALLY THAT THE PRODUCT BOUGHT BY RESPONDENTS IS L-E-Ds. IF NO, THANK AND TERMINATE.]

- 1. Product is L-E-D [CONTINUE]
- 2. Other type of bulbs/products [THANK AND TERMINATE]
- 99. Refused [CONTINUE]

I2. [IF CODE 1 IN I1] To the best of your knowledge, was the price of this/these L-E-D light bulb(s) discounted at the cash register? [CODE ONE ONLY]

- 1. Yes
- 2. No [ASK AGAIN. IF STILL SAYS NO, THANK AND TERMINATE]
- 98. (Don't Know) [ASK AGAIN. IF STILL DK, THANK AND TERMINATE]
- 99. (Refused) [THANK AND TERMINATE]

I3. The survey will take about five minutes. You will receive a \$5 cash incentive as a thank you for your cooperation. Would you be willing to answer the survey?

1. Yes [CONTINUE – GO TO P1]
2. No [THANK AND TERMINATE]

Purchase (P Series)

P1. Are there any L-E-Ds currently installed in your home? [CODE ONE ONLY]

1. Yes
2. No
98. (Don't Know)
99. (Refused)

P2_LED. How many L-E-Ds did you purchase today? [ENTER THE NUMBER OF BULBS NOT PACKAGES. PROBE TO AVOID ACCEPTING A RANGE]

Enter number of L-E-Ds bought: ____

98. (Don't Know)
99. (Refused) Thank and Terminate

[IF P2_LED=0 OR DON'T KNOW READ P2a_LED - CONFIRM THAT THE RESPONDENT BOUGHT L-E-D BULBS TODAY, AS PER RESPONSE IN I1. IF NO SUCH PURCHASE, THANK AND TERMINATE.]

P2a_LED. Earlier you stated that you did purchase L-E-D bulbs. Can you confirm if you purchased L-E-D bulbs today?

1. Yes [GO TO P2_LEDconfirm]
2. No [CANCEL INTERVIEW]

P2_LEDconfirm. How many L-E-Ds did you purchase today?

Enter number of L-E-Ds bought: ____

98. (Don't Know) THANK AND TERMINATE
99. (Refused) THANK AND TERMINATE

P3a. [If P2_LED or P2_LEDconfirm=1] For which of the following reasons did you buy this L-E-D bulb. Do you plan on installing it... [READ – CODE ONE ONLY - **SHOW PICTURES TO ALL RESPONDENTS**]

1. To replace another LED bulb
2. To replace a CFL bulb
3. To replace a halogen bulb
4. To replace an incandescent
5. Into a new lamp or light fixture
97. (Other [SPECIFY_____])
98. (Don't Know)
99. (Refused)

P3b. [If P3a<> 5]. Do you plan on installing this L-E-D bulb... [READ – CODE ONE ONLY]

1. To replace a bulb once it burns out
2. To replace a bulb that is still working
97. (Other [SPECIFY_____])
98. (Don't Know)
99. (Refused)

P4. [If P2_LED or P2_LEDconfirm>1] For which of the following reasons did you buy these [INSERT NUMBER OF LEDs FROM P2_LED or P2_LEDconfirm] L-E-D bulbs? How many, if any, of these [Of the [INSERT NUMBER OF LEDs FROM P2_LED or P2_LEDconfirm] L-E-D bulbs will be installed... **[TOTAL NUMBER OF BULBS RECORDED CAN'T BE HIGHER THAN COUNT IN P2_LED OR P2_LEDconfirm] [SHOW PICTURES TO ALL RESPONDENTS]** NOTE TO INTERVIEWER – ALL CATEGORIES NEED A NUMBER, ADD IN ZEROS FOR ANY THAT WERE NOT SELECTED.

- a. To replace another LED bulb
- b. To replace a CFL bulb
- c. To replace a halogen bulb
- d. To replace an incandescent
- e. Into a new lamp or light fixture
- f. For some other reason? Please specify:_____

___ Response ___98 Don't Know ___99 Refused

- P5. [If P4a or P4b or P4c or P4d >0]. Concerning the bulbs that you will use to replace existing bulbs: do you plan on installing these L-E-D bulbs mostly ... [READ – CODE ONE ONLY]
1. To replace bulbs once they burn out
 2. To replace bulbs that are still working
 97. (Other [SPECIFY _____])
 98. (Don't Know)
 99. (Refused)
- P6a. [If P2_LED or P2_LEDconfirm=1] Do you plan on installing this L-E-D bulb in a specific room in particular? [CODE ONE ONLY]
1. Yes
 2. No, in whichever room a bulb is needed
 98. (Don't know)
 99. (Refused)
- P6b. [If P6a=1] In which room do you plan on installing this bulb? [CODE ONE ONLY]
1. Kitchen
 2. Living room
 3. Bedroom
 4. Bathroom
 5. Dining room
 6. Hallway or staircase
 7. Closet or storage
 96. (Other, specify: _____)
 98. (Don't know)
 99. (Refused)
- P7a. [If P2_LED or P2_LEDconfirm>1] Do you plan on installing these L-E-D bulbs in specific rooms in particular? [CODE ONE ONLY]
1. Yes
 2. No, in whichever rooms a bulb is needed
 98. (Don't know)
 99. (Refused)

P7b. [If P7a=1] How many of these [INSERT NUMBER OF LEDs FROM P2_LED or P2_LEDconfirm] L-E-D bulbs will be installed in a...? [READ]

NOTE TO INTERVIEWER – ALL CATEGORIES NEED A NUMBER, ADD IN ZEROS FOR ANY THAT WERE NOT SELECTED. SUM OF BULBS CANNOT EXCEED NUMBER FROM P2_LED or P2_LEDconfirm

1. Kitchen
2. Living room
3. Bedroom
4. Bathroom
5. Dining room
6. Hallway or staircase
7. Closet or storage
96. (Other, specify:_____)
98. (Don't know)
99. (Refused)

Awareness of Program and Efficiency Nova Scotia (AW Series)

AW1. Have you ever heard of the Efficiency Nova Scotia program which offers instant savings at the cash register for the purchase of energy-efficient products such as L-E-D light bulbs, programmable thermostats and appliances? [CODE ONE ONLY]

1. Yes [GO TO CS1]
2. No [GO TO AW3]
98. (Don't Know) [GO TO AW3]
99. (Refused) [GO TO AW3]

CS1. How did you find out about this program? [DON'T READ; ALLOW MULTIPLE RESPONSE BUT DO NOT PROBE FOR MULTIPLE]

1. (TV ads)
2. (Print ads)
3. (Radio ads)
4. (In-store promotions)
5. (Store flyer)
6. (Store personnel)
7. (Efficiency Nova Scotia website)
8. (Facebook or other social media)
9. (Online advertisement)
10. (YouTube video)
11. (Word of mouth)
12. (Through an Efficiency Nova Scotia representative during an in-store engagement event)
97. (Other [SPECIFY _____])
98. (Don't know)
99. (Refused)

AW3. Prior to today, had you ever heard of Efficiency Nova Scotia, the organization that has the responsibility for helping Nova Scotians reduce their energy use? [CODE ONE ONLY]

1. Yes
2. No
98. (Don't Know)
99. (Refused)

Free-Ridership (FR Series)

FR0a. You bought L-E-Ds today. Efficiency Nova Scotia offered a discount on packages of L-E-Ds. Before paying at the cash register, were you aware that a discount was offered on the purchase of L-E-Ds? [CODE ONE ONLY]

1. Yes [GO TO FR0c]
2. No [GO TO FR0b]
98. (Don't Know) [GO TO FR0b]
99. (Refused) [GO TO FR0b]

FR0b. [ASK IF NOT AWARE OF THE DISCOUNT (FR0a=2, DK, REF)] I just want to make sure I understand - You did not know about the discount on specific packages of L-E-Ds before paying at the register? [CODE ONE ONLY]

1. Yes, I knew about the discount
2. No, I did not know about the discount [GO TO SECTION PR]
98. (Don't know) [GO TO SECTION PR]
99. (Refused) [GO TO SECTION PR9]

[ASK THE FOLLOWING FR QUESTIONS IF AWARE OF THE DISCOUNT (FR0a=1) OR (FR0b=1), OTHERWISE SKIP TO SECTION PR]

FR0c. Before the beginning of the rebate campaign, which began on September 29th, were you aware that discounts on LEDs would be offered this fall?

1. Yes
2. No [SKIP TO FR0e]
98. (Don't Know) [SKIP TO FR0e]
99. (Refused) [SKIP TO FR0e]

FR0d. [ASK IF YES IN FROc] Did you postpone your purchase of L-E-Ds to take advantage of the discount?

1. Yes
2. No
98. (Don't Know)
99. (Refused)

FR0e. How did you learn about the discount offered on the purchase of specific packages of LEDs?
[DO NOT READ RESPONSES – CODE AS MANY AS APPLY]

1. (TV ads)
2. (Print ads)
3. (Radio ads)
4. (In-store signage)
5. (Store flyer)
6. (Store personnel)
7. (Efficiency Nova Scotia website)
8. (Facebook/Social Media)
9. (Online advertisement)
10. (YouTube video)
11. (Word of Mouth)
12. (Through an Efficiency Nova Scotia representative during an in-store customer engagement event)
13. (From previous participation)
96. (Other [SPECIFY: _____])
98. (Don't Know)
99. (Refused)

FR0f. Did you see the stickers, shelf signs or posters in the light bulb section of the store promoting the discount offered on L-E-Ds? [CODE ONE ONLY]

1. Yes
2. No
98. (Don't know)
99. (Refused)

FR1. You mentioned that you were aware, before paying at the cash register, that a discount was offered on the purchase of L-E-Ds. Did knowing this play a part in your decision to buy L-E-Ds today? [CODE ONE ONLY]

1. Yes
2. No
98. (Don't know)
99. (Refused)

FR2a. If the discount on L-E-Ds had NOT been offered today, what would you have bought today?
Would you have... [READ, CODE ONE ONLY]

- 1. Bought L-E-Ds anyway
- 2. Bought other type of bulbs
- 3. Not bought any bulb
- 98. (Don't know)
- 99. (Refused)

FR2b. [ASK IF FR2a=2] Which type(s) of bulb would you have purchased instead today? [READ -
ALLOW MULTIPLE - SHOW PICTURES IF NEEDED]

- 1. Incandescent
- 2. Halogen
- 3. CFLs
- 96. Other, SPECIFY: _____
- 98. (Don't know)
- 99. (Refused)

FR3. How likely would you have been to buy the L-E-Ds that you purchased today if you had to pay
the full price? Please answer on a scale of 0 to 10, with a 0 indicating that you "Definitely Would
Not Have Bought these L-E-Ds" and a 10 indicating that you "Definitely Would Have Bought
these L-E-Ds." [PROBE TO AVOID ACCEPTING A RANGE]

____ Response ____98 Don't Know ____99 Refused

FR4. If the discount had NOT been offered, when would you have purchased the L-E-Ds that you
purchased today? Would it have been...? [CODE ONE ONLY]

- 1. [ASK IF FR0d=1] Earlier
- 2. Definitely today
- 3. Probably today
- 4. Probably at a later date
- 5. Definitely at a later date
- 96. (Would not have purchased them at all) **[SKIP to PR Series]**
- 98. (Don't Know)
- 99. (Refused)

FR5. Without the discount, would you have definitely purchased the same number of L-E-Ds, probably purchased the same number, probably purchased fewer or definitely purchased fewer? [CODE ONE ONLY]

1. Definitely the same number
2. Probably the same number
3. Probably fewer
4. Definitely fewer
98. (Don't know)
99. (Refused)

Products Rebated (PR Series)

PR1. [ASK IF AW1=1] Besides the L-E-D/L-E-Ds that you purchased with a discount today, are you aware of any other energy efficiency products that are discounted by Efficiency Nova Scotia? [CODE ONE ONLY]

1. Yes [GO TO PR2]
2. No [GO TO PR3]
98. (Don't Know) [GO TO PR3]
99. (Refused) [GO TO PR3]

PR2. [ASK IF PR1 = 1] What are those products? Any others? [DO NOT READ RESPONSES – CODE AS MANY AS APPLY]

1. (L-E-D fixtures)
2. (Clothes Line)
3. (Dimmer switches)
4. (Motion sensors)
5. (Power bars or Smart strips)
6. (Heavy-duty timers)
7. (Programmable thermostats)
8. (Refrigerators)
9. (Clothes washers)
10. (Air purifiers)
11. (Dehumidifiers)
12. (Bathroom fans)
13. (Kitchen range hood fans)
96. (Other, SPECIFY: _____)
98. (Don't Know)
99. (Refused)

Demographics (D Series)

These final questions are asked for statistical purposes only. The information collected is strictly confidential and will only be used in group results.

[ASK ALL RESPONDENTS]

D1. What type of residence do you live in? [READ FIRST SEVEN RESPONSES; SELECT ONE RESPONSE]

1. Detached single-family house
2. Semi-detached house
3. Mobile home or house trailer
4. Townhouse or duplex which share adjacent walls
5. Row house (Single story apartment building)
6. Apartment or condo building that has fewer than five stories
7. Apartment or condo building that has five or more stories
96. (Other [SPECIFY: _____])
98. (Don't know)
99. (Refused)

D2. Do you own or rent this residence? [CODE ONE ONLY]

1. Own/buying [GO TO D4]
2. Rent/lease [GO TO D3]
96. (Other (Describe) _____) [GO TO D3]
99. (Refused) [GO TO D3]

D3. Do you or does your landlord pay the electric bills for your residence? [CODE ONE ONLY]

1. (I pay the electric bills)
2. (My landlord pays the electric bills)
96. (Other [Describe _____])
98. (Don't Know)
99. (Refused)

D4. Do you allow me to record your gender? [DO NOT READ.CODE ONE ONLY]

1. (Male)
2. (Female)
99. (Refused)

END. Those are all the questions I have for you. I thank you very much for your time and cooperation. Here is your \$5 for participating in our survey.

Appendix VI

IS: PARTICIPANT SURVEY RESULTS

The participant survey results are presented in the following tables.

P1. Are there any L-E-Ds currently installed in your home?

LED Lamps Currently Installed	2015	2016	2017
Sample Size	255	246	100
Yes	84%	87%	90%
No	16%	13%	7%
Don't know	-	-	3%

P2. How many L-E-Ds did you purchase today?

Number Purchased	2015	2016	2017
Sample Size	255	217**	100
1-2 LEDs	25%	19%	18%
3-4	34%	29%	29%
5-7	24%	23%	10%
8-10	7%	14%	31%
11 or more	9%	15%	12%
Average*	5.1	6.8	6.2
*Don't know/Refused excluded from Average calculations			
**A number of respondents are missing this question in the Spring data as it was optional			

P3a/P4. For which of the following reasons did you buy this/these L-E-D bulb(s)? Do you plan on installing it...

Reason for Purchasing LED Bulbs	2015	2016	2017
Sample Size	255	246	100
To replace a CFL bulb	46%	34%	48%
To replace a halogen bulb/incandescent bulb	46%	51%	27%
To replace another LED bulb	2%	9%	15%
Into a new lamp or light fixture	5%	6%	7%
For some other reason	-	-	3%

P5. Concerning the bulbs that you will use to replace existing bulbs: do you plan on installing these L-E-D bulbs mostly...

Reason for Purchasing LED Bulbs	2015	2016	2017
Sample Size	95*	220	91
To replace bulbs that are still working	71%	72%	60%
To replace bulbs once they burn out	22%	25%	35%
Others	5%	2%	4%
Don't know/Refused	2%	-	-
*Base: Fall Survey only, respondents who were replacing an existing bulb			

P6a/P7a. Do you plan on installing this/these L-E-D bulb(s) in a specific room(s) in particular?

P6b/P7b. In which room(s) do you plan on installing this/these bulb(s)?

Specific Installation Location	2017
Sample Size	100
Yes	42%
No, in whichever rooms a bulb is needed	58%
Room Plan on Installing	2017
Sample Size*	42
Bathroom	18%
Kitchen	15%
Bedroom	15%
Living room	15%
Garage	9%
Basement	9%
Dining room	5%
Outside	5%
Hallways or staircase	2%
Family room	2%
Closet or storage	1%
Others	3%
*Base: Respondents who planned on installing bulb(s) in specific rooms	

AW1. Have you ever heard of the Efficiency Nova Scotia program which offers instant savings at the cash register for the purchase of energy-efficient products such as L-E-D light bulbs, programmable thermostats and appliances?

ENS Awareness	2015	2016	2017
Sample Size	255	246	100
Yes	69%	58%	63%
No	31%	41%	36%
Don't know	1%	1%	1%

CS1. How did you find out about this program?

Sources of Awareness*	2015	2016	2017
Sample Size**	175	142	63
In-store promotions	47%	40%	32%
TV ads	19%	12%	16%
Word of mouth	11%	15%	13%
ENS website	9%	10%	13%
Store flyer	-	1%	11%
Through an ENS representative during an in-store customer engagement event	2%	6%	10%
Facebook or other social media	1%	7%	6%
Print ads	18%	14%	5%
Online advertising	-	5%	5%
Another ENS program	-	-	5%
Radio ads	9%	11%	2%
Store personnel	6%	11%	-
Others	7%	2%	3%
Don't know	1%	1%	-
*Multiple responses			
**Base: Respondents who were aware of Instant Savings			

AW3. Prior to today, had you ever heard of Efficiency Nova Scotia, the organization that has the responsibility for helping Nova Scotians reduce their energy use?

ENS Awareness	2015	2016	2017
Sample Size	255	246	100
Yes	96%	92%	92%
No	4%	7%	7%
Don't know	-	-	1%

FR0aa/FR0a. You bought L-E-Ds today. Efficiency Nova Scotia offered a discount on packages of L-E-Ds. Before paying at the cash register, were you aware that a discount was offered on the purchase of L-E-Ds?

FR0bb/FR0b. I just want to make sure I understand - You did not know about the discount on specific packages of L-E-Ds before paying at the register?

Discount Awareness	2015	2016**	2017
Sample Size*	255	246	100
Yes, was aware of discount before paying	79%	90%	94%
No, was not aware of discount before paying	21%	10%	6%
*Base: Respondents who purchased LED lamps on the day of the survey			
**Slight wording change in 2016			

FR0c. Before the beginning of the rebate campaign, which began on September 29th, were you aware that discounts on L-E-Ds would be offered this fall?

Fall Program Awareness	2016**	2017
Sample Size*	109	94
Yes, aware that discounts would be offered this fall	16%	15%
No, not aware that discounts would be offered this fall	81%	82%
Don't know	4%	3%
*Base: Respondents who were aware of discount prior to purchase		
**Results are from fall only		

FR0d. Did you postpone your purchase of L-E-Ds to take advantage of the rebate?

Postponed Purchase of LEDs to Take Advantage of Rebate	2016** (#)	2017 (#)
Sample Size*	17	14
Yes	12	5
No	5	9
*Base: Respondents who were aware of discount prior to campaign beginning **Results are from fall only		

FR0cc/FR0e. How did you learn about the discount offered on the purchase of specific packages of L-E-Ds?

Learn of Discount	2015**	2016**	2017**
Sample Size*	201	221	94
***In-store promotions	79%	66%	78%
Store personnel	18%	15%	16%
Store flyer	-	1%	9%
Through an ENS representative during an in-store engagement event	1%	9%	6%
TV ads	4%	3%	3%
Print ads	8%	6%	1%
Word of mouth	4%	5%	1%
Online advertisement	-	2%	1%
Radio ads	3%	5%	-
Facebook/Social media	-	2%	-
ENS website	2%	1%	-
From previous participation	-	1%	-
Others	-	-	1%
Don't know	-	-	2%
*Base: Respondents who were aware of discount prior to purchase **Multiple responses ***Wording change in 2017			

FR0cc1/FR0f. Did you see the stickers, shelf signs or posters in the light bulb section of the store promoting the discount offered on L-E-Ds?

In-store Promotion Awareness	2015	2016	2017
Sample Size*	201	221	94
Yes, saw stickers, shelf signs, posters	90%	88%	94%
No, did not see stickers, shelf signs, posters	10%	11%	5%
Don't know	-	-	1%
*Base: Respondents who were aware of discount prior to purchase			

FR11/FR1. You mentioned that you were aware, before paying at the cash register, that a discount is offered on the purchase of L-E-Ds. Did knowing this play a part in your decision to buy L-E-Ds today?

Discount Influenced Purchase	2015	2016	2017
Sample Size*	201	221	94
Yes	88%	87%	85%
No	11%	12%	15%
Don't know	-	1%	-
*Base: Respondents who were aware of discount prior to purchase			

FR21a/FR2a. If the discount on L-E-Ds had NOT been offered today, what would you have bought today? Would you have... .

Purchases if Discount Had Not Been Offered	2015	2016	2017
Sample Size*	201	221	94
Not bought any bulbs	70%	59%	55%
Bought L-E-Ds anyway	26%	37%	38%
Bought other type of bulbs	4%	4%	5%
Don't know	-	-	1%
*Base: Respondents who were aware of discount prior to purchase			

FR21b/FR2b. Which type(s) of bulb would you have purchased instead today?

Other Type of Bulb That Would Have Been Purchased	2015 (#)	2016 (#)	2017 (#)
Sample Size*	9	9	5
Halogen	2	3	2
Incandescent	2	2	1
CFLs	2	1	-
Others	-	1	1
Don't know	3	2	1
*Base: Respondents who were aware of discount prior to purchase, and who would have bought another type of bulb if discount had not been offered			

FR31/FR3. How likely would you have been to buy the L-E-Ds that you purchased today if you had to pay the full price? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely Would Not Have Bought these L-E-Ds” and a 10 indicating that you “Definitely Would Have Bought these L-E-Ds.”

Likelihood of Buying LEDs without Discount	2015**		2016**		2017**	
	Sample Size*	Mean*	Sample Size*	Mean*	Sample Size*	Mean*
Likelihood of buying LEDs if discount had not been offered	201	3.1	221	3.5***	94	4.2
*Base: Respondents aware of discount prior to purchase **Don't know/Refused excluded from calculations ***Slight wording change in fall 2016						

FR41/FR4. If the discount had NOT been offered, when would you have purchased the L-E-Ds that you purchased today? Would it have been...?

Length of Time Before Purchasing LEDs	2015	2016	2017
Sample Size*	201	221	94
Definitely today	14%	16%	21%
Probably today	8%	10%	9%
Probably at a later date	30%	33%	32%
Definitely at a later date	39%	39%	34%
Would not have purchased them at all	8%	2%	4%
*Base: Respondents aware of discount prior to purchase			

FR51/FR5. Without the discount, would you have definitely purchased the same number of L-E-Ds, probably purchased the same number, probably purchased fewer or definitely purchased fewer?

Number of Bulbs Likely To Purchase Without Discount	2015	2016	2017
Sample Size*	184	216	90
Definitely the same number	20%	17%	24%
Probably the same number	17%	13%	18%
Probably fewer	14%	24%	30%
Definitely fewer	47%	45%	28%
Don't know	2%	1%	-
*Base: Respondents who were aware of discount prior to purchase, and would have purchased bulbs at some point without discount			

PR1. Besides the L-E-D/L-E-Ds that you purchased with a discount today, are you aware of any other energy efficiency products that are discounted by Efficiency Nova Scotia?

Other Discounted Product Awareness	2015	2016**	2017
Sample Size*	175	142	63
Yes, aware of other products	42%	36%	40%
No, not aware of other products	56%	61%	56%
Don't know	2%	3%	5%
*Base: Respondents who were aware of Instant Savings			
**Slight wording change in 2016			

PR2. What are those products? Any others?

Other Discounted Products*	2015	2016	2017
Sample Size**	73	58	25
Heat Pumps	-	-	48%
Programmable thermostats	33%	41%	44%
Refrigerators	26%	19%	24%
Power bars or smart strips	19%	22%	16%
****LED fixtures	12%	3%	12%
Windows	-	-	8%
Hot water tank	-	-	8%
***Dimmer switches	27%	38%	4%
Clotheslines and clothes dryers	5%	12%	4%
Kitchen range hood fans	-	-	4%
Dehumidifiers	-	-	4%
***Heavy-duty Timers	15%	3%	-
Motion sensors	4%	19%	-
Clothes washers	5%	12%	-
Others	4%	2%	8%
Don't know/Refused	7%	14%	8%
*Multiple responses **Base: Among those aware of other products discounted by ENSs ***Slight wording change in 2015 ****Slight wording change in 2016 and 2017			

D1. What type of residence do you live in?

Type of Home	2015	2016	2017
Sample Size	255	246	100
Detached single-family house	80%	86%	74%
Apartment or condo building that has fewer than five stories	4%	3%	11%
Semi-detached house	7%	5%	10%
Townhouse or duplex which shares adjacent walls	5%	1%	4%
Mobile home or house trailer	2%	2%	1%
Apartment or condo building that has five or more stories	2%	3%	-

D2. Do you own or rent this residence?

Home Ownership	2015	2016	2017
Sample Size	255	246	100
Own/buying	92%	92%	87%
Rent/lease	8%	8%	13%

D3. Do you or does your landlord pay the electric bills for your residence?

You Pay Electric Bills	2015	2016	2017
Sample Size*	21	18	13
I pay the electricity bill	95%	94%	69%
My landlord pays the electricity bill	5%	6%	31%
*Base: Respondents who rent or lease their home			

D4. Gender

Gender	2015	2016	2017
Sample Size**	254	245	100
Male	59%	62%	53%
Female	41%	38%	47%
**Refused excluded from calculations			

Appendix VII

IS: UNITARY SAVINGS CALCULATIONS FOR MEASURES NOT UPDATED IN 2017

For 2017, the Evaluator reviewed only the unitary savings of LED lamps and fixtures, which are the products generating by far the most savings for the program component, as well as clothes washers and refrigerators whose baseline changed as a result of new federal regulations. For other products, the Evaluator relied on 2016 values since the unitary savings of these products have remained fairly stable over the last years.

This appendix presents the gross unitary savings calculation details of the measures for which the 2016 evaluation values were maintained since none of their parameters required an update this year.

Dimmer Switches

ENS and the Evaluator used a unitary savings value of 17.0 kWh per year for dimmer switches. This value is taken from the 2016 Evaluation Report and takes into account the NEHROU metered value of 2.7 hrs/day for all types of bulbs, a dimmer switch savings value of 20 percent of the wattage, which is based on the OPA 2011 Prescriptive Measures and Assumptions, and a fixture wattage value equal to two 43 W lamps.

Indoor Motion Sensors

ENS and the Evaluator used a unitary savings value of 45.8 kWh per year for the indoor motion sensors under Instant Savings. This value is taken from the 2016 Evaluation Report and is based on the fixture wattage of 86 W, which corresponds to two 43 W bulbs, and an old operating time of 2.7 hours per day in conformity with the NEHROU Study for all types of bulbs.² Using a 54 percent reduction in operating time due to the motion sensor and based on the 2010 OPA Prescriptive Measures and Assumptions list,³ the efficient case operating time is set at 1.24 hours per day.

Indoor Motion Sensor with Dimmer Switches

ENS and the Evaluator used a unitary savings value of 53.6 kWh per year for indoor motion sensors with dimmer switches. This value is taken from the 2016 Evaluation Report and is based on the combined savings associated with the installation of both a dimmer switch and motion sensor. Using 20 percent savings for dimmed wattage and 54 percent for new operating time with sensor, as well as an operating time value of 2.7 hours per day and fixture wattage equal to two 43 W bulbs, the unitary savings of 53.6 kWh per year was established.

² See Section 9.1.1 for more details.

³ Ontario Power Authority (OPA), *2010 Prescriptive Measures and Assumptions*, published January 1, 2010.

Outdoor Motion Sensors

ENS and the Evaluator used a unitary savings value of 159 kWh per year for outdoor motion sensors, based on last year's evaluation results. This value is based on the OPA 2011 Prescriptive Measures and Assumptions,⁴ in which an old operating time of 4.75 hours per day and a new operating time of 2.95 hours per day are assumed. The displaced wattage has been adapted from the values contained in the OPA 2011, which assumes that 85 percent of outdoor lighting is for security spotlights with an average wattage of 275.6 W.⁵ The OPA also assumes that the remaining 15 percent is for porch lighting, which has an average wattage of 55.5 W. Therefore, the average lamp wattage was estimated at 242.6 W.

Power Bars With Integrated Timer

ENS and the Evaluator used a unitary savings value of 53.7 kWh per year according to last year's evaluation results. This original value was derived from the 2011 OPA report,⁶ with a small adjustment made to the number of days used per year, namely the total 12-month period was set at 365 days, instead of 12 times 30 days (360 days).

Load Sensing Power Bars (Smart Strips)

ENS and the Evaluator used a unitary savings value of 53.8 kWh per year for load sensing power bars sold through Instant Savings. This value is based on last year's evaluation report which uses information provided in the 2015 Pennsylvania Public Utility Commission Technical Reference Manual (TRM), which cites documents produced by New York State Energy Research and Development Authority (also known as NYSERDA) and the Energy Center of Wisconsin. Since six-plug power bars are the most common product sold through Instant Savings, the unitary savings value is an average calculated based on the unitary savings for five-plug and seven-plug units sold for an unspecified use.

Heavy-Duty Outdoor Timers

ENS and the Evaluator used a unitary savings value of 122 kWh per year for heavy-duty outdoor timers, based on the 2016 Evaluation Report. This value is obtained from the survey results of the OPA 2012 Consumer Program Evaluation⁷ which outlines a distribution pattern of heavy-duty timer end-uses that is similar to that of Instant Savings.

⁴ Ontario Power Authority (OPA), *2011 Prescriptive Measures and Assumptions Version 1*, March 2011.

⁵ Representative lamp mix: $(85\% \times 2 \times 150\text{W incandescent}) + (10\% \times 2 \times 90\text{W halogen}) + (5\% \times 2 \times 26\text{W CFL}) = 275.6\text{ W}$.

⁶ Ontario Power Authority (OPA), *2011 Prescriptive Measures and Assumptions Version 1*, March 2011.

⁷ Research Into Action, *Final Report: 2012 Consumer Program Evaluation*, Report presented to OPA, October 11, 2013, p. 154.

Programmable Thermostats

For programmable thermostats, ENS has been using a unitary savings value of 221 kWh per year since the 2011 evaluation. This value is based on the results from Hydro-Québec's 2009 program evaluation of electronic thermostats in residential new construction⁸ and includes energy savings generated by the thermostat's accuracy performance and temperature setback for three types of dwellings (single-detached units, duplex/triplex/townhouses, and apartments). The unitary savings value was calculated through a weighted average based on the proportion of every dwelling type in the Nova Scotia residential market, as defined in the 2011 ENS Socket Study. Therefore, the unitary savings value associated with programmable thermostats remains 221 kWh per year.

Clotheslines and Outdoor Drying Racks

ENS and the Evaluator used a unitary savings value of 150 kWh per year for clotheslines and outdoor drying racks, based on last year's evaluation. The value is based on the 2011 OPA calculations⁹ using an average number of 416 loads per year, with the displacement of 68 loads per year if an outdoor method is used for clothes drying. NRCan data are also used to establish the average unit energy consumption of electric clothes dryers at 916 kWh per year for 2008, as the average appliance was seven years old, based on the results of the RDI annual survey for the 2014 evaluation.

⁸ Econoler, *Évaluation du programme thermostats électroniques – Volet nouvelle construction au marché résidentiel*, Final Report presented to Hydro-Québec, February 9, 2009.

⁹ Ontario Power Authority (OPA), *2011 Prescriptive Measures and Assumptions Version 1*, March 2011.

Appendix VIII

IS: ALGORITHM FOR FREE-RIDERSHIP CALCULATION

The figure below presents the algorithm for calculating the free-ridership level. The participant survey questionnaire included questions designed to assess the planning, quantity, efficiency, period, cost and influence of the program. Each group of questions was transposed into a level of program attribution, which was used to calculate the free-ridership level associated with each participant.

Section 1 – Free-ridership level for those who were unaware of discount before paying	
FR0a. Before paying at the cash register, were you aware that a discount was offered on the purchase of LEDs?	IF Yes : GO TO Section 2 IF No OR REF: Ask FR0b
FR0b. [ASK IF FR0a=2, DK, REF]) I just want to make sure I understand - You did not know about the discount on specific packages of LEDs before paying at the register?	IF Yes: : GO TO Section 2 IF No OR REF: FR0b = 100%
PA1 Score:	FR0b
Free-Ridership Level for those who were unaware of discount before paying	PA1 OTHERWISE: GO TO Section 2
Section 2 – Free-ridership level for those who postponed their purchase because of the program	
FR0c. Before the beginning of the campaign on September 29 th , were you already aware that discounts on LEDs would be offered this fall?	IF Yes : GO TO FR0d IF No OR REF: GO TO Section 3
FR0d. [ASK IF FROc=1] Did you postpone your purchase of LEDs to take advantage of the discount?	IF Yes: : FR0d = GO TO FR4 IF No OR REF: FR0d = Empty
FR4. If the discount had NOT been offered, when would you have purchased the L-E-Ds that you purchased today? Would it have been...? 1. [ASK IF FR0d=1] Earlier 2. Definitely today 3. Probably today 4. Probably at a later date 5. Definitely at a later date 6. (Would not have purchased them at all) 9. (Don't know / Refused)	IF 1: FR4 = 100% OTHERWISE: Go to Path 3
PA2 Score:	FR4
FR5. Without the discount, would you have definitely purchased the same number of LEDs? 1. Definitely the same number 2. Probably the same number 3. Probably fewer 4. Definitely fewer 9. (Don't know / Refused)	IF 1: FR5 = 100% IF 2: FR5 = 50% IF 3: FR5 = 25% IF 4: : FR5 = 0% IF 9: : FR5 = 0%
PA3 Score:	FR5
Free-Ridership Level for those who postponed their purchase because of the program	MEAN VALUE OF (PA2;PA3) OTHERWISE GO TO Section 3

Section 3 – Free-ridership level for regular participants (aware of discount, did not postpone purchase)	
FR3. How likely would you have been to buy the LEDs that you purchased today if you had had to pay the full price? (Scale 0 to 10)	FR3 = Answer x 10% IF 99: FR3 = EMPTY
FR2a. If the discount on L-E-Ds had NOT been offered today, what would you have bought today? 1. LEDs 2. Another type of bulbs 3. No bulbs 9. (Don't know / Refused)	IF 1: FR2a = 100% IF 2: FR2a = Use FR2b IF 3: FR2a = 0% IF 9: FR2a = EMPTY
FR2b. [ASK IF FR2a=2] Which type of bulb would you have purchased instead? 1. Incandescent 2. Halogen 3. CFLs 9. (Don't know / Refused)	IF 1 OR 2: FR2b = 0% IF 3: FR2b = 50% IF 9: FR2b = EMPTY
PA4 Score:	
FR4. If you had had to pay the full price, when would you have purchased the LEDs that you purchased today? 2. Definitely today 3. Probably today 4. Probably at a later date 5. Definitely at a later date 6. (Would not have purchased them at all) – SKIP TO FR5 9. (Don't know / Refused)	IF 2: FR4 = 100% IF 3: FR4 = 50% IF 4: FR4 = 25% IF 5: FR4 = 0% IF 6: FR4 = 0% IF 9: FR4 = 0%
PA5 Score:	
FR5. Without the discount, would you have purchased the same number of LEDs? 1. Definitely the same number 2. Probably the same number 3. Probably fewer 4. Definitely fewer 9. (Don't know / Refused)	IF 1: FR5 = 100% IF 2: FR5 = 50% IF 3: FR5 = 25% IF 4: FR5 = 0% IF 9: FR5 = 0%
PA6 Score:	
Inconsistency Test #1	IF FR3 ≥ 70% AND FR2a-b = 0%: PA4 = EMPTY
Inconsistency Test #2	IF FR3 ≤ 30% AND FR5 ≥ 50% PA6 = EMPTY
Free-Ridership Level (after inconsistency tests) for regular participants	MEAN VALUE OF: (PA4 ; PA5 ; PA6)

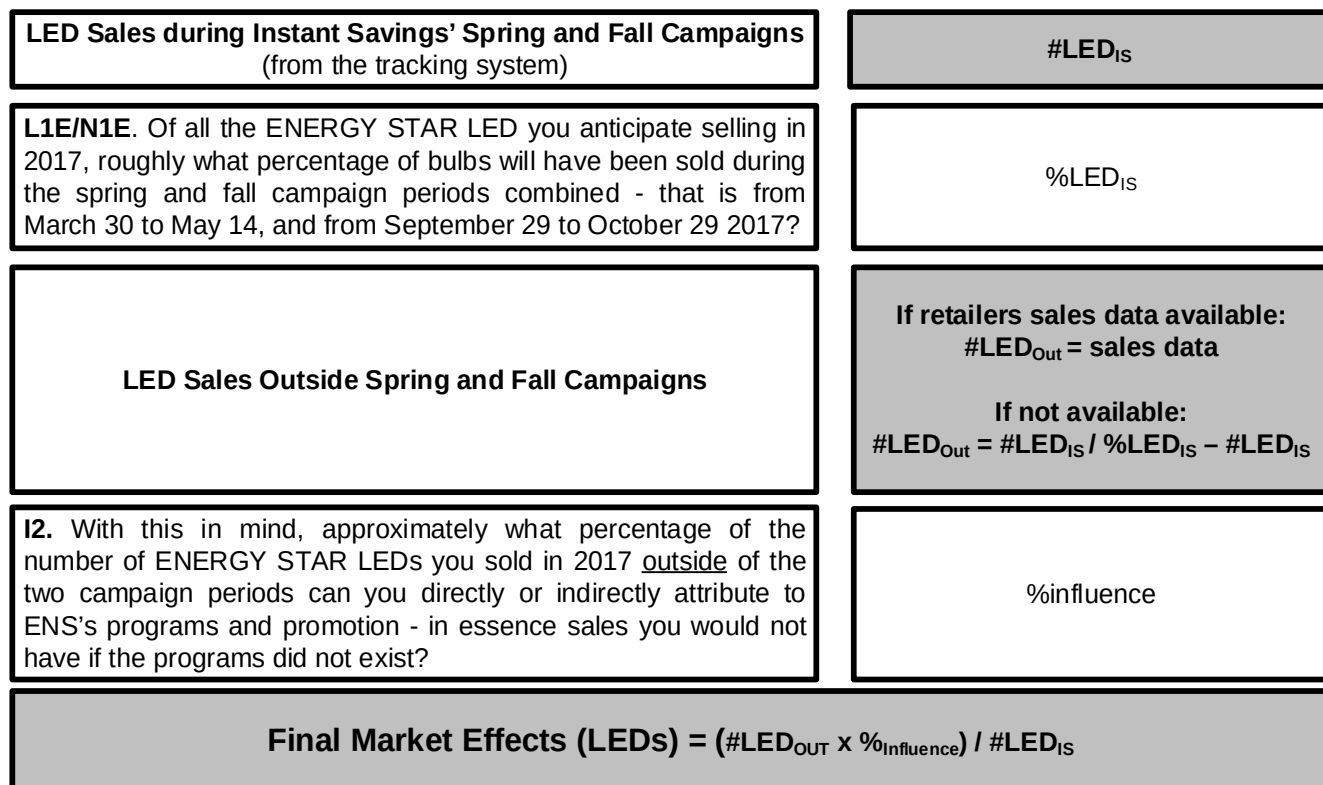
Appendix IX

IS: INTERNAL SPILLOVER METHODOLOGY

The retailer interviews were used to estimate the level of spillover by measuring the market effects attributable to the program for LED lamps. Instant Savings discounts were offered during two distinct periods: in the spring and in the fall. During and between these two periods, eligible product sales may have occurred due to program influence, even if participants were unaware of the discount. This influence can be due to greater knowledge and awareness of energy-efficient products and from a change in retailers' offers. These sales should be attributable to the program in the form of market effects.

Market effects were evaluated by asking the retailers to estimate program attribution for eligible products sold outside of the campaigns. Their answers were analyzed to measure the market effects attributable to Instant Savings and estimate the spillover effects for each product targeted. Market effects were obtained by applying the percentage of program attribution declared by the retailers to the sales of eligible products outside the two campaigns.

The figure below illustrates the methodology used to calculate the spillover level.





ECONOLER

EXISTING RESIDENTIAL PROGRAM

2017 DSM EVALUATION

EFFICIENCY NOVA SCOTIA

Final Report

March 15, 2018



ABBREVIATIONS

AHRI	Air conditioning, Heating and Refrigeration Institute
ASHP	Air-source heat pump
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning
AWHP	Air-to-water heat pump
CDD	Cooling degree day
COP	Coefficient of performance
CRA	Corporate Research Associates
DA	Delivery agent
DEER	Database for Energy Efficiency Resources
DHW	Domestic hot water
DOE	Department of Energy
DSM	Demand-side management
DWHR	Drain water heat recovery
EA	Energy advisor
EAP	Energy Action Plan
EFLH	Equivalent full load hours
ENS	Efficiency Nova Scotia
EPI	Efficient Product Installation
EUL	Effective useful life
GHG	Greenhouse gas
GHS	Green Heat savings
GSHP	Ground-source heat pump
HDD	Heating degree day
HEA	Home Energy Assessment
HPWH	Heat pump water heater
HSPF	Heating seasonal performance factor
LED	Light-emitting diode

MSHP	Mini-split heat pump
MURB	Multi-unit Residential Building
NERHOU	Northeast Residential Hours of Use (study)
NRCan	Natural Resources Canada
NTGR	Net-to-gross ratio
OPA	Ontario Power Authority
PUC	Public Utility Commission
PV	Photovoltaic
RDI	Residential Direct Install
RP&C	Rental Properties and Condos
SEER	Seasonal energy efficiency ratio
SHEC	Space heating energy consumption
TRM	Technical reference manual

DEFINITIONS

Accuracy	Reflects the proximity of measurements to the true value.
Adjustment ratio	The ratio of evaluated results to tracked results. This ratio expresses the adjustment made to tracked savings or other tracked values such as effective useful life.
Base case	To determine gross savings, a base case is established providing detailed information about the reference (e.g. pre-existing or standard) measure or equipment chosen to be compared with the efficient measure or equipment. For the reference measure or equipment, the base case may include such information as the hours of operation, wattage and the base consumption.
Bias	Systematic deviations of measurements from the true value.
Billing calibration	An activity that consists of adjusting the expected energy savings based on the relative difference between the results of the energy simulations and the actual energy consumption of the building or system.
Confidence interval	The estimated range of values which is likely to include the unknown population parameters.
Displaced wattage	The displaced wattage is defined as the difference between the wattage values of the baseline equipment or product and the efficient equipment or product.
EnerGuide rating	An EnerGuide (official brand of Natural Resources Canada) rating is a standard measure of the home's energy performance. It is a measure of the efficiency of the building only and does not take into account occupant behaviour. It shows how energy efficient the home is through modelled heat losses of the home, based on several factors including building envelope characteristics, heated volume, heating systems and air leakage.
Effective useful life	The period a measure is expected to be in service and provide both energy and peak demand savings. This value combines the equipment life and the measure persistence, which includes factors such as business turnover or early retirement.
Equipment life	The number of years installed equipment will operate before it fails.
Equivalent CO ₂	A unit of measurement indicating the amount of carbon dioxide to which various kinds of emitted greenhouse gases are equivalent in terms of warming effects. In this report, the gases' global-warming potential is estimated over a timescale of 100 years.
Equivalent effective useful life	The number of years by which the first-year savings estimate is multiplied to obtain lifetime energy savings. This value takes into account variations in annual energy savings throughout the effective useful life due to increased baselines.

Evaluated savings	Gross and net savings calculated by the Evaluator using the parameters (unitary savings values, installation rates, interactive effects, net-to-gross ratio, etc.) validated or measured during the evaluation process. Unless otherwise specified, the evaluated savings are the first-year savings.
Evaluation plan	The evaluation plan summarizes the program description, objectives, base cases, documentation, evaluation methodology, budget and schedule.
First-year savings	The first full year of energy savings generated by an energy efficiency measure.
Free-ridership	Percentage of gross savings attributable to participants who would have implemented the same or similar energy efficiency measures, with no change in timing, in the absence of the program.
Gross energy savings	Energy savings generated by energy efficiency measures, before applying the net-to-gross ratio.
Induced consumption	Energy consumption of appliances that would have been unplugged and not replaced by participants in the absence of the program.
Interactive effects	Effects on the energy consumption of other systems in the building (such as heating and cooling) due to the installation of an energy efficiency measure.
Internal spillover	Savings attributable to participants who continue to implement the energy efficiency measure introduced by a program after participating in it once, without participating in the program a second time.
In-service rate	The proportion of incentivized products that are installed and operating. This rate is usually applied to programs through which rebates are offered in-store and products are likely to be stored for a certain period before being installed, such as LED bulbs.
Lifetime energy savings	The energy savings that occur over the lifetime of an energy efficiency measure. Lifetime energy savings account for a measure's effective useful life and any increase in the baseline efficiency level (which reduces attributable annual savings) over its lifetime.
Line loss factor	The multiplier to convert savings at the customer meter to savings at the utility generator. It accounts for the electrical losses of the transmission and distribution system.
Margin of error	The amount of random sampling error.
Market effects	The impact of the program on the market (such as increased product availability, practices, and prices) that extends beyond changing the program participants' behaviour. This includes spillover among non-participants.
Net energy savings	Energy savings that can be reliably attributed to a program. This includes effects, such as free-ridership and spillover, that negatively or positively affect the energy savings attributable to a program.
Net-to-gross ratio	The ratio of net energy savings to gross energy savings.

Non-sampling error	Errors arising during the course of all survey activities other than sampling. Non-sampling errors tend to lead to bias in measurements and are very difficult to quantify.
Peak coincidence factor	The percentage of measure demand savings that coincide in time with the annual peak demand of the entire electricity system.
Peak demand savings	The demand savings that coincide in time with the expected annual peak demand period of the entire electricity system.
Precision	The extent to which repeated measurements agree with one another.
Random sampling error	The error in measurement due to the fact that measurements are taken from a subset of the population and not the entire population.
Sample size	The number of observations or replicates included in a statistical sample.
Secondary market impacts	Energy consumption of appliances that would have been transferred to the secondary market if said appliances had not been retired.
Tracked savings	Gross and net savings calculated by ENS in the tracking system, based on various parameters such as number of participants, unitary savings values, installation rates, interactive effects, and the net-to-gross ratio.
Unitary savings	Energy or peak demand savings established on a unitary basis. This unit can either be a product (e.g., an 8 W LED lamp), a capacity (e.g., one-ton capacity of an air-source heat pump) or a participant (e.g., one participant taking part in a behaviour-based program).

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EXECUTIVE SUMMARY

This report presents the demand-side management (DSM) results of the 2017 evaluation of the Existing Residential program operated by Efficiency Nova Scotia (ENS), which is comprised of three components: (1) Home Energy Assessment (HEA); (2) Green Heat; and (3) Efficient Product Installation (EPI).

Table 1 presents the participation level, as well as gross and net savings for each Existing Residential program component and for the program as a whole.

Table 1: Overall Participation and Savings for Existing Residential

	Participation Level	Gross Savings	NTGR	Net Savings
HEA				
Energy Savings	931 participants	8.306 GWh	0.76	7.007 GWh
Lifetime Energy Savings		166.116 GWh	0.76	140.139 GWh
Peak Demand Savings		2.348 MW	0.76	1.981 MW
Green Heat				
Energy Savings	1,829 measures installed	5.026 GWh	0.59	2.980 GWh
Lifetime Energy Savings		91.027 GWh	0.59	53.925 GWh
Peak Demand Savings		5.114 MW	0.60	3.073 MW
EPI				
Energy Savings	13,672 participants	19.439 GWh	0.92	17.877 GWh
Lifetime Energy Savings		170.989 GWh	0.92	157.288 GWh
Peak Demand Savings		2.317 MW	0.92	2.129 MW
Total				
Energy Savings		32.771 GWh		27.864 GWh
Lifetime Energy Savings ¹		428.132 GWh		351.352 GWh
Peak Demand Savings		9.779 MW		7.183 MW

¹ Throughout this report, energy savings always refer to first-year energy savings rather than lifetime energy savings, unless specified otherwise.

Home Energy Assessment

HEA encourages homeowners to improve the energy efficiency and comfort of their homes by improving their building envelopes, space-heating systems, and water-heating systems. Eligible measures and resulting energy savings are identified by energy advisors (EAs) hired by the delivery agents (DAs) to provide pre-retrofit and post-retrofit assessments (also called D and E assessments respectively). HEA underwent two significant changes in the last two years. Provincial funding ceased in April 2015, thus limiting participation to electrically heated households only. In October 2015, HEA began supporting measures beyond insulation, namely space-heating equipment, such as wood or pellet stoves and heat pumps, as well as water-heating equipment, such as solar domestic water heaters and heat pump water heaters.

The 2017 HEA evaluation consisted of a program documentation review, interviews with the program manager and four EAs, a telephone survey of 70 participants and an effective useful life (EUL) literature review.

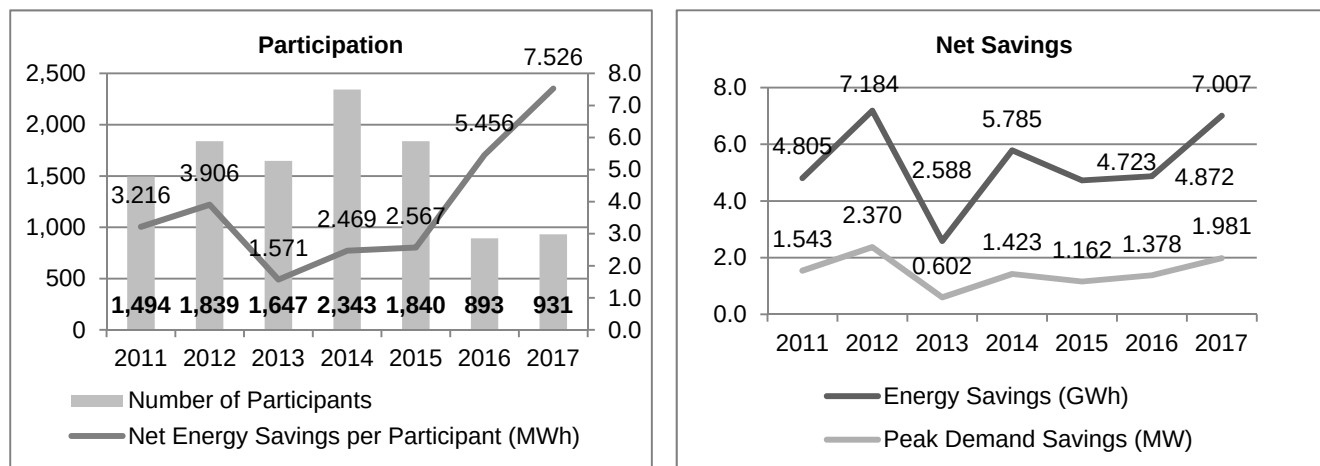
HEA Key Findings

HEA Performance

HEA aimed to achieve 5.4 GWh in net energy savings and 1.3 MW in net peak demand savings at the generator for 2017. The Evaluator has determined that HEA achieved 7.007 GWh in net energy savings and 1.981 MW in net peak demand savings at the generator with 931 participants. These savings represent 4,576 tonnes of CO₂ eq in terms of annual avoided greenhouse gas (GHG) emissions. By applying a weighted average EUL value of 20 years, the net lifetime energy savings have been established at 140.139 GWh.

Figure 1 illustrates HEA's evolution in terms of participation and net energy and peak demand savings from 2011 to 2017. The 2017 participation level was similar to that in 2016, but was much lower than in previous years. This decrease was attributable to the discontinuation of provincial funding in April 2015, which has resulted in participation only by homes that are primarily electrically heated. Although the participation level has decreased, the net electrical energy savings per participant have increased due to this change. When provincial funding was available, those participants using a non-electrical main heat source were also considered DSM participants if they had a backup electrical heat source. However, the proportion of savings accounted for by such participants in HEA's total electrical savings was quite low since their electrical savings were generated only by their secondary heating systems. Compared with last year, HEA's net electrical savings per participant increased significantly in 2017, which can be explained by a higher number of participants each installing a space-heating appliance this year.

Figure 1: HEA Performance Overview, 2011-2017



HEA Market Evaluation Highlights

Satisfaction with HEA was high among participants and EAs in 2017. Participants gave an average satisfaction rating of 8.6 (on a scale of 1 to 10, where 1 indicates “not at all satisfied” and 10, “completely satisfied”). Those less satisfied respondents mentioned that the rebate was too low and the program component requirements were unclear. The respondents made two main recommendations for improvement: greater clarity about the incentive structure or financing options and how to access incentives. Some specific aspects of HEA also received high participant satisfaction ratings, including the initial assessment overall, customer service and the EA’s expertise.

EAs’ satisfaction with HEA overall was high, as indicated by an average rating of 8.3 on the same 10-point scale. Praise was given about HEA’s environmental benefits, clear instructions on program component delivery provided by ENS and the seamless integration of Natural Resources Canada’s (NRCan) standards and requirements into HEA. Although EAs viewed the tiered incentive approach as an effective one for encouraging participants to implement more measures, they found the rebate calculation challenging.

Among the potential topics shortlisted for future training sessions, training on the latest technologies was identified as the most useful topic by EAs.

HEA Energy Savings

The objective of the 2017 HEA impact evaluation was to determine the net energy and peak demand savings. To calculate gross savings, the Evaluator reviewed the contents of the 2017 tracking system. The Evaluator employed the same method as used by ENS to calculate energy savings generated by building envelope upgrades and space-heating systems. This method uses the space-heating consumption values determined by HOT2000 simulations for the D and E assessments, and an overestimation ratio of 16 percent established by a billing analysis conducted in the 2015 HEA evaluation. The Evaluator also revised the unitary savings values used to calculate the savings associated with domestic hot water (DHW) measures, which are not modelled in HOT2000.

The net-to-gross ratio (NTGR) was established by measuring free-ridership and internal spillover through a participant survey. For 2017, a free-ridership level of 25 percent was established, which was lower than the levels established by the previous evaluations. The results also revealed an internal spillover of 1 percent, which was lower than the levels established by the previous evaluations. This difference can be explained by the fact that participants declared during the telephone survey that they implemented air-sealing measures after their participation in HEA, which do not generate high savings. By applying these free-ridership and internal spillover levels, the Evaluator established the NTGR at 0.76, as listed in Table 2 below.

Table 2: HEA Net-to-gross Ratio

	2017
Free-ridership Level	25%
Spillover Level	1%
Net-to-gross Ratio	0.76

Another spillover effect associated with unconverted D assessment savings was also considered in the net energy and peak demand savings calculations. This spillover corresponds to the savings generated through the measures implemented by those participants who did not complete their E assessments by the end of the allocated 12-month period. For this evaluation, the Evaluator used the savings values established in the 2016 evaluation. The total spillover-induced energy and peak demand savings from unconverted D assessment participants were 0.632 and 0.179 MW at the meter respectively.

Net savings were estimated by first multiplying the gross savings by the NTGR and then adding the unconverted D assessments' spillover-induced savings. In 2017, HEA achieved 7.007 GWh in net energy savings and 1.981 MW in net peak demand savings at the generator, as summarized in Table 3.

Table 3: Comparison of HEA Tracked and Evaluated Savings at the Generator

	Initial Gross Savings	Adjusted Gross Savings	NTGR	Net Savings
Energy Savings				
Tracked Savings from ENS	8.945 GWh	8.298 GWh	0.78	7.145 GWh
Evaluation Results	8.959 GWh	8.306 GWh	0.76	7.007 GWh
Peak Demand Savings				
Tracked Savings from ENS	2.532 MW	2.348 MW	0.78	2.029 MW
Evaluation Results	2.535 MW	2.348 MW	0.76	1.981 MW

In this evaluation, the calculated gross energy savings slightly exceed those tracked by ENS due to the lower revised unitary savings deducted for the measures for which some participants claimed savings in both HEA and Green Heat. By contrast, the evaluated net energy and peak demand savings values are both 2 percent lower than those tracked by ENS. This difference is explained by a decrease in the NTGR value due to a reduction in the 2017 spillover level compared to 2016.

HEA Recommendations

HEA received mostly positive feedback from participants and EAs, and exceeded its planned energy and peak demand savings for 2017.

In addition to the general recommendations presented for all ENS program components in the 2017 DSM Programs Evaluation Executive Summary, the Evaluator has made recommendations for improving each Existing Residential component. What follows are the recommendations specifically made for HEA. The recommendations for improving Green Heat and EPI are presented further below in this executive summary. The following recommendations are also found in Appendix I.

2017 HEA-R1. Review the current incentive structure to look for possible ways to simplify it. EAs and participants alike consider rebate calculations complicated. Knowing that ENS has already begun reviewing the incentive structure to make necessary changes, the Evaluator recommends continuing this effort while trying to make this structure as simple and straightforward as possible for both EAs and participants.

2017 HEA-R2. Conduct a billing analysis to review the overestimation ratio. The Evaluator has found that a new version of HOT2000 was used to calculate savings for 9 percent of HEA participants. The Evaluator predicts that this proportion will probably increase in 2018. The Evaluator recommends conducting a new billing analysis in the next evaluation to establish an overestimation ratio specific to the new version of HOT2000 for HEA.

Green Heat

Green Heat provides financial incentives to homeowners and encourages them to reduce electricity used for heating by either installing high-efficiency electrical systems or replacing existing electrical heating systems with units that use a Green Heat qualified energy source. The categories of heating system equipment rebated under Green Heat are heat pumps, biomass and solar thermal.

In August 2017, Green Heat underwent a series of changes, including a change in process. The 2017 Green Heat offerings and eligibility criteria are categorized into two paths identified as the old path and new path throughout this report. Homeowners who were pre-approved for Green Heat before August 1, 2017 were eligible under the old path. Participants could choose between a rebate option and a low-interest financing option. Once approved, applicants for the rebate option had up to six months to install the equipment and submit their rebate application forms to ENS. On August 1, 2017, Green Heat was relaunched as a mail-in rebate program component, thereby eliminating the pre-approval process. Homeowners now have 90 days after the purchase and installation of eligible equipment to submit the required documentation to receive incentives, and financing has been discontinued. That said, ENS is working with Nova Scotia Power to cross-promote the on-bill financing option they offer.

Other changes under the new path relate specifically to heat pumps. The incentive amounts for four of the five heat pump types are now determined on a refrigeration ton basis rather than a fixed amount per unit. Additionally, mini-split heat pumps (MSHPs) are now offered to both electrically and non-electrically heated homes, whereas only electrically heated homes qualified for this incentive under the old path. All other Green Heat equipment types remain eligible to electrically-heated homes only.²

The 2017 Green Heat evaluation is based on a program component documentation review, interviews with the program manager and 20 contractors, two telephone surveys with 91 old path and 50 new path participants, 25 on-site visits, a savings review, and billing analyses.

Green Heat Key Findings

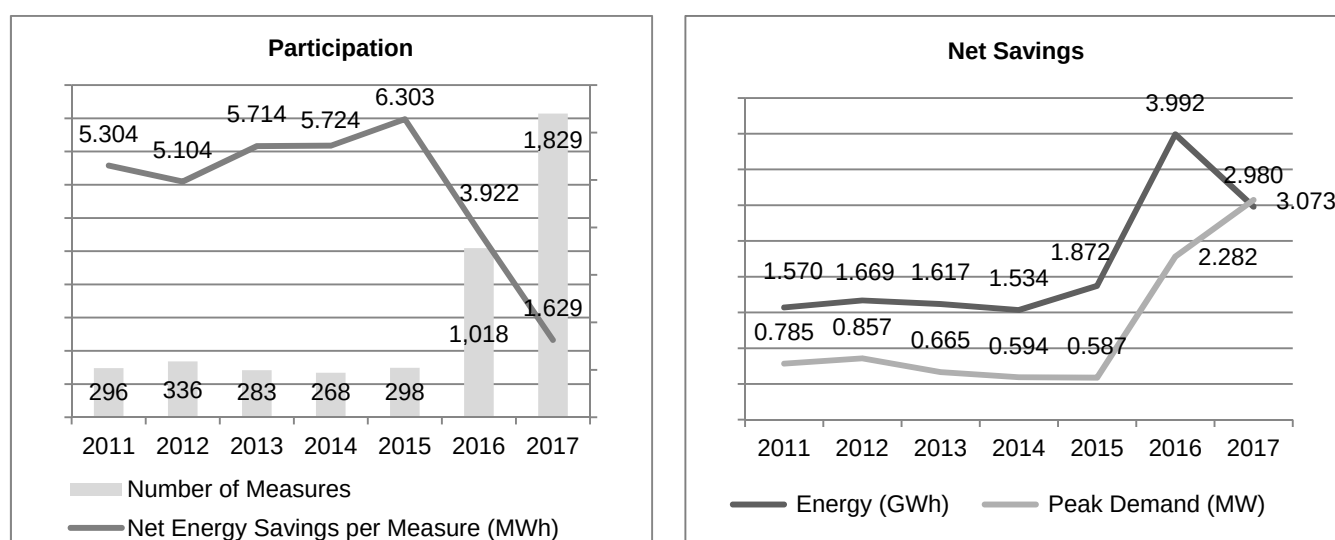
Green Heat Performance

Green Heat aimed to achieve 3.5 GWh in net energy savings and 1.7 MW in net peak demand savings at the generator for 2017. The Evaluator found that it achieved 2.980 GWh in net energy savings and 3.073 MW in net peak demand savings at the generator, with 1,829 measures installed. These savings represent 1,946 tonnes of CO₂ eq in terms of annual avoided GHG emissions. The net lifetime energy savings, based on a weighted average EUL value of 18.10 years, are 53.925 GWh.

² From August 1 to November 20, 2017, incentives for centrally ducted heat pumps, air-to-water heat pumps and ground-source heat pumps were offered to non-electrically heated participants. Those measures were no longer offered to non-electrically heated participants after November 20, 2017. However, this transition toward revised eligibility requirements led to a number of participants receiving incentives after November 20.

Figure 2 below provides an overview of the evolution of Green Heat participation levels, as well as net energy and peak demand savings from 2011 to 2017. The 2017 participation level was much higher than in previous years. As previously mentioned, non-electrically heated participants were eligible to install an MSHP under Green Heat for some of 2017, which was not the case in previous years and partially explains the increase in participation. Eighty-seven percent of the measures installed through Green Heat in 2017 were MSHPs. In total, 1,288 MSHPs were installed in electrically heated homes, while 303 MSHPs were installed in non-electrically heated homes. Air-source heat pumps (ASHPs) were also offered to non-electrically heated homes for a few months in 2017 and this resulted in an increase in participation for this measure. Moreover, the removal of the pre-approval process as of August 2017 likely contributed to higher participation.

Figure 2: Overview of Green Heat Performance, 2011-2017



Despite the increase in participation, net energy savings were lower in 2017 than 2016. This is essentially due to the lower average energy savings obtained for MSHPs and ASHPs as a result of the billing analyses conducted in 2017. However, peak demand savings increased similarly to participation levels since they were not affected by the billing analysis findings.

Green Heat Process and Market Evaluation Highlights

Participants were largely satisfied with most elements of Green Heat, except the rebate amounts which received lower satisfaction ratings. Participants particularly appreciated the quality of the equipment installed in their home, the eligibility confirmation process, the clarity of Green Heat requirements, and Green Heat as a whole. Answers to the survey questions revealed greater concern about the equipment and its installation, including equipment reliability and heating capacity or identifying a qualified contractor, than about any other aspect of Green Heat participation, such as completing the paperwork or working with ENS.

Participants appear equally satisfied with the old and new paths and the latter is less burdensome on ENS. The new Green Heat process is viewed positively by most contractors. Although about one third of interviewed contractors were unfamiliar with the new Green Heat path, the remaining contractors who knew about the new path appeared to be more satisfied with the new path compared to the old path.

Almost all contractors reported promoting Green Heat to participants, and the program manager agreed that marketing efforts by ENS and the utility have supported contractor promotion of the program. These promotion efforts have not changed dramatically since the launch of the new path process. Contractors reported that highlighting the long-term money and energy savings of energy-efficient equipment is the most effective approach to selling that equipment, and participant data largely corroborated contractors' assertions.

Despite contractor promotion, most participants indicated awareness of MSHPs before their interaction with Green Heat and over half of MSHP participants reported word-of-mouth as the source of awareness about MSHPs. The new path works well for MSHP participants (the vast majority of participants), but not for non-MSHP participants. Unlike MSHP participants, non-MSHP participants do not have a simple list of rebated equipment to choose from, which can result in participants and contractors selecting equipment that does not qualify for incentives. Improving outreach to potential participants was the improvement most recommended by participants, especially among new path participants.

Green Heat Energy Savings

To calculate Green Heat gross energy savings, the Evaluator reviewed the unitary and calculated savings values used for each type of equipment category based on the information in the tracking system, site visit results, literature reviews and two billing analyses.

Again this year, a billing analysis was conducted with participants who installed an MSHP to review energy savings. The Evaluator performed this analysis with a larger sample of participants than 2016 to establish more accurate unitary savings values. A total of 170 participants were included in the final analysis which revealed an average energy savings value per unit of installed capacity of 0.179 kWh/Btu/h for fully electrically heated households, while a value of 0.060 kWh/Btu/h was obtained for mainly electrically heated households (i.e. for households with a non-electric secondary system). For MSHPs installed in non-electrically heated households,³ the Evaluator calculated energy savings based on the heating capacity and efficiency level of each heat pump, along with an equivalent full-load hours (EFLH) value of 528 hours per year established through the MSHP billing analysis.

³ Households whose main heating system is non-electric are described as non-electrically heated households throughout this report, regardless of whether or not they use secondary electrical heating systems.

For the first time, a billing analysis was performed for the 2017 evaluation with participants who had installed an ASHP in previous years. A total of 33 participants were included in the final analysis which yielded an average energy savings value per unit of installed capacity of 0.101 kWh/Btu/h for participants who installed an ASHP in electrically heated households. By using the ASHP billing analysis results, the Evaluator also established an EFLH value of 604 hours that was used to estimate the energy savings of non-electrical participants. Revised energy savings for ASHPs are significantly lower than those tracked by ENS. This is partially because participants often have other heating systems (electrical or non-electrical) that also contribute to the home heating load.

The net-to-gross ratio (NTGR) values listed in Table 4 below were established by using the free-ridership levels (based on the participant survey results) for each category of measures. Participants who took part in the old path were surveyed for all types of measures, while those who took part in the new path were surveyed only if they had installed MSHPs given the small population size at the time the survey was conducted. New path participants using an electrical heating system prior to installing an MSHP exhibited a significantly higher free-ridership level than old path participants (51% compared to 35%). The Evaluator attributed this difference to the fact that participants can now submit a Green Heat application up to 90 days after purchasing their system and that less paperwork is now required, which might result in higher participation among less motivated individuals. Free-ridership values for old path participants remained similar to 2016. Also, an NTGR value of 1.00 was used for the three heat pump water heaters (HPWH) installed under Green Heat given the cost and recent introduction of the technology.

Table 4: Green Heat Net-to-gross Ratio

Measure Category	FR Old Path	FR New Path	Average Free-ridership Level	Net-to-gross Ratio
Biomass and Solar Measures	36%	-	36%	0.64
Central Heat Pumps	44%	-	44%	0.56
MSHPs - Fully electrically heated	35%	51%	42%	0.58
MSHPs - Mainly electrically heated	35%	51%	40%	0.60
MSHPs – Non-electrically heated	-	33%	33%	0.67
Heat Pump Water Heaters	-	-	0%	1.00

Applying the NTGR to the gross savings yields 2.980 GWh and 3.073 MW in net energy and peak demand savings respectively at the generator for 2017.

Table 5: Comparison of Green Heat Tracked and Evaluated Savings at the Generator

	Initial Gross Savings	Adjusted Gross Savings	NTGR	Net Savings
Energy Savings				
Tracked Savings from ENS	8.510 GWh	8.510 GWh	0.61	5.170 GWh
Evaluation Results	8.510 GWh	5.026 GWh	0.59	2.980 GWh
Peak Demand Savings				
Tracked Savings from ENS	4.271 MW	4.271 MW	0.61	2.604 MW
Evaluation Results	4.271 MW	5.114 MW	0.60	3.073 MW

*Different NTGRs were established for MSHP, heat pump, biomass and solar measures. The average NTGR values presented in this table correspond to the ratio of net savings to gross savings for all measure categories combined.

The evaluated gross energy savings are 41 percent below the tracked gross energy savings. This is mainly due to the decrease in the unitary savings for MSHPs and ASHPs. The evaluated net energy savings are 42 percent below the tracked value. This difference is due to the slight decrease in the NTGR resulting from the higher free-ridership level mainly for new path participants with electric heating who installed MSHPs. For those participants, the difference in free-ridership level was 16 percentage points between the old path and the new path.

The evaluated net peak demand savings are 18 percent higher than those tracked by ENS. This difference mainly results from the adjustment made for participants who installed an MSHP or an ASHP in non-electrically heated households, for which ENS had tracked 0.0 MW of peak demand savings.

Green Heat Market Evolution

The Evaluator analyzed available market data to understand the state of the MSHP market in Nova Scotia, gleaned insights into how the MSHP market is evolving, particularly in the context of recent changes to the MSHP offering in Green Heat.

The market share for heat pumps as primary heating systems in Nova Scotia grew considerably from 6 percent in 2013 to 11 percent in 2015. Furthermore, the number of Green Heat participants who installed MSHPs grew from 862 to 1,591 between 2016 and 2017, an increase of 85 percent. The number of incented systems for electrically heated homes in 2017 increased by 33 percent over 2016 levels. The other 2017 increases in the number of incented systems installed came from participants with non-electrically heated homes, who became eligible for Green Heat in August 2017.

Despite the higher prevalence of MSHPs on the market and in Green Heat, the efficiency of MSHP units has not increased significantly since 2015, with the average Heating Seasonal Performance Factor (HSPF) decreasing from 10.86 in 2015 to 10.33 in 2017. While the maximum efficiency of units incented through Green Heat has increased somewhat over time (from 12.34 to 13.04), there is very little change in the overall efficiency of the incented units over the period.

The market for MSHPs continues to evolve. While Green Heat qualified MSHPs reportedly constitute 90 percent of sales according to interviewed contractors, this share is expected to likely shift downward with the new eligibility criteria established in August 2017 which will push participants to buy even higher efficiency MSHPs.

New standards and regulations do not appear to have a large impact on the MSHP market. Heat pumps are not expected to become a building code requirement in the near future. A minor increase to heat pump energy efficiency levels was applied as a result of Amendment 13 to the Energy Efficiency Regulations of Canada. However, this change had little impact on the market and high efficiency units rebated through Green Heat.

While these market indicators provided some indication of the evolution of the MSHP market, the Evaluator was unable to provide an indication of MSHP market adoption on the theoretical curve of technology diffusion as further data is required to fully assess the transformation of this market in Nova Scotia.⁴

Green Heat Recommendations

The Evaluator noted that changes made to Green heat were successful in increasing overall participation compared to previous years. However, the improved methods for MSHP and ASHP savings calculations demonstrated that savings per installed measure were lower than anticipated; thus planned energy savings were not achieved.

In addition to the general recommendations made for all ENS program components in the 2017 DSM Programs Evaluation Executive Summary, the Evaluator makes the following recommendations on how to improve Green Heat. These recommendations are also listed in Appendix VII.

2017 GH-R1. Perform the ASHP billing analysis again in 2018. Similar to MSHPs, the billing analysis resulted in a major change made to the average savings values for ASHPs. As part of this analysis, participants were categorized based on their existing heating system type. Because of the small sample sizes for each category, it was difficult to establish distinct savings for each category. The Evaluator believes that the ASHP billing analysis should be conducted again in 2018 to obtain a larger sample of participants and improve the accuracy of savings.

⁴ Everett M. Rogers, *Diffusion of Innovations – Fifth Edition*, August 16, 2003

2017 GH-R2. Conduct a survey with a larger sample of participants who installed MSHPs in non-electrically heated households. As part of the 2017 evaluation, a participant survey was conducted to establish the baseline scenario for MSHPs installed in previously non-electrically heated households. Unfortunately, the sample size was small because a low number of participants had installed MSHPs in non-electrically heated households at the time of the survey. The Evaluator believes that a survey with participants living in non-electrically-heated households should be conducted again in 2018 to determine the most appropriate baseline scenario to be used for such participants. This survey should ask participants about Green Heat's influence on their decision to purchase an MSHP and how this impacted the timing of their decision. Since MSHPs installed in non-electrically heated households generated lower savings, this feedback could provide more insight on whether the inclusion of this measure in Green Heat should be reconsidered.

2017 GH-R3. Improve the collection of technical information about ASHPs. Peak demand savings for ASHPs are based on technical information such as heating capacity and the coefficient of performance (COP) at a temperature of -15°C . In 2015, the Evaluator was able to locate technical information on 15 ASHP models and established an average unitary peak demand savings value of 3.04 kW. Although it was recommended in the 2015 evaluation report that ENS start collecting performance data about ASHPs at -15°C , such information is still not tracked by ENS. In the absence of more accurate performance data, the unitary savings value of 3.04 kW is still used. Considering the fact that the number of ASHPs installed through Green Heat has significantly increased in the past two years (from 52 in 2015 to 143 in 2017), the Evaluator reiterates the recommendation to start tracking ASHP performance data at -15°C to increase the accuracy of the peak demand savings calculations.

2017 GH-R4. Gather additional information to further characterize the MSHP market. While the market indicators presented in the Market Evolution section of this report provide some indication of the evolution of the market for MSHPs, certain key data points were unavailable or rely on information from participating contractors. As a result, the Evaluator was unable to formulate a clear conclusion on the current state of the MSHP market in Nova Scotia. Additional data should be collected in 2018, such as:

- › Market share of efficient MSHPs in Nova Scotia from a broader data set, including market share of secondary systems
- › Minimum efficiency levels of units sold by contractors
- › Data on the incremental cost difference between standard versus high-efficiency MSHPs and Green Heat eligible MSHPs

2017 GH-R5. Develop a way for potential participants to better understand which ASHP equipment is eligible. Non-MSHP participants do not have a simple list of rebated equipment to choose from and therefore must rely on contractors to determine if equipment is eligible. To drive interest in non-MSHP measures, such as ASHPs, and prevent dissatisfied participants who purchased equipment thinking it was eligible for a rebate, ENS should develop a list of eligible equipment, similar to the list established for MSHPs. Contractors could be asked to develop and update this list.

Efficient Product Installation

In January 2017, the former Rental Properties & Condos (RP&C) and Residential Direct Install (RDI) program components were merged together to form the EPI program component. EPI provides Nova Scotian homeowners and tenants with direct free-of-charge installation of energy-efficient products, such as light-emitting diode (LED) lamps and nightlights, low-flow showerheads, pipe insulation and smart power controllers for audiovisual equipment. EPI is available to all residents of Nova Scotia with a priority given to low-income households. EPI encourages participants to also consider other ENS residential program components.

The 2017 evaluation of EPI was based on a program component documentation review, an interview with the program manager, a telephone survey of 100 participants, 110 on-site visits and a unitary savings review.

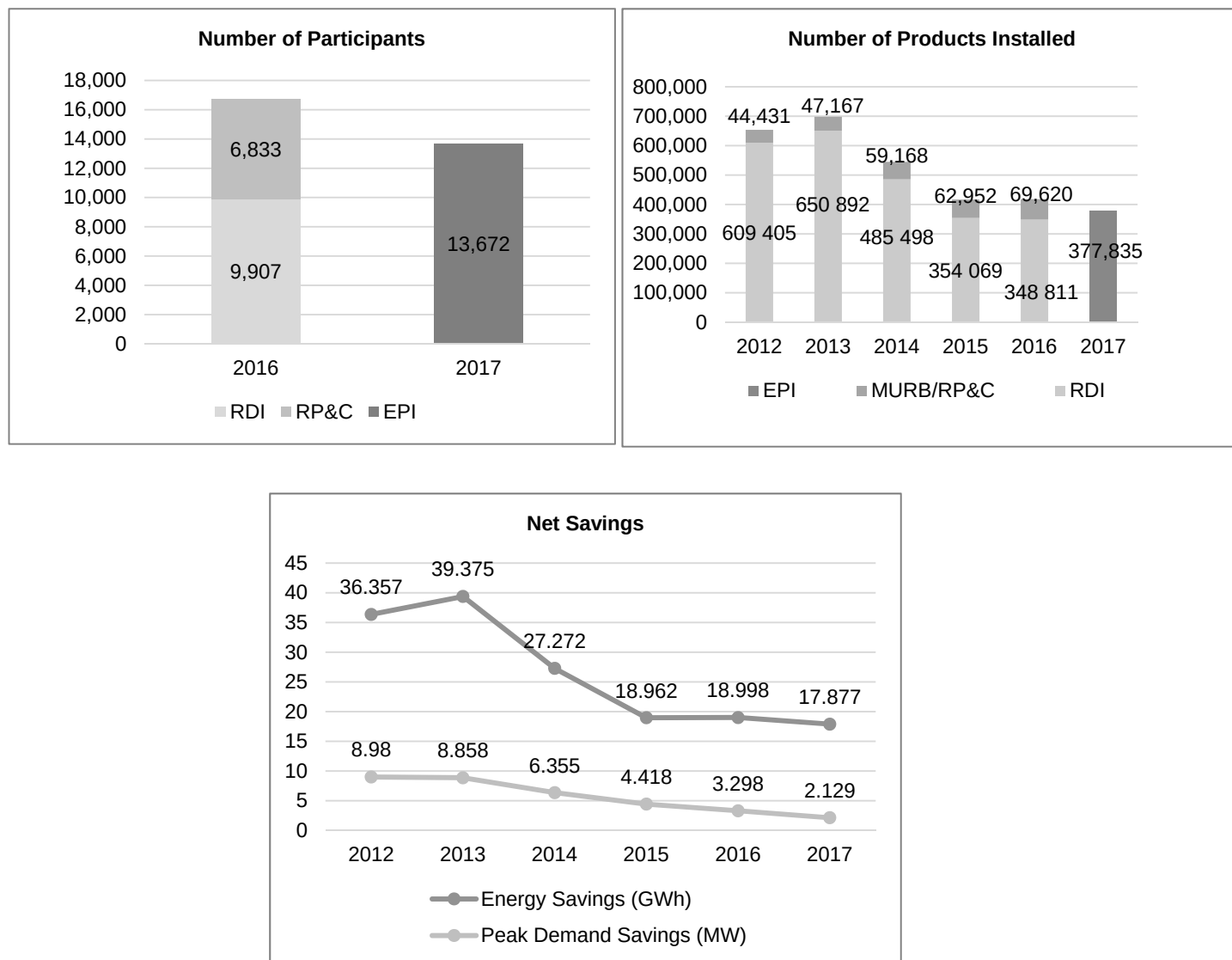
EPI Key Findings

EPI Performance

ENS's EPI program component aimed to achieve 24.4 GWh in net energy savings and 3.6 MW in net peak demand savings at the generator in 2017. The Evaluator found that it achieved 17.877 GWh in net energy savings and 2.129 MW in net peak demand savings at the generator in 2017. These savings represent 11,675 tonnes of CO₂ eq in terms of annual avoided GHG emissions. By applying a weighted average EUL value of 8.80 years, EPI's net lifetime energy savings have been established at 157.288 GWh.

As highlighted in Figure 3 below, a total number of 13,672 households participated in EPI in 2017, which was 18 percent lower than the total number of participants in RDI and RP&C combined in 2016. A total of 377,875 efficient products were installed in 2017, which was 10 percent lower than in 2016.

Figure 3: Overview of EPI's Performance (Previously RDI⁵ and RP&C⁶)



⁵ The number of participants in RDI 2016 was revised to 9,907 to correct a transcription error in the RDI 2016 evaluation report.

⁶ The Multi-Unit Residential Building (MURB) program component became the RP&C program component in 2014.

The average number of products per participant has increased overall, partially because of the higher proportion of participants living in single-family homes in 2017, which typically have more products installed because of a bigger dwelling size compared to apartments. Still, the number of A-type lamp replacements in single-family homes decreased significantly from 28 lamps with RDI in 2016 to 21 lamps with EPI in 2017. The Evaluator believes that this was mainly due to the decreasing number of lighting sockets occupied by incandescent lamps, because participants purchased other lighting technologies to replace their burned-out lamps. The decrease in the number of A-type lamp replacements had a big impact on EPI since this product type accounted for 62 percent of this program component's total gross savings.

EPI Market Evaluation Highlights

EPI achieved a very high level of satisfaction among participants, who gave it an average rating of 9.0 on a 10-point scale, which was consistent with the scores obtained by RDI and RP&C in the past evaluations, indicating that the transition to EPI has been smooth and successful. As with RDI in 2016, the main reason cited for this high level of satisfaction with EPI was the interaction with the installer. Other aspects of EPI, such as the quality of work completed, the time required to complete the work, the energy-efficient products installed, and the information provided by the installer, also received strong satisfaction ratings.

EPI Energy Savings

To calculate EPI's gross energy savings, the Evaluator reviewed the unitary savings values of each category of product installed through EPI based on the information in the tracking report, the site visits' results and a literature review. The installation rate was established for every category of product based on the site visit results. It was found that all the product categories had an installation rate above 89 percent, except for smart power controllers, which had an installation rate of 57 percent.

In 2016, smart power controllers had an installation rate of 78 percent, which was established using the participant survey results. Since the 2016 site visit results suggested that the actual installation rate might be lower, the 2017 sample of site visits including smart power controllers was increased to 76 participants to allow the Evaluator to obtain a satisfactory margin of error for establishing the installation rate. The low installation rate has thus been confirmed by the 2017 evaluation, despite the efforts made by ENS to target tech-savvy participants and limit the number of devices installed in each home. The Evaluator has no further recommendation to make on how to improve the installation rate and recommends continuing to offer this product type through EPI if it is still cost-effective despite its low installation rate.

The net energy savings were estimated using an NTGR, which represents the proportion of gross savings that can be reliably attributed to EPI. This year, the NTGR was separately established for non-low-income owners and tenants, because the Evaluator expected different results for each group. For low-income participants, the NTGR was assumed to be 1.

To estimate the NTGR, the Evaluator measured free-ridership for LED lamps, while considering free-ridership nil for the other products. The free-ridership level was established at 26 percent for owners and 14 percent for tenants, resulting in an overall free-ridership level of 25 percent for LED lamps. The Evaluator established the internal spillover level at 6 percent for owners and at 1 percent for tenants, resulting in an overall level of 6 percent. Overall, the weighted average NTGR for low-income and non-low-income participants combined was established at 0.92 as shown in Table 6.

Table 6: EPI's Net-to-gross Ratios

	LED Lamps		Other Products	
	Non-low-income Participants	Low-income Participants	Non-low-income Participants	Low-income Participants
NTGR	0.81	1.00	1.06	1.00
Proportion of Gross Savings	66%	34%	61%	39%
NTGR for All Participants	0.87		1.04	
Overall NTGR	0.92			

In 2017, EPI generated 17.877 GWh in net energy savings and 2.129 MW in net peak demand savings at the generator. Net lifetime savings were estimated at 157.288 GWh. Table 7 below compares the tracked and the evaluated savings at the generator.

Table 7: Comparison of EPI Tracked and Evaluated Savings at the Generator

	Initial Gross Savings	Adjusted Gross Savings	NTGR*	Net Savings
Energy Savings				
Tracked Savings from ENS	21.257 GWh	20.460 GWh	0.88	18.082 GWh
Evaluation Results	21.308 GWh	19.439 GWh	0.92	17.877 GWh
Peak Demand Savings				
Tracked Savings from ENS	3.487 MW	3.461 MW	0.87	3.012 MW
Evaluation Results	2.401 MW	2.317 MW	0.92	2.129 MW

*The average NTGR values listed in this table correspond to the ratio of the net savings to the gross savings for all the product categories combined.

The overall evaluated net energy savings are less than 1 percent lower than the tracked net energy savings. The decrease in the overall installation rate (from 96% to 91%) was balanced out by the increase in the NTGR value (from 0.88 to 0.92). The decrease in the overall installation rate was mainly attributable to the decrease in the smart power controller installation rate (from 78% to 57%). The adjustments made to the unitary savings and the interactive effects had only a small impact.

The evaluated net peak demand savings were 29 percent lower than the tracked net peak demand savings. This difference was mainly associated with the lower evaluated peak demand-to-energy ratios used for lighting products based on the findings of the Residential Lighting Metering Study.

EPI Recommendations

EPI achieved high levels of participation and savings even though its predecessors, RDI and RP&C, had been in the market for several years. Furthermore, participant satisfaction remains very high. The biggest challenge for EPI in the coming years will be related to the diminishing potential for LED lamp installation as fewer incandescent lamps are found in participating households.

In addition to the general recommendations made for all the ENS program components in the 2017 DSM Programs Evaluation Executive Summary, the Evaluator has one main recommendation on how to improve EPI, which is presented below and can also be found in Appendix XV.

2017 EPI-R1. Document the energy-saving potential related to halogen incandescents and CFL lamp replacements. The tracking report indicated that the average number of A-type LED lamps installed per household significantly decreased among participating single-family homes. Although EPI achieved high savings in 2017, this trend suggests that fewer incandescents are present in homes, and will consequently provide fewer opportunities for LED replacements in the future. The Evaluator recommends that ENS start gathering information about the types of lamps installed in EPI participants' homes to analyze the savings potential that can be tapped if general-service lamp types other than incandescents are made eligible for replacement.

INTRODUCTION

Efficiency Nova Scotia (ENS) is a franchise held by EfficiencyOne⁷ and is responsible for helping Nova Scotians improve the energy efficiency of their homes and workplaces. ENS designs, markets and delivers energy efficiency and conservation programs for various segments of the population. ENS receives funding for its activities from Nova Scotia Power (NSP) and the Province of Nova Scotia. The funds received from NSP cover the costs of activities designed to help reduce electricity consumption, whereas funds from the Province of Nova Scotia are primarily used for activities designed to help reduce the use of other fuels by households with lower incomes.

Econoler was commissioned to evaluate ENS's 2017 demand-side management (DSM) program portfolio comprised of six electricity efficiency programs and assess the impact of energy efficiency codes and standards introduced in Nova Scotia. To carry out this assignment, Econoler collaborated with Research Into Action, Equilibrium Engineering and Corporate Research Associates (CRA).

Econoler served as team leader in the 2017 evaluation and was involved in every aspect of the evaluation. Specifically, Econoler was in charge of coordinating and supervising all activities, conducting final reviews of all data collection instruments, performing impact evaluation calculations, as well as preparing and reviewing the evaluation reports. Research Into Action carried out the process evaluations, while Equilibrium Engineering conducted the on-site visits and contributed to some impact evaluation analyses. CRA conducted the interviews and surveys with participants and partners, as well as analyzed and reported on the data collected from these activities. Throughout this report, this team is referred to as the Evaluator.

For each program, the Evaluator prepared a DSM evaluation report presenting the general findings, electrical first-year and lifetime energy savings, peak demand savings and avoided greenhouse gas (GHG) emissions.

Table 8 below lists the various programs assessed as part of the 2017 evaluation and indicates their respective components and the types of evaluations conducted. In this table, "C" means a complete evaluation, and "R" indicates that reduced evaluation activities were performed, as compared to 2016. Section 1 of the DSM Programs Evaluation Executive Summary presents the scope of work in further detail, along with the rationale for the types of evaluations performed for each program component.

⁷ On January 1, 2015, ENS became a franchise owned by the Province of Nova Scotia and was licensed to the new not-for-profit organization EfficiencyOne.

Table 8: Types of Evaluations Conducted for Each Program Component

Program	Program Component	2016			2017		
		Process	Market	Impact	Process	Market	Impact
Residential Efficient Product Rebates Program	Appliance Retirement		C	C			R
	Instant Savings		C	C		R	R
Existing Residential Program	Home Energy Assessment		C	C		C	C
	Green Heat		C	C	C	C	C
	Efficient Product Installation		C	C		C	C
New Residential Program	New Home Construction		C	C		C	C
Efficient Product Rebates Program	Business Energy Rebates		C	C		C	R
Custom Incentives Program	Custom		C	C	C*	C	R
	Energy Management Information Systems	C	C	C		C	C
	Strategic Energy Management**	C	C	C			
Direct Installation Program	Small Business Energy Solutions	C	C	C		C	C
*The process evaluation specifically targets the Retrofit service of the Custom program component. ** Due to the start date of the latest Strategic Energy Management (SEM) cohort, SEM did not have any participants who achieved savings in 2017; therefore, no evaluation was conducted for 2017.							

This evaluation report is for the Existing Residential program, which is comprised of three components: Home Energy Assessment (HEA), Green Heat and Efficient Product Installation (EPI). In both 2017 and 2016, all program components underwent a complete market and impact evaluation. A process evaluation was added for Green Heat in 2017 because of the numerous changes implemented to this program component. Each program component's description, evaluation methodology and main evaluation findings are presented in the following sections.

1 HEA OVERVIEW

This evaluation report first focuses on the HEA evaluation results. Results from the Green Heat and EPI program components follow.

This section describes the HEA program component, follows up on the 2016 evaluation recommendations and gives an overview of its participation history.

1.1 Description

HEA is meant to help homeowners in Nova Scotia improve energy efficiency and comfort in their homes by providing education and financial incentives in the form of rebates or low-interest financing for the implementation of measures that reduce electricity consumption. Eligible measures include building envelope measures, such as draft proofing, installation of ENERGY STAR® certified windows, doors or skylights, as well as exterior wall, exposed floor, basement and crawl space insulation. In October 2015, HEA began supporting new measures, namely space-heating equipment, such as wood/pellet stoves, heat pumps and domestic hot water (DHW) measures. In the past, measures that reduced the consumption of other fuels were funded by the Province of Nova Scotia. However, provincial funding under HEA came to an end in April 2015, and any funding spent beyond April 2015 was provided to honour only the commitments made prior to April 2015. Since then, only electrically-heated households have been eligible.

HEA has been offering a new incentive structure since October 2015 (Version 2.0 of HEA), which is meant to encourage homeowners to perform as many upgrades as possible. This new incentive structure offers higher incentives for measures or upgrades bundled together. Specifically, each eligible measure is first categorized as either “Green” or “Smart” according to its level of energy efficiency and the role it plays in a home’s energy usage. Depending on the Green and Smart upgrades combined, a participant can receive a maximum incentive of up to \$5,000.

HEA uses the EnerGuide home evaluation framework and is administered in collaboration with Natural Resources Canada (NRCan). HEA is supported by delivery agents (DAs) across Nova Scotia, who provide pre- and post-retrofit assessments (also called a “D assessment” and “E assessment” respectively). Up until August 2016, four DAs were involved in HEA; three were then added to the list of DAs. Participating homeowners initiate the HEA process by contacting one of the DAs serving their area to schedule a pre-retrofit assessment with an energy advisor (EA). EAs are hired by DAs to perform comprehensive energy assessments.

The pre-retrofit assessment is carried out to examine the house, complete a blower door test and collect information, such as the levels of insulation (attic, exterior wall, etc.), the numbers and types of doors and windows, as well as the types of ventilation, heating and hot water systems. The EA also educates and informs participants about their house as a system, and discusses possible effective upgrades for achieving energy savings. Assessments provide an opportunity to educate as many potential participants as possible across Nova Scotia about the benefits of renovating their homes to improve energy efficiency and comfort level. Once the pre-retrofit assessment is completed, a home energy assessment report (called the Energy Efficiency Evaluation Report) is sent to the homeowner within a few weeks. This report includes a set of upgrade recommendations and an EnerGuide rating of the home. This EnerGuide rating, along with the efficiency levels of the proposed upgrades, is calculated using HOT2000, a simulation tool developed by NRCan. Until September 1, 2017, the EnerGuide rating presented in the HEA report was a rating between 0 and 100. Since then, a new version of HOT2000 and of the rating system have been put in place; with these new versions, a rating in gigajoules (GJ) reflects the modelled consumption of a home and 0 GJ is the best rating a home can achieve.

ENS has also developed a report known as the Energy Action Plan (EAP) to help homeowners who may struggle with how to move forward with upgrades. The EAP includes brief information about the energy assessment, as well as the estimated costs, savings and payback.

Homeowners then have 12 months to complete the upgrades they have decided to undertake and schedule a post-retrofit assessment. During the post-retrofit assessment, the EA verifies the upgrades made and performs another blower door test. Based on the results of the post-retrofit assessment, a final EnerGuide rating is established. The participant's cost for the pre-retrofit assessment is \$99, and there is no cost for the post-retrofit assessment.

HEA aimed to achieve 5.4 GWh in net energy savings and 1.3 MW in net peak demand savings at the generator for 2017.

1.2 Follow-up on the 2016 Evaluation Report Recommendations

The HEA component was evaluated in 2016 and recommendations were made by the Evaluator for its improvement. Table 9 below provides a brief summary of the implementation status of each recommendation presented in the executive summary section of the 2016 evaluation report.

Table 9: Implementation Status of Recommendations in the 2016 Executive Summary

2016 Recommendation	Status
2016 HEA-R1. Assign staff to answer EA questions about HEA.	Implemented
2016 HEA-R2. Use the unitary savings established as part of the 2016 HEA evaluation to determine the savings generated by the DHW measures.	Implemented
2016 HEA-R3. Maintain follow-ups with EAs and continue to conduct project reviews to assess the progression of simulation file quality.	Implemented

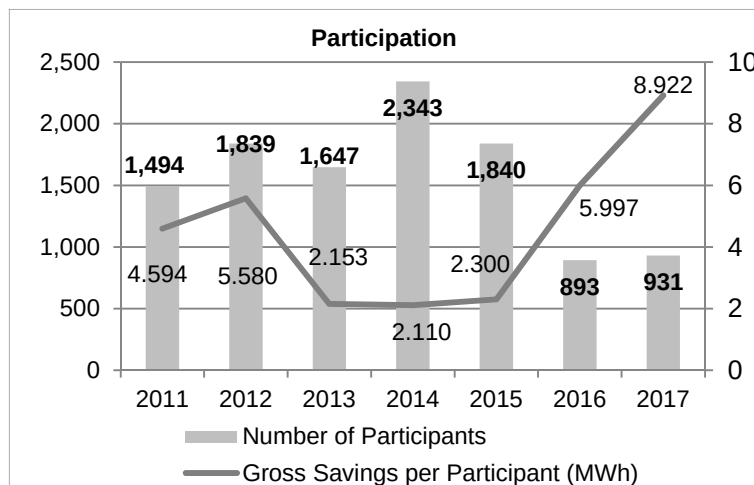
All three 2016 recommendations were implemented by ENS. To assist with the implementation of recommendation 2016 HEA-R1, the HEA program manager and efficiency specialist have been assigned to answer EA questions about HEA. Furthermore, a shared-folder system was put in place by ENS to allow information to be more effectively transmitted to and from the DAs and EAs.

ENS has continued reviewing projects in 2017, as per Recommendation 2016 HEA-R3, to ensure the overall quality of the simulations and that all the data needed to model the homes is collected and recorded.

1.3 Participation History

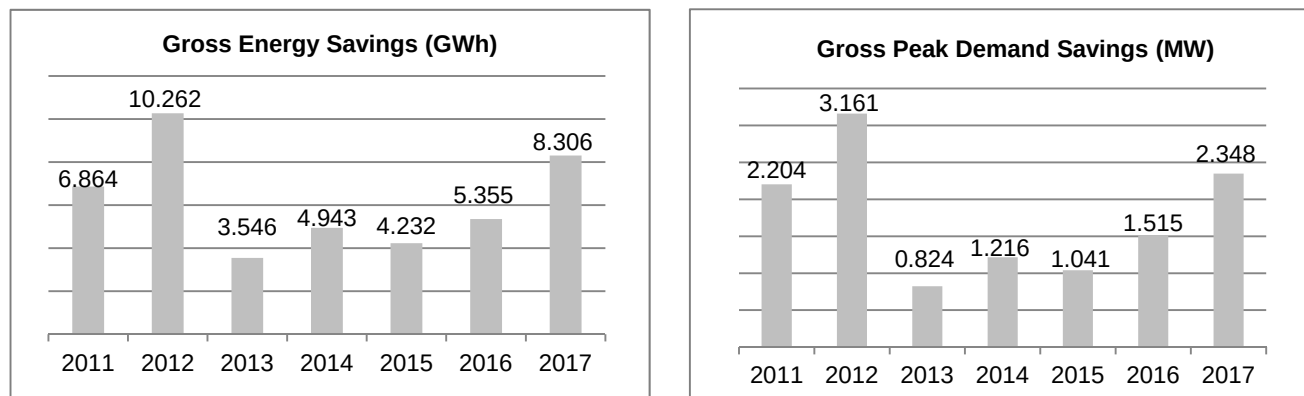
A total of 931 participants took part in HEA in 2017. The number of participants shown in Figure 4 below refers to those participants whose projects generated electrical savings, regardless of whether or not their homes were primarily electrically heated. The participation level in 2017 was similar to last year's, but was still much lower than in previous years. This lower participation level was a lasting consequence of the discontinuation of provincial funding for HEA beginning in April 2015; as a result, since then, only homes primarily heated by electricity have participated in HEA. Nevertheless, the average gross savings per participant have been increasing significantly since then, reaching 8.922 MWh in 2017. Since October 2015, space-heating equipment have been eligible for an incentive under HEA, thus helping increase per-participant average savings. Sixty-three percent of the participants in 2017 installed a space-heating appliance, a leap from last year's 14 percent. The discontinuation of provincial funding for HEA also led to an increase in the average per-participant savings. When the provincial funding was available, homes with non-electric heating systems were eligible under HEA, resulting in lower electric savings per participant because space-heating is the main source of savings under this program component.

Figure 4: Overview of Participation in HEA, 2011-2017



Despite a participation level similar to that in 2016, in 2017, HEA's total gross energy and peak demand savings were higher than those in 2016. In 2017, HEA achieved 8.306 GWh in gross energy savings and 2.348 MW in gross peak demand savings. Figure 5 below provides an overview of HEA's gross savings evolution from 2011 to 2017.

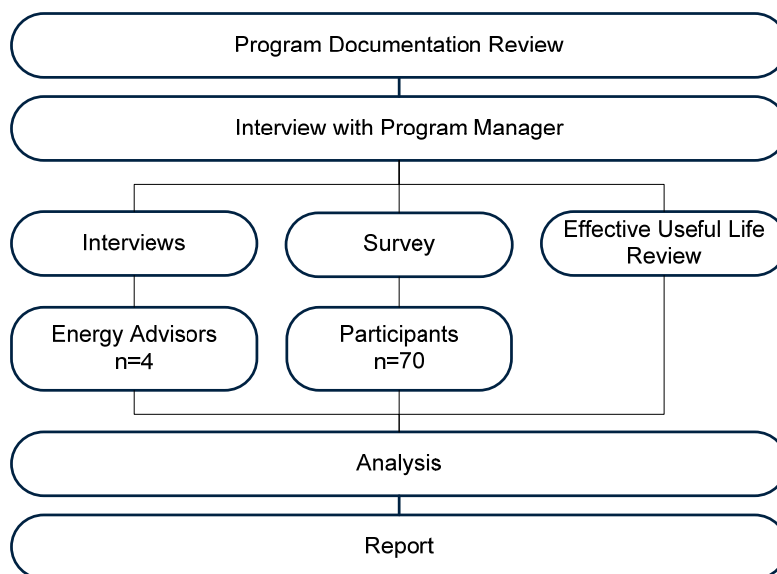
Figure 5: Evolution of HEA Gross Savings, 2011-2017



2 HEA EVALUATION METHODOLOGY

This section presents the methodology used and the activities carried out for the 2017 HEA evaluation. Figure 6 shows the various data collection activities carried out for the evaluation.

Figure 6: Methodological Model



The Evaluator first reviewed the program component documentation and then met with the program manager in August 2017 to verify the implementation status of the previous evaluation recommendations and learn about recent program component changes. Based on the information obtained from this interview, a list of questions and topics to be included in the data collection instruments were prepared.

Once the meeting with the program manager and the program component documentation review were completed, specific evaluation activities were undertaken, as described in the following subsections.

For evaluation activities that yield quantitative results based on a sample, the Evaluator aimed to achieve a maximum margin of error of 10 percent at a confidence level of 90 percent. This means that if measurement was conducted many times with different samples, the data would be within 10 percentage points above or below the percentage reported 90 percent of the time. Thus, the margin of error indicates the relative level of precision⁸ of the measurement, while its associated confidence level indicates the probability of a measure falling within this margin of error.⁹

⁸ Precision refers to how reproducible a set of measurements is. It does not take into account, however, how close the measured values are to the true values, as this would refer to accuracy.

⁹ As part of this evaluation, the confidence level and the margin of error only take random sampling errors into account; they do not reflect non-sampling errors or biases, such as data entry errors, inaccurate responses from respondents or the inability to contact certain people.

As part of this evaluation, the Evaluator calculated the margin of error for survey samples, free-ridership levels, installation rates and savings adjustment ratios where applicable. The margins of error are presented alongside the results in the applicable sections. Examples of calculations used to establish margins of error can be found in Appendix II of the 2017 DSM Programs Evaluation Executive Summary.

Interviews with Energy Advisors

In October and November 2017, CRA conducted four interviews with EAs to learn about, among other things, these partners' involvement in HEA, their participation process, as well as their perception and level of satisfaction regarding HEA.

The guide used for the interviews is provided in Appendix II. All the appendices are presented in the Existing Residential Program – Appendices.

Participant Survey

In October 2017, CRA conducted a telephone survey with a total of 70 HEA V2.0 participants¹⁰, using computer-assisted telephone interviewing technology. The average length of the survey was 19 minutes. The questionnaire and the complete survey results are provided in Appendix III and Appendix IV respectively.

The participant survey was meant to collect feedback on the following aspects of HEA:

- › Participation motivations
- › Satisfaction with HEA
- › Verification of the upgrades recommended and implemented
- › Free-ridership (including the cross-influence from ENS promotion and other program components)
- › Internal spillover
- › Barriers to the implementation of recommended upgrades
- › Recommendations for improvements
- › Demographics

The total number of HEA participants was 931 for the entire year of 2017. Drawing a random sample of 70 from a population of 931 yields a margin of error of 9.5 percent at a 90 percent confidence level.

Effective Useful Life Review

As part of the 2017 evaluation, to examine the effective useful life (EUL) values used by ENS to calculate lifetime energy savings, the Evaluator conducted a thorough literature review by consulting technical reference manuals (TRMs), evaluation reports and relevant studies.

¹⁰ Version 2.0 of the program component is representative of the current HEA eligible measures and incentives.

3 HEA MARKET EVALUATION

This section discusses the participant and partner perspectives on the HEA program component.

3.1 Participant Perspectives

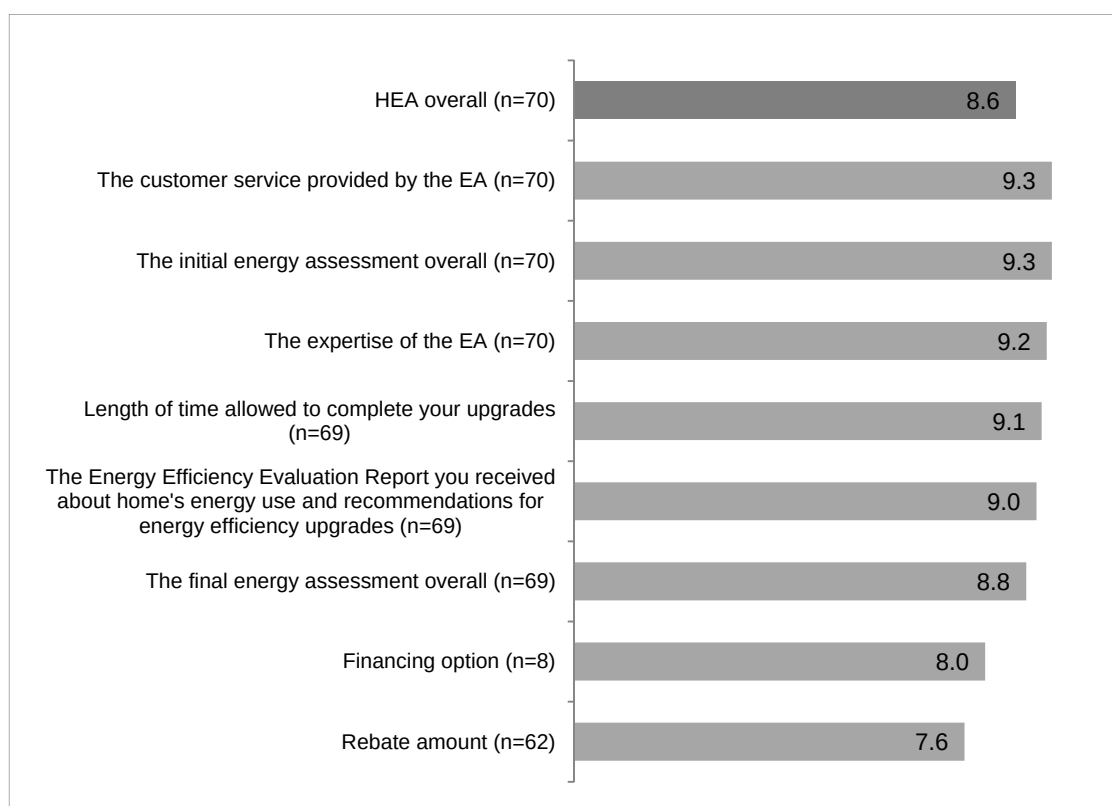
A survey was conducted with 70 HEA participants as part of HEA evaluation. All surveyed participants were from Version 2.0 of the program component. In addition to the questions designed for impact evaluation purposes, survey participants were asked questions regarding satisfaction, barriers to participation, influence from other ENS activities, and recommendations.

Participants cited a number of reasons for participating in HEA, with saving energy being the main reason (30%), followed by getting expert advice on which upgrades to install (23%). This last finding highlights the importance of the support and expertise aspect of HEA, which is mostly provided through the EAs.

There was a high level of satisfaction with HEA overall, with an average rating of 8.6 (on a scale of 1 to 10, where 1 indicates “not at all satisfied” and 10, “completely satisfied”). Those who were less satisfied (12 respondents) mentioned that the rebate was too low and the program component requirements were unclear as the main reasons for their dissatisfaction.

Participants also indicated high satisfaction with various aspects of HEA. Satisfaction was the highest for the initial assessment overall, customer service and expertise of the EA (see Figure 7).

Figure 7: Participant Satisfaction with HEA (10-point Scale)



Participants were specifically asked about the Energy Action Plan (EAP), a report outlining how to move forward with the recommended upgrades. Nearly six in 10 participants (57%) recalled receiving the report, and most of those who recalled receiving the report read the report (90%). The report was considered useful, as indicated by an average rating of 8.0 out of 10 (where 1 indicates “wasn’t at all useful”, and 10, “was extremely useful”). Negative feedback about the EAP indicated that the report did not provide new information, the information was not specific or detailed enough or the upgrades were not useful in general, whereas the main positive feedback was that the report was informative and covered a lot of information.

When it came to deciding which upgrades to implement, reducing energy costs (an average rating of 9.6 out of 10, with 1 indicating “not at all important”, and 10, “extremely important”), reducing energy consumption (9.5) and increasing comfort at home (9.0) were considered more important than increasing the home’s value of (7.5), or using the lowest cost option (6.3).

In terms of recommendations to improve HEA, some participants wanted greater clarity regarding the incentive structure or financing options and how to reach incentives (10%), some wanted to see increased rebates (9%), or wanted to see more products and measures made eligible for rebates (7%).

3.2 Partner Perspectives

Interviews with four EAs were conducted as part of the HEA evaluation. The following subsections discuss the results of these interviews.

3.2.1 Involvement in and Satisfaction with HEA

Satisfaction with HEA overall was high, as indicated by an average rating of 8.3 on a 10-point scale (with 1 meaning “not at all satisfied” and 10, “completely satisfied”) among the EAs. Praise was given about HEA’s environmental benefits, clear instructions on program component delivery provided by ENS and the seamless integration of NRCan’s standards and requirements into HEA. According to one EA, allowing only electrically heated homes to participate could undermine HEA’s overall appeal. Another EA expressed a concern with the time-benefit ratio and dissatisfaction with the amount of time needed to complete an assessment in bigger and sometimes older homes, considering that only a small number of measures are finally implemented by some homeowners. According to this EA, homeowners do not always have a clear idea about the amount of energy savings that HEA can provide, thereby causing some homeowners to implement just some and not all of the upgrades that they could have in houses with high savings potential.

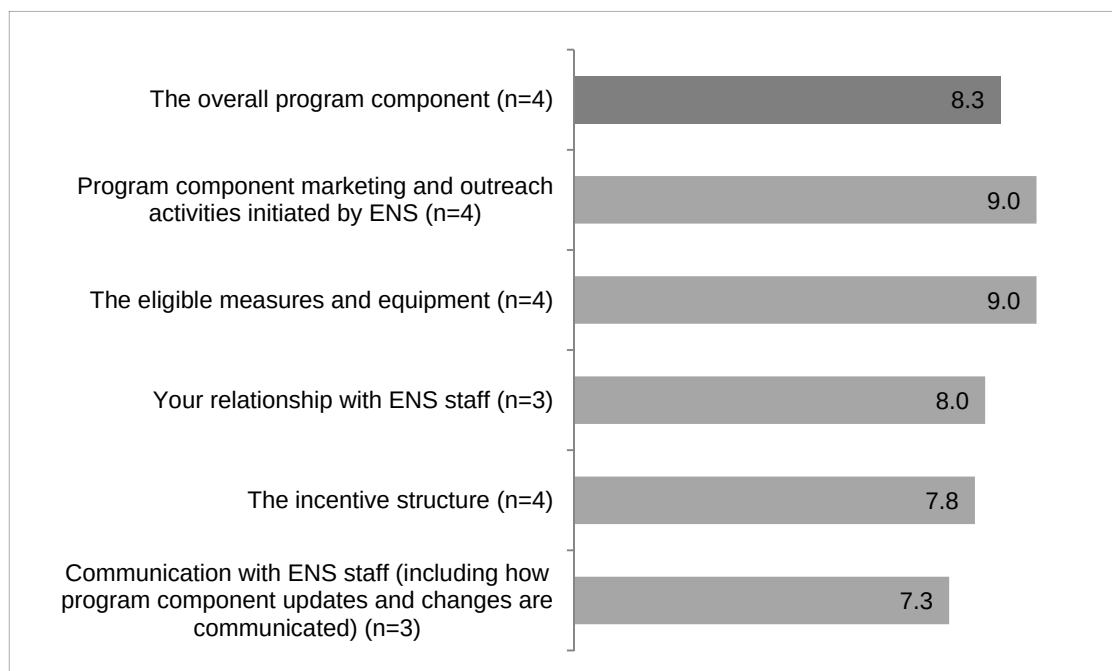
EAs’ satisfaction with the eligible measures and equipment was high (9.0 out of 10). Recommendations were made about the measures that should be made eligible, including the removal of solar air heating options, and the inclusion of photovoltaic (PV) panels. Regarding the incentive structure, EAs appreciate the tiered approach, which prorates the rebates provided to homeowners based on the energy efficiency levels of implemented measures, in addition to the number of recommendations acted upon. That said, the rebate calculation method is considered too complex for homeowners to understand and it is poorly explained in the program component materials, according to EAs. One EA recommended increasing the amount of incentive for deep energy retrofits (e.g., making an existing home almost Net Zero), as well as for PV panels and heat recovery ventilators, which may require homeowners to make higher installation investments.

The EAs’ satisfaction with HEA marketing and outreach activities initiated by ENS was high (an average rating of 9.0 out of 10). EAs mentioned having seen ENS-sponsored advertisements mostly on social media and at home shows. One EA mentioned not knowing much about the other ENS services and program components.

Three of the four EAs reported being in contact with ENS staff. Two of those EAs were highly satisfied with their relationship and communication with ENS, including how program component updates and changes are communicated. These EAs praised ENS staff on their availability, promptness to return calls or answer queries, and flexibility in considering requests. The other EA was less satisfied overall with its relationship with ENS, expressing concern with how ENS supports homeowners’ points of view without considering the EA’s version when a conflict occurs. This EA was also dissatisfied with HEA changes that happen too often.

Figure 8 below provides an overview of the average satisfaction ratings provided by the EAs for each aspect of HEA.

Figure 8: EA Satisfaction with HEA and its Aspects (10-point Scale)



The EAs were provided with the opportunity during the interview to voice both their likes and dislikes about HEA. They provided positive and negative feedback, which was similar to their reasons for satisfaction or dissatisfaction with HEA. On the positive side, all the EAs mentioned various aspects they enjoyed about HEA, such as the tiered incentive approach, the environmental benefits resulting from HEA, the integration with NRCan requirements (thus requiring little additional expertise to deliver HEA), that HEA's measures and incentives are aligned with homeowners' expectations and it can provide homebuyers with an idea about the required upgrades prior to purchasing a home. On the negative side, three of the four EAs mentioned what they most disliked about HEA is that HEA only allows electrically heated homes to participate. Additionally, two EAs believed the complex rebate calculation approach included in the Customer Rebate Guide is a downfall. Indeed, some surveyed participants mentioned the need to clarify the incentive structure and how to reach incentives as a main area for HEA's improvement.

3.2.2 Opinions on Training

Two of the four EAs said that no further training or information is needed to help them better understand or deliver HEA. The other two provided suggestions on what would be helpful. One said that a meeting should be held once a year to communicate about program component guidelines and incentives, as well as to provide everyone with an opportunity to ask questions. The other mentioned the unique climate challenges related to Nova Scotia's terrain and coastal location (i.e., wind, mist, and salty air) and how it may impact homes' energy efficiency as an interesting training topic.

Among the nine shortlisted potential topics for future training sessions, training on the latest technologies was identified as the most useful topic, as indicated by an average rating of 8.8 out of 10. Training about better understanding the other programs offered by ENS, building envelope retrofit construction best practices and the HOT2000 software (advance training only) followed. The following topics had less appeal among the EAs: indoor air quality, and information to be collected on site.

When asked about other training topics, one EA mentioned training on variable refrigerant flow systems.

Training delivered in person or online through webinars is most appealing to EAs, while phone calls and paper documentation are less appealing delivery methods.

Table 10 below provides an overview of the average usefulness scores on a 10-point scale for each of the proposed training topics.

Table 10: The EAs' Usefulness Ratings of the Proposed Training Topics

Training Topics	Number of Responses			Mean*
	Rating 8-10	Rating 6-7	Rating 1-5	
Newer technologies like heat pump water heaters, solar PV, etc. (n=4)	4	0	0	8.8
The other programs offered by ENS (n=4)	1	2	1	7.3
Building envelope retrofit construction best practices (n=4)	1	1	2	6.3
HOT2000 software (n=4)	2	1	1	6.0
Other non-energy benefits, such as GHG emissions and increased comfort (n=4)	2	1	1	5.8
The program component in general including its guidelines, incentives and eligible measures (n=4)	1	0	3	5.0
Indoor air quality, including moisture and ventilation issues (n=4)	1	1	2	4.3
The information that needs to be collected on site, including how to use and fill out the data collection forms or other program component documents (n=4)	0	1	3	3.3

* Scale: 1 = Not at all useful; 10 = Extremely useful

3.2.3 Barriers to Participation and Recommendations for Improvement

The EAs offered diverse feedback regarding opportunities for ENS to increase the number of participants that register for a pre-retrofit assessment. Suggestions included that ENS engage in more outreach with real estate professionals (e.g., real estate agents and home inspectors), contractors, and home improvement retailers, because they are the main sources of participant referrals for HEA according to the EAs. Real estate agents could also advertise the listed homes' EnerGuide ratings as a selling point and a means for educating consumers about the value of energy-efficient homes. In fact, ENS has already started undertaking an initiative called the EnerGuide Real Estate Listings to provide EnerGuide evaluations for those interested in buying or selling a home and share the associated EnerGuide information. Other suggestions included increased incentives, expanded ENS online marketing, and the extension of HEA to non-electrically heated homes.

Additionally, the EAs noted that their respective DA could increase their own marketing activities, attend home shows, and set up vendor booths at appropriate local retailers' stores to raise awareness of HEA.

Generally, the EAs believe that the cost of completing recommended upgrades is a major factor preventing homeowners from moving forward with HEA once the pre-retrofit assessment is completed. One EA suggested that higher incentives and a better description of the return on investment should be offered to homeowners to encourage the implementation of all the upgrades, especially those that are rarely implemented. This feedback highlights the importance and relevance of a tool such as the EAP. The other EAs did not offer any feedback about this matter.

3.2.4 Market Trends

When looking at how energy efficiency has changed over the last few years, increasing awareness about energy-efficient products for homes, their decreasing costs and their increasing perceived value were commonly discussed, particularly about heat pumps. In addition to the growing popularity of heat pumps, the EAs observed that some changes have occurred in the insulation of both the attic and the basement over the past five years and, more specifically, homeowners are making better insulation choices and are more frequently insulating their basements.

Two EAs have noticed differences in the efficiency level of the products and equipment implemented in newly constructed homes compared to those implemented in existing homes over the past few years. While the technology installed in both types of homes is considered similar, the construction code now requires a higher R-value that increases newly constructed homes' energy efficiency compared to existing homes. It was also noted that homeowners may pay closer attention to the quality of the equipment installed, whereas home builders may look to meet the minimum requirements set by the construction code. As for products, it has been observed that heat pumps and light-emitting diode (LED) lighting are prevalent in the new home construction market.

All the EAs believed that existing homes have greater potential for improving energy efficiency because they are probably not up to the current building code. The EAs suggested that ENS should include additional measures to be incentivized, including PV panels, and tankless water heaters.

Two EAs suggested that ENS consider taking two actions to improve HEA's effectiveness: implementing a mandatory EnerGuide rating system for homes for sale (1 mention), and providing training on the introduction of variable refrigerant flow systems (1 mention).

4 HEA IMPACT EVALUATION

The objective of the 2017 HEA impact evaluation is to determine the gross and net electrical energy and peak demand savings.

4.1 Gross Savings

The gross savings correspond to the change in energy consumption resulting from the building envelope measures, DHW measures as well as space and water heating equipment installed by HEA participants, regardless of why they participated.¹¹ The Evaluator revised the gross savings tracked by ENS by reviewing the savings calculations by eligible measure category.

4.1.1 HEA Energy Efficiency Measures

No new energy efficiency measures were made available to participants in 2017; the eligible upgrades were the same as those assessed during the 2016 evaluation. Table 11 below lists the upgrades currently eligible under HEA and identifies the measures for which the savings can be calculated by using HOT2000 energy consumption modelling.

¹¹ Definition adapted from: National Renewable Energy Laboratory, *The Uniform Methods Project Chapter 23: Estimating Net Savings: Common Practices*, September 2014, p. 3.

Table 11: HEA Eligible Energy Efficiency Upgrades

Eligible HEA Upgrade Measures	HOT2000 Energy Consumption Modelling Being Used to Calculate Savings	HOT2000 Energy Consumption Modelling not Being Used to Calculate Savings
Building Envelope Measures		
Attic Insulation	x	
Cathedral Ceiling Insulation	x	
Flat Roof Insulation	x	
Basement Foundation Wall Insulation	x	
Crawlspace Exterior Wall Insulation	x	
Floor above Crawlspace Insulation	x	
Basement Header Insulation	x	
Exposed Floor Insulation	x	
Basement Slab Insulation	x	
Exterior Wall Insulation	x	
Air Sealing	x	
Windows, Doors and Skylights	x	
Space Heating Equipment		
Ductless Mini-split Heat Pump	x	
Central Ducted Air Source Heat Pump	x	
Air-to-water Heat Pump (AWHP)	x	
Geothermal Heat Pump	x	
Wood or Pellet Stove		x
Wood or Pellet Furnace/Boiler		x
Solar Air		x
Heat Recovery Ventilation	x	
Domestic Water Heating Equipment		
Heat Pump Water Heater		x
Drain Water Heat Recovery		x
Solar DHW System		x

For impact evaluation purposes, the savings calculation has been divided in two categories: space heating savings (including building envelope and space heating measures), and DHW savings.

4.1.2 Space Heating Savings

Savings for the building envelope and space heating measures are calculated by comparing the D and E modelled space heating consumption levels established by the HOT2000 simulation, using the following equation:

$$\text{Space Heating Savings (kWh)} = \frac{\% \text{Electric Heating}_{D \text{ Audit}} \times [(SHEC (MJ)_{D \text{ Audit}} \times (1 - \text{Overestimation Ratio})) - GHS] \times \left(\frac{SHEC (MJ)_{D \text{ Audit}} - SHEC (MJ)_{E \text{ Audit}}}{SHEC (MJ)_{D \text{ Audit}}} \right) + GHS}{3.6 \text{ MJ/kWh}}$$

Where space heating energy consumption (SHEC) corresponds to the total SHEC (all fuel types combined) and Green Heat savings (GHS) corresponds to the Green Heat unitary savings values for wood, pellet or solar air equipment.

The savings calculation is based on the difference (reduction) in percentages between D and E assessment SHEC levels. This difference in percentage was applied to the pre-assessment (D) space heating consumption value, after it was adjusted with an overestimation ratio. When wood, pellet or solar air equipment is installed, an adjustment is made to account for the savings separately since these upgrades are not modelled using HOT2000. Finally, the percentage of electric heating from the D assessment is applied to the overall result.

This method was used in the tracking system for all the participants who implemented building envelope measures and installed new space heating equipment in 2017. When a fuel switch occurred, energy savings were credited to the “former” fuel (the D assessment).

This modelling-based gross savings calculation method was developed by ENS and the Evaluator for the 2016 evaluation and is still appropriate for 2017.

The Overestimation Ratio

As shown in the space-heating savings formula, an overestimation ratio is used to adjust the modelled space heating consumption values generated by the HOT2000 software, which tends to slightly overestimate savings. For this year's evaluation, the Evaluator still used the overestimation ratio of 16 percent established in the 2015 evaluation.

The analysis conducted in 2015 compared participants' heating consumption calculated by HOT2000 with the actual space-heating consumption based on electrical billing data for a full year. A regression analysis was conducted to isolate the portion of electrical energy consumption that varies according to outdoor temperatures and corresponds to the space-heating electricity consumption.

The billing analysis was performed for HEA participants between 2013 and 2015. The analysis for the period before the upgrades was made for 305 participants, while the analysis for the period after the upgrades was completed for 208 participants. Since there was no significant variation between the two overestimation ratios, the Evaluator decided to use the average deviation between the heating consumption levels obtained from the HOT2000 simulations and the participants' actual consumption levels obtained for both periods and this deviation revealed an average overestimation ratio of 16 percent.

For 9 percent of HEA's participants, a new version of HOT2000 was used to calculate their savings. Since these participants currently only represent a small proportion of HEA participants, the Evaluator considered that the use of the overestimation ratio of 16 percent for all projects is still valid for 2017. If this new version of HOT2000 is used for a bigger proportion of 2018 participants, the Evaluator would recommend conducting a new billing analysis to estimate a new overestimation ratio in the next evaluation.

Space-heating Equipment Not Simulated in HOT2000

Wood and pellet space-heating equipment was not simulated in HOT2000. These measures' tracked unitary savings values correspond to the tracked savings values used in Green Heat for the same types of equipment. These unitary savings values were revised as part of the 2017 Green Heat evaluation.

For those cases where the electrical heating system in use prior to the installation of the wood and pellet space-heating equipment is considered to be electric baseboards, the tracked savings were considered accurate and the Evaluator made no adjustment to the unitary savings value.

For those participants who used an air-source heat pump (ASHP) as their main heating system prior to the installation of their stoves, the tracked unitary savings values were divided by the average coefficient of performance (COP) of 2.1. This COP was estimated based on the Heating Seasonal Performance Factor (HSPF) for a standard ASHP, defined as the equivalent of an HSPF Region V value of 7.13 in the Pennsylvania Public Utility Commission (PUC) TRM.¹² As mentioned in the 2017 Green Heat evaluation, one small adjustment was applied to the two unitary savings values used for participants with a heat pump as the baseline to account for a calculation error in the 2016 evaluation report.¹³ Thus, a revised unitary savings value of 4,973 kWh for wood stoves with a heat pump baseline and a revised unitary savings value of 4,266 kWh for pellet stoves with a heat pump baseline were used.

No solar air equipment was installed through HEA or Green Heat in 2017. Therefore, no unitary savings value was established for this equipment category.

Table 12 below lists the tracked and revised savings values for each type of equipment.

¹² Pennsylvania Public Utility Commission, *Technical Reference Manual*, June 2016, (Section 2.2.1 –Electric HVAC)

¹³ Unitary savings values with electrical resistance should be divided by a COP of 2.1 rather than 2.0.

Table 12: Tracked and Revised Unitary Savings for Space-heating Equipment

Category of Equipment	Tracked Savings Value (kWh)	Revised Savings Value (kWh)
Wood Stove – With Electric Baseboard Baseline	10,443	10,443
Wood Stove – With Heat Pump Baseline	5,222*	4,973
Pellet Stove – With Electric Baseboard Baseline	8,959	8,959
Pellet Stove – With Heat Pump Baseline	4,480*	4,266
Wood Furnace or Boiler	13,804	13,804
Pellet Furnace or Boiler	13,765	13,765
Solar Air	-	-
*A mistake was detected in the 2016 evaluation report: a COP of 2 was used instead of 2.1.		

4.1.3 Domestic Hot Water Savings

Savings for DHW measures are calculated using a unitary savings value specific to each type of measure implemented. The Evaluator established unitary savings for the small number of DHW measures implemented by 2017 participants. The unitary savings values were favoured over the simulation results from HOT2000 to ensure a more accurate estimate of the energy savings associated with DHW measures. Indeed, the overestimation ratio for the values generated by the HOT2000 software was calculated using only space heating consumption values, and thus, could not be used for modelling DHW's energy consumption. The next section discusses the analysis conducted by the Evaluator to review the unitary savings values used by ENS.

Drain Water Heat Recovery

ENS uses a unitary savings value of 805 kWh per year. This value was determined in last year's evaluation using the online calculator from the Center for Energy Advancement through Technology Innovation¹⁴, which takes into account the number of showers per household per day, the average shower duration, the shower flow and the Halifax groundwater temperature. It was assumed that two showers per day are taken per household and each shower lasts approximately eight minutes. The number of showers per household per day was determined by multiplying the average number of persons per household from the 2016 HEA participant survey (2.4 persons) and the number of showers per person per day (0.67 showers) from the Residential End of Uses of Water Study.¹⁵ The average shower duration was also established using the Residential End of Uses of Water Study.¹⁶ The estimated shower flow rate is 9.5 litres per minute, which is based on the maximum rated flow for showerheads in the building code. The shower temperature was set at 41°C.

The calculation assumed a drain water heat recovery (DWHR) system configuration which preheats cold water between the hot water tank and shower and an R3-60 model unit, which meets the HEA minimum efficiency requirement and is included in the list of NRCan eligible models.

The Evaluator considered that the online calculator is still appropriate for estimating the savings generated by a DWHR system installed. Based on the 2017 HEA participant survey, the average number of persons per household was revised to 2.5 persons. However, by multiplying it with the number of 0.67 showers per day, the number of showers per household per day is still two considering that the online calculator rounds up the number to the nearest digit. The other parameters remain unchanged. Therefore, the unitary savings value of DWHR system remains at 805 kWh. This year, no DWHR systems were installed under HEA, but this unitary savings value could be used for future tracking.

Solar Domestic Hot Water System

For solar DHW systems, ENS uses a unitary savings value of 2,612 kWh per year based on the 2016 evaluation report. This value was established from the savings generated by the solar DHW systems installed through Green Heat in 2015 and 2016.

¹⁴ Center for Energy Advancement through Technology Innovation (CEATI), *Drain Water Heat Recovery Energy Savings Calculator*, <http://www.ceati.com/calculator/>, (Last accessed November 15, 2017).

¹⁵ Mayer, P. W., W. B. Oreo et al., *Residential End Uses of Water*, AWWA Research Foundation, 1999, pp. 99-102.

¹⁶ Mayer, P. W., W. B. Oreo et al., *Residential End Uses of Water*, AWWA Research Foundation, 1999, pp. 99-102.

The Evaluator reviewed the unitary savings value by considering the systems installed through Green Heat in 2015, 2016 and 2017. A total of 39 solar DHW systems were installed during this period through Green Heat. Under Green Heat, each system was modelled using RETScreen. For HEA, since the design details of the installed solar DHW systems are not included in the HEA tracking system, the unitary savings value is determined based on the average value of DHW systems installed through Green Heat.

The unitary savings value was established by the Evaluator at 2,803 kWh per year for the solar DHW systems installed through HEA in 2017.

Heat Pump Water Heater

The annual unitary savings value used by ENS for heat pump water heater (HPWH) installed through HEA is the same as the one established in the 2016 Green Heat evaluation report. This value was established by ENS by using calibrated HOT2000 models representing nine home archetypes of various sizes, age classes and solar orientations, considered representative of the Nova Scotia's housing stock. The homes were each modelled using two different electric heating system baselines for the primary heating source (electric radiant baseboards and a mini-split heat pump [MSHP]) and a standard electric resistance water heater. Then, the same homes were modelled with a HPWH, and the savings were calculated by finding the difference in the total modelled energy values between the homes equipped with a standard water heater and those same homes equipped with a HPWH. The Evaluator considered ENS's savings calculation methodology still valid for 2017 and applied it without making any modification.

The annual unitary savings for a HPWH installed through HEA was established at 2,183 kWh per year.

4.1.4 Peak Demand Savings

Peak demand savings correspond to the demand savings that coincide (in time) with the peak demand of the electricity system. The projected electricity demand peak period in Nova Scotia is between 5 p.m. and 7 p.m. in the months of December to February on a non-holiday weekday.

For HEA, peak demand savings were calculated using the on-peak demand-to-energy ratio of 0.283 MW/GWh for space heating savings, and 0.162 MW/GWh for DHW savings set by Navigant in the 2016-2018 DSM Plan. These ratios were established based on the modelled system coincident peak demand savings and energy savings for a projected deployment of measures. Navigant used local data to establish the ratios for 2017. The Evaluator considers that the approach used by Navigant to establish the on-peak demand-to-energy ratios is valid and therefore used it to estimate peak demand savings.

4.1.5 Interactive Effects

In a home, interactive effects occur when the implementation of energy-efficiency measures has an impact on the energy consumption of other factors, such as heating and cooling. The interactive effects regarding the space-heating measures implemented through HEA were already considered in the calculations of the savings since the calculations are based on the simulation models, which encompass the total electricity consumption of the house. As for the DHW measures, interactive effects are considered to be nil for DWHRs and solar DHW systems because they do not impact space-heating or cooling loads. As for HPWHs, the interactive effects depend on the location of the system. Since there were only five HPWHs installed through HEA in 2017, the interactive effects were considered negligible. Hence, no further interactive effects have been considered in the savings calculation.

4.1.6 Effective Useful Life

As part of the 2017 evaluation, the Evaluator reviewed the EUL values used by ENS in the calculations of energy savings that will persist over time.

For HEA, the EUL values of all the measures eligible for the program component were reviewed based on the findings of a literature review. When establishing the EUL for a given measure, the Evaluator considered the most common values found in TRMs, evaluation reports or relevant studies. Those sources that based their EUL estimates on measured data or other reliable methods were preferred, whenever these were available.

Table 13 presents the tracked and the revised EUL values by measure category. It is worth mentioning that a weighted average of the revised EUL values was used to calculate lifetime energy savings generated by building-envelope measures and space-heating systems. For DHW measures, the revised EUL value was applied to each DHW system.

Table 13: Summary of Effective Useful Life Values by Measure Category

Measure	ENS Tracked EUL	Revised EUL	Reference
Envelope Measure			
Attic Insulation	26.7	25	GDS Measure Life Report, Table 3; value for insulation ¹⁷
Cathedral Ceiling Insulation			
Flat Roof Insulation			
Basement Foundation Walls			
Crawlspace Exterior Walls			
Floor above Crawlspace			
Basement Header Insulation			
Exposed Floor Insulation			
Basement Slab Insulation			
Exterior Wall			
Air Sealing		15	GDS Measure Life Report, Table 3; value for air sealing
Windows, Doors and Skylights	20	DEER 2014 EUL Table; value for windows ¹⁸	
Space-heating Equipment			
Ductless Mini-split Heat Pump	26.7	18	GDS Measure Life Report, Table 1; value for retrofit heating and cooling systems
Central Ducted Air Source Heat Pump			
Air-to-water Heat Pump			
Geothermal Heat Pump		25	United States DOE; value for geothermal heat pumps vapour-compression components ¹⁹
Wood or Pellet Stove		18	GDS Measure Life Report, Table 1; value for retrofit heating and cooling systems
Wood or Pellet Furnace/Boiler			

¹⁷ GDS Associates, Inc., *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*, Report prepared for the England State Program Working Group, June 2007.

¹⁸ Database for Energy Efficiency Resources (DEER), *DEER2014 EUL Table*, 2014, https://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwig3cq25e_UAhUBVz4KHTc-CjsQFggnMAA&url=http%3A%2F%2Fwww.deeresources.com%2Ffiles%2FDEER2013codeUpdate%2Fdownload%2FDEER2014-EUL-table-update_2014-02-05.xlsx&usq=AFQjCNH2stM_7JBjJbqBDBKHnEdml-AvpQ, (Last accessed February 28, 2018)

¹⁹ United States Department of Energy, Geothermal Heat Pump | Department of Energy, <http://energy.gov/energysaver/articles/geothermal-heat-pumps>, (Last accessed February 28, 2018).

Measure	ENS Tracked EUL	Revised EUL	Reference
Solar Air		20	ENERGY STAR, Save Money and More with ENERGY STAR Qualified Solar Water Heaters ²⁰
Heat Recovery Ventilation		20	Natural Gas Energy Efficiency Potential in Massachusetts ²¹
Domestic Water Heating Equipment			
Heat Pump Water Heater	26.7	10	DEER 2014 EUL Table; value for heat pump water heater
Drain Water Heat Recovery		20	State of Ohio Energy Efficiency TRM ²²
Solar DHW System		20	ENERGY STAR, Save Money and More with ENERGY STAR Qualified Solar Water Heaters

A literature review of various TRMs revealed that most jurisdictions refer to the GDS Associate's Measure Life Report²³ when estimating the measure life of building envelope and heating measures. This report was published in 2007 to provide a set of EUL values that could be consistently used across the New England states. The EUL values documented in this report were obtained through a literature review as well as stakeholder consultations.

ENS currently uses a EUL value of 26.7 years for all measures installed through HEA. The Evaluator suggests using separate EUL values for each type of measure to more accurately calculate lifetime energy savings. For insulation and air sealing measures, the Evaluator revised the EUL value to 25 years and 15 years respectively since most jurisdictions use these EUL values from the GDS report. For windows, the literature review revealed that most jurisdictions use an EUL value of 20 years based on the Database Energy Efficiency Resources (DEER). Therefore, the Evaluator chose to use this EUL value for windows.

²⁰ ENERGY STAR, *Save Money and More with ENERGY STAR Qualified Solar Water Heaters*, https://www.energystar.gov/products/water_heaters/water_heater_solar/benefits_savings, (Last accessed February 27, 2018).

²¹ GDS Associates Inc. and Summit Blue Consulting, *Natural Gas Energy Efficiency Potential in Massachusetts*, Report prepared for GasNetworks, 2009

²² Vermont Energy Investment Corporation, *State of Ohio Energy Efficiency Technical Reference Manual*, August 2010

²³ GDS Associates, Inc., *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*, Report prepared for the England State Program Working Group, June 2007, Table 1, pp. 1-3..

Regarding ASHPs, which include central ducted heat pumps, MSHPs and AWHPs, the literature review revealed that the EUL value is between 15²⁴ and 18 years.²⁵ Two sources were commonly used by TRMs, namely the DEER (EUL of 15 years) and GDS Report (EUL of 18 years). These EUL values are consistent with other sources such as the American Society of Heating, Refrigerating and Air Conditioning (ASHRAE)²⁶, (which sets the measure life of residential air-to-air heat pumps at 15 years), and NRCan²⁷ (which suggests a service life between 15 and 20 years). Since most jurisdictions use 18 years for ASHPs, the Evaluator considers that the value of 18 years already used by ENS is accurate.

For ground-source heat pumps (GSHPs), the literature review revealed that the EUL value for such heat pumps is higher than for ASHPs because the compressor is protected from the environment and has less mechanical and thermal stress.²⁸ The EUL values documented in TRMs range between 18 and 30 years. Some jurisdictions refer to the GDS report for residential heating measures (18 years for retrofit or 25 years for new construction), while others refer to the U.S. Department of Energy (DOE)²⁹ (EUL of 25 years). NRCan also recommends a range of 20 to 25 years. The Evaluator decided to keep the EUL value at 25 years since this value is in line with the literature review findings.

The Evaluator calculated an overall EUL value for building-envelope measures and heat pumps since the savings associated with these measures are combined under HOT2000. By using the proportions of participants who installed building-envelope measures and heat pumps, a weighted overall EUL value of 20 years was established for these measures.

Since very few TRMs document the specific EUL of biomass measures, the Evaluator decided to keep using the EUL value documented in the GDS report for residential retrofit heating measures. This value is consistent with the value suggested by the ASHRAE³⁰ for furnaces (18 years) and the value suggested by the DEER³¹ for boilers and furnaces (20 years).

²⁴ EUL value used in the following TRMs consulted: Pennsylvania, New York, California, Oregon, and Idaho.

²⁵ EUL value used in the following TRMs consulted: Maine, Vermont, Massachusetts, Rhode Island, Mid-Atlantic, Illinois, Minnesota, Connecticut, and Wisconsin.

²⁶ ASHRAE, *ASHRAE Equipment Life Expectancy Chart*, http://www.culluminc.com/wp-content/uploads/2013/02/ASHRAE_Chart_HVAC_Life_Expectancy%201.pdf, (Last accessed February 28, 2018)

²⁷ Natural Resources Canada (NRCan), *Air-Source Heat Pumps*, Updated March 27, 2017, <http://www.nrcan.gc.ca/energy/publications/efficiency/heating-heat-pump/6831> (Last accessed November 9, 2017).

²⁸ Natural Resources Canada (NRCan), *Ground-Source Heat Pumps (Earth-Energy Systems)*, Updated March 27, 2017, <http://www.nrcan.gc.ca/energy/publications/efficiency/heating-heat-pump/6833> (Last accessed November 9, 2017).

²⁹ <https://energy.gov/energysaver/geothermal-heat-pumps>

³⁰ ASHRAE, *ASHRAE Equipment Life Expectancy Chart*, http://www.culluminc.com/wp-content/uploads/2013/02/ASHRAE_Chart_HVAC_Life_Expectancy%201.pdf, (Last accessed February 28, 2018).

³¹ Database for Energy Efficiency Resources (DEER), *DEER2014 EUL Table*, 2014, https://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwig3cq25e_UAhUBVz4KHTc-CjsQFqgnMAA&url=http%3A%2F%2Fwww.deeresources.com%2Ffiles%2FDEER2013codeUpdate%2Fdownload%2FDEER2014-EUL-table-update_2014-02-05.xlsx&usq=AFQjCNH2stM_7JBIJbqBDBKHnEdml-AvpQ, (Last accessed February 28, 2018)

By applying the proportion of gross savings, the weighted overall EUL value of building-envelope measures and heat pumps calculated previously, and the EUL values for biomass measures, the Evaluator established a weighted average EUL value of 20 years for space-heating measures and used this average value to calculate lifetime energy savings for these measures.

As for hybrid HPWHs, most jurisdictions refer to either the DEER (EUL of 10 years for HPWHs) or the DOE (EUL of 13 years for gas-fired, electric, and oil-fired storage water heaters). Since the DEER documents a value specifically for HPWHs, the Evaluator decided to use an EUL value of 10 years rather than the tracked value of 13 years. Only a small number of jurisdictions document the EUL value of DHW solar systems. Since ENERGY STAR provides an EUL value specifically tailored to DHW solar measures, the Evaluator has revised the EUL value to 20 years. As for solar air heating systems, the Evaluator assigned an EUL value of 20 years to this measure since little information was found in the literature about this type of solar system. The Evaluator considers that the EUL of solar air heating systems is at least equivalent to that of solar DHW systems because solar air heating systems do not typically have a mechanical component.

For heat recovery ventilation and drain water heat recovery systems, not many jurisdictions document the EUL value for these systems. The Evaluator chose to use an EUL value of 20 years for both measures since this value is in line with the EUL value proposed in the Massachusetts report and the Ohio TRM.

4.1.7 Revised Gross Savings

The annual gross savings for HEA are presented in Table 14 below. The difference between the tracked and revised gross savings is due to the following three changes made to the tracked gross savings: first, the unitary savings values of wood and pellet heating equipment were adjusted for the participants who already had an ASHP; second, the unitary savings value for solar DHW systems was revised; third, the Green Heat deductions were also revised. When tracking HEA's savings, ENS deducts the energy savings for those participants who participated in both HEA and Green Heat to ensure that energy savings are not claimed twice for the same upgrade. The Evaluator adjusted these deductions by applying the 2017 Green Heat revised savings for those participants who applied to Green Heat in 2017. For those who applied in 2016, the 2016 evaluated values were used.

The gross savings at the generator were estimated by applying a line loss factor of 1.099 between the meter and the generator. This value was established by calculating a weighted average of the line loss factors of the HEA projects according to their rate codes. The residential code has a line loss factor of 10 percent while the municipal rate code has a line loss factor of 4.6 percent. Overall, the annual gross energy and peak demand savings at the generator amounted to 8.306 GWh and 2.348 MW respectively. Based on the revised EUL values for various types of measures, the 2017 annual gross energy savings represents 166.116 GWh in lifetime energy savings.

Table 14: Revised Gross Energy and Peak Demand Savings for HEA

	Space Heating	DWHR	Solar DHW	HPWH	Total
Number of Participants/Units	931	0	3	5	931
Evaluated Energy Savings					
Unitary Savings Value (kWh/unit)	-	805	2,803	2,183	-
Tracked Gross Energy Savings – at the Meter (GWh)	7.495	-	-	-	7.495
Revised Gross Energy Savings – at the Meter (GWh)	7.538	0.000	0.008	0.011	7.558
Line Loss Factor	1.099	1.099	1.099	1.099	1.099
Revised Gross Energy Savings – at the Generator (GWh)	8.285	0.000	0.009	0.012	8.306
Effective Useful Life (years)	20	10	20	20	-
Gross Lifetime Energy Savings – at the Generator (GWh)	165.691	0.000	0.185	0.240	166.116
Peak Demand Savings					
Demand-to-energy Ratio (MW/GWh)	0.283	0.162	0.162	0.162	-
Revised Gross Peak Demand Savings – at the Meter (MW)	2.133	0.000	0.001	0.002	2.136
Line Loss Factor	1.099	1.099	1.099	1.099	1.099
Revised Gross Peak Demand Savings – at the Generator (MW)	2.345	0.000	0.001	0.002	2.348

4.2 Net-to-gross Ratio

The net-to-gross ratio (NTGR) allows for determining the net savings, i.e., the energy savings that can be reliably attributed to a program component. More precisely, the NTGR represents the positive or negative impact of effects on the gross savings. For HEA, two effects are considered, namely free-ridership and internal spillover.

4.2.1 Free-ridership

Free-ridership can occur when participants would have still implemented energy efficiency upgrades and measures in the absence of a program component. The assessment of the free-ridership level was based on a self-report approach, which involved asking participants a set of questions during a telephone survey. The questionnaire included questions about all the applicable variables related to the decision-making process, including planning, efficiency, timing and cost. Additional questions were used to determine whether participants' decisions to install the measures had been influenced by previous participation in one of ENS energy efficiency program components or ENS's efforts to raise awareness about energy efficiency.

The feedback collected from the participant survey was converted into an overall free-ridership level for each participant. The algorithm underlying free-ridership calculations is presented in Appendix V. As presented in Table 15, the free-ridership level was established at 25 percent, which was slightly below the free-ridership level in previous years (28% in 2016, 31% in 2015, 31% in 2014, 30% in 2013, 30% in 2012 and 31% in 2011).

Table 15: Average Free-ridership Level

Average Free-ridership Level	Sample Size	Population Size	Margin of Error
25%	61	931	5.2%

4.2.2 Internal Spillover

The participant survey was also used to assess internal spillover, which can occur when participants implement additional energy efficiency measures recommended in their initial energy assessments after their participation in the program component, i.e., after having completed their final energy assessment.

The spillover assessment involved asking participants a set of questions during the telephone survey. The methodology used to calculate the level of internal spillover is presented in Appendix VI.

As presented in Table 16, the 2017 survey results revealed an internal spillover factor of 1 percent, which was lower than the past few years (6% in 2016, 5% in 2015 and 6% in 2014). This year, most of the surveyed participants exhibiting spillover installed air sealing measures, which generated lower savings than the measures installed in 2016 such as central air source heat pumps and efficient water heating systems.

Table 16: Average Internal Spillover Level

Average Internal Spillover Level	Sample Size	Population Size	Margin of Error
1%	69	931	4.1%

4.2.3 NTGR Calculation

The NTGR is calculated using the following equation:

$$NTGR = (1 - \% \text{ free-ridership} + \% \text{ internal spillover})$$

By applying the free-ridership and spillover factors established for HEA, the NTGR value has been estimated at 0.76.

4.3 Unconverted D Assessment Spillover

Since the 2014 evaluation, another spillover effect associated with unconverted D assessment savings has been considered. This effect corresponds to the savings associated with those measures implemented by participants who did not complete an E assessment by the end of the 12-month period allocated (expired participants or unconverted D assessment participants). These savings are added to the gross savings as a kind of spillover. However, since the unconverted D assessment spillover savings do not depend on the number of regular HEA participants, they are accounted for in measurement units instead of a percentage, without being included in the NTGR.

In the previous evaluation, a survey conducted by ENS with 232 expired participants demonstrated that 54 percent of respondents declared having installed at least one upgrade. An average electrical savings per participant of 2,283 kWh was used for the 2016 evaluation. This value was obtained by averaging the sum of 2,207 kWh and 2,359 kWh, which were respectively the average electrical energy savings with influence from ENS generated by 2014 and 2015 expired participants. No E assessment was conducted for any unconverted D household this year. The methodology and the parameters used in the previous evaluation are still considered appropriate for determining the total unconverted D assessment spillover-related savings. Therefore, the value of 54 percent and the average value of 2,283 kWh were still used for this evaluation.

The total unconverted D assessment spillover-related savings are calculated using the following equation:

$$\begin{aligned}
 &\textit{Unconverted D Assessment Spillover Energy Savings} \\
 &= (\textit{Total number of unconverted D participants}) \\
 &\times (\% \textit{ who declared having implemented measures after their D assessment}) \\
 &\times \left(\textit{average electrical savings per house visited and weighted} \right) \\
 &\quad \textit{with \% of influence from ENS}
 \end{aligned}$$

The peak demand savings were established by applying the same demand-to-energy ratio as the one used for space-heating measures installed by regular HEA participants because the majority of measures installed by unconverted D participants were building envelope upgrades. The 2017 unconverted D assessment spillover energy and peak demand savings for HEA were estimated at 0.632 GWh and 0.179 MW at the meter respectively. Detailed results are shown in Table 17 below.

Table 17: Unconverted D Assessment Spillover

2017 Results	
Total Number of Unconverted D Assessment Participants	513
Ratio of Unconverted D Assessment Participants Who Implemented at Least One Measure	54%
Total Number of Unconverted D Assessment Participants Who Implemented at Least One Measure	277
Average Electrical Savings per Participant in kWh (with influence from ENS)	2,283
Total Unconverted D Assessment Spillover Energy Savings – at the Meter (GWh)	0.632
Demand-to-energy Ratio (MW/GWh)	0.283
Total Unconverted D Assessment Spillover Peak Demand Savings – at the Meter (MW)	0.179

4.4 Net Savings

Net savings represent the savings that can be reliably attributed to a program component. They are calculated by applying the aforementioned NTGR value to the evaluated gross savings and adding the unconverted D assessment spillover savings, as shown in the following equation:

$$\text{Net Savings} = \text{Gross Evaluation Savings} \times \text{NTGR} + \text{Unconverted D Assessment Spillover Savings}$$

The 2017 net energy and peak demand savings for HEA have been estimated respectively at 7.007 GWh and 1.981 MW at the generator (see Table 18). Using the 2016 Nova Scotia-specific factor³² for GHG emissions generated by electricity production, 0.6531 kg CO₂ eq/kWh at the generator, it was estimated that the net energy savings resulted in 4,576 tonnes of avoided CO₂ eq annually. Based on the weighted average EUL of 20.0 years, the net lifetime energy savings were established at 140.139 GWh.

³² At the time of writing, 2017 data was not available. The Nova Scotia-specific factor was obtained from NSP's 2016 total system emissions data (7,079,268 CO₂ eq tonnes) and total electricity generation (10,839 GWh) from the following two sources:

Nova Scotia Power, *Total System Emissions*, <http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx>, (Last accessed December 17, 2017).

Emera Inc., *Management's Discussion & Analysis As at February 10, 2017*, <http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693> (Last accessed December 17, 2017)

Table 18: Evaluated Net Energy and Peak Demand Savings for HEA

Savings	Total
Energy Savings	
Revised Gross Energy Savings – at the Meter (GWh)	7.558
NTGR	0.76
Unconverted D Assessment Spillover Energy Savings – at the Meter (GWh)	0.632
Net Energy Savings – at the Meter (GWh)	6.376
Line Loss Factor	1.099
Net Energy Savings – at the Generator (GWh)	7.007
Effective Useful Life (years)	20.0
Net Lifetime Energy Savings – At the Generator (GWh)	140.139
Peak Demand Savings	
Revised Gross Peak Demand Savings – at the Meter (MW)	2.136
NTGR	0.76
Unconverted D Assessment Spillover Peak Demand Savings – at the Meter (MW)	0.179
Net Demand Savings – at the Meter (MW)	1.803
Line Loss Factor	1.099
Net Demand Savings – at the Generator (MW)	1.981

Table 19 below compares the energy and peak demand savings established through this evaluation and those calculated in the tracking system.

Table 19: Comparison of Tracked and Evaluated Savings at the Generator

	Initial Gross Savings	Adjusted Gross Savings	NTGR	Net Savings
Energy Savings				
ENS Tracked Savings	8.945 GWh	8.298 GWh	0.78	7.145 GWh
Evaluation Results	8.959 GWh	8.306 GWh	0.76	7.007 GWh
Peak Demand Savings				
ENS Tracked Savings	2.532 MW	2.348 MW	0.78	2.029 MW
Evaluation Results	2.535 MW	2.348 MW	0.76	1.981 MW

In this evaluation, the calculated gross energy savings slightly exceed those tracked by ENS due to the lower revised unitary savings deducted for the measures for which some participants claimed savings in both HEA and Green Heat. By contrast, the evaluated net energy and peak demand savings values are both 2 percent lower than those tracked by ENS. This difference is explained by a decrease in the NTGR value due to a reduction in the 2017 spillover level compared to 2016.

5 GREEN HEAT OVERVIEW

The following sections present the Green Heat evaluation results. The evaluation results of the EPI program component follow.

This section describes Green Heat, follows up on the 2016 evaluation recommendations and provides an overview of participation history.

5.1 Description

The goal of Green Heat is to provide financial incentives to homeowners to encourage them to reduce electricity use for heating by either installing high-efficiency electrical systems or replacing electrical systems with systems that use another energy source. ENS staff manages and administers Green Heat.

More specifically, the following categories of heating system equipment are rebated:

- › Heat pumps: high-efficiency space heating systems and DHW heating systems
- › Biomass: high-efficiency wood and pellet stoves, and central heating systems
- › Solar thermal: solar hot water and solar space heating systems

Starting August 2017, Green Heat underwent a series of changes. The 2017 Green Heat offerings and eligibility criteria are categorized into two paths identified as the old path and new path throughout this report. These two paths are further described below.

Old Path

Homeowners who were pre-approved for Green Heat before August 1, 2017 were eligible under the old path. Through this path, homeowners could apply to ENS directly by filling out a pre-approval application form. Then, the program manager would get in touch with applicants to assess their eligibility. Eligibility considerations mainly related to the heating source (electricity only as the main heating source) and varied depending on the type of equipment installed. Participants could choose between a rebate option and a low-interest financing option. Once approved, applicants for the rebate option had up to six months to install the equipment and submit their rebate application forms to ENS. Participants who qualified for the financing option had up to two months (60 days) to install the equipment and send their financing application forms to ENS.

New Path

On August 1, 2017, Green Heat was relaunched as a mail-in rebate program component, thereby eliminating the pre-approval process. Homeowners now have 90 days after the purchase and installation of eligible equipment to submit the required documentation to receive incentives. Another change under the new path relates to the incentive structure specifically for heat pump equipment. As shown in Table 20 below, the incentive amounts for four of the five heat pump types are now determined on a refrigeration ton basis rather than a fixed amount per equipment as the old path offered. Moreover, the incentives for wood and pellet furnaces decreased from \$1,400 to \$1,000. It should be noted that ENS has discontinued its financing option under the Green Heat new path and that applicants interested in financing equipment are now referred to the HEA program component or NSP for MSHPs. Indeed, ENS is working with NSP to cross-promote the on-bill financing option that they are offering to customers interested in installing MSHPs. The following table summarizes current Green Heat incentives under the new path.

Table 20: New Path Incentives

Heat Pump Equipment	Incentive
Mini-split Heat Pump	\$200/Refrigeration ton
Air-source Heat Pump (Centrally Ducted)	\$400/Refrigeration ton
Air-to-water Heat Pump	\$400/Refrigeration ton
Ground-source Heat Pump	\$500/Refrigeration ton
Heat Pump Water Heater	\$150/Unit
Biomass Equipment	Incentive
Wood/Pellet Stove or Fireplace Insert	\$500/Unit
Wood/Pellet Boiler or Centrally Ducted Forced Air Furnace	\$1,000/Unit
Solar Thermal Equipment	Incentive
Solar Thermal: Air-to-air	\$400/Unit
Solar Thermal: Domestic Hot Water	\$1,000/Unit

MSHPs were added to the Green Heat offerings in 2015 and quickly became very popular, now accounting for the majority of products installed through Green Heat. Another change under the new path involves new eligibility criteria for this type of equipment. For instance, eligible MSHPs must now be installed by a certified Refrigeration and Air Conditioning Mechanic installer. Additionally, MSHPs are now offered to both electrically and non-electrically heated homes, whereas only electrically heated homes qualified for this incentive under the old path. All other Green Heat equipment types remain eligible to electrically-heated homes only.³³

Green Heat aimed to achieve net electricity savings of 3.5 GWh and net peak demand savings of 1.7 MW at the generator in 2017.

5.2 Follow-up on 2016 Evaluation Report Recommendations

Green Heat was evaluated in 2016 and recommendations for improvement were made by the Evaluator. Table 21 below summarizes the implementation status of each recommendation presented in the Executive Summary of the 2016 Evaluation Report.

Table 21: Implementation Status of Recommendations in the 2016 Executive Summary

2016 Recommendations	Status
2016 GH-R1. Monitor market progress to adapt the program component offer to the evolving market.	Implemented
2016 GH-R2. Increase program component advertising to households and collaborate with contractors.	Partially Implemented
2016 GH-R3. Consider real baseline conditions in the savings calculation.	Implemented
2016 GH-R4. Perform the MSHP billing analysis again in 2017.	Implemented
2016 GH-R5. Continue researching more accurate sources to estimate the runtime hours of central heating systems.	Implemented

³³ For a short period, from August 1, 2017 to November 20, 2017, centrally ducted heat pumps, air-to-water heat pumps and ground-source heat pumps were offered to non-electrically heated homes as well.

All 2016 Green Heat recommendations have been implemented by ENS, except for Recommendation 2016 GH-R2 which still requires some effort. To implement that recommendation, ENS has developed digital marketing materials and conducted digital and social media-based marketing campaigns to increase Green Heat awareness among homeowners. ENS has also reinforced its collaboration and communication efforts with contractors, professionals and members of the Efficiency Trade Network (ETN), including hosting sessions around the province to introduce the Green Heat changes. That said, as attested to in the Process Evaluation Section of this report, over one third of contractors were not aware of the change in the Green Heat process (new path) three months after the change took place. This suggests that improvements in communication and awareness can still be made. Complete contractor and participant feedback about Green Heat, including the support and communications provided by ENS, is presented in the Process Evaluation Section further below.

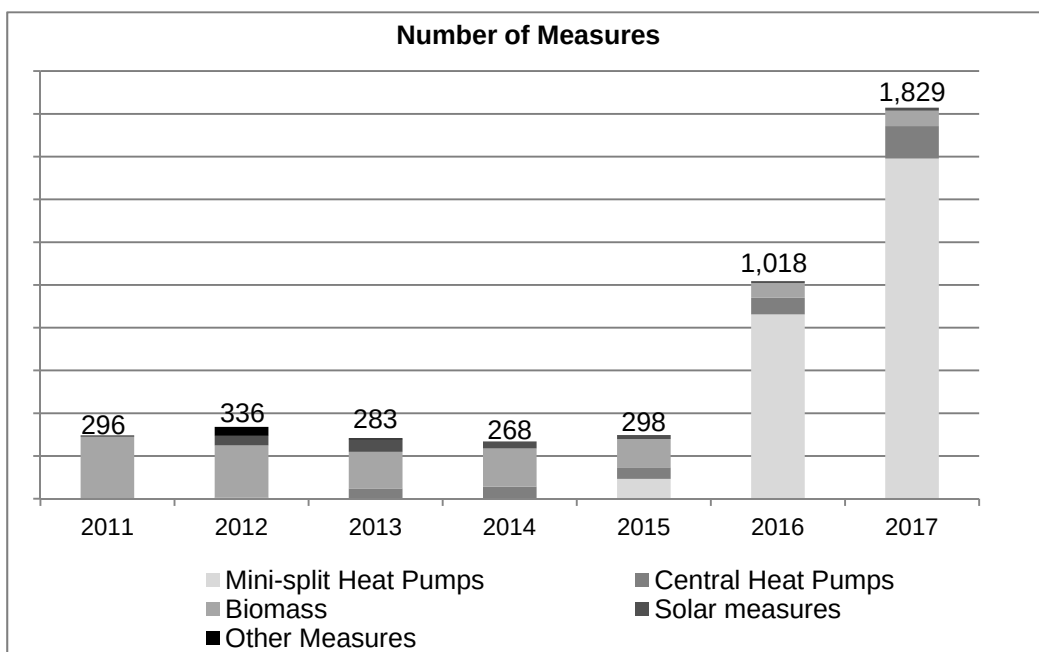
Recommendation 2016 GH-R1 involves monitoring various key market indicators that include equipment sales and prices. To implement this recommendation, ENS asked the Evaluator to conduct a market evolution assessment. The results of this analysis are presented in Section 9.

Pursuant to Recommendation 2016 GH-R3, ENS updated tracked savings to reflect the 2016 evaluation results. Consequently, tracked savings for MSHPs are now based on the 2016 billing analysis results. As for Recommendations 2016 GH-R4 and 2016 GH-R5, another billing analysis was performed as part of the 2017 evaluation to more accurately estimate the savings associated with the installation of MSHPs by including more participants. Moreover, a billing analysis of ASHPs was performed to estimate central heating system savings as well as corresponding runtime hours. The results of these analyses are presented in Subsection 8.1.4.

5.3 Participation History

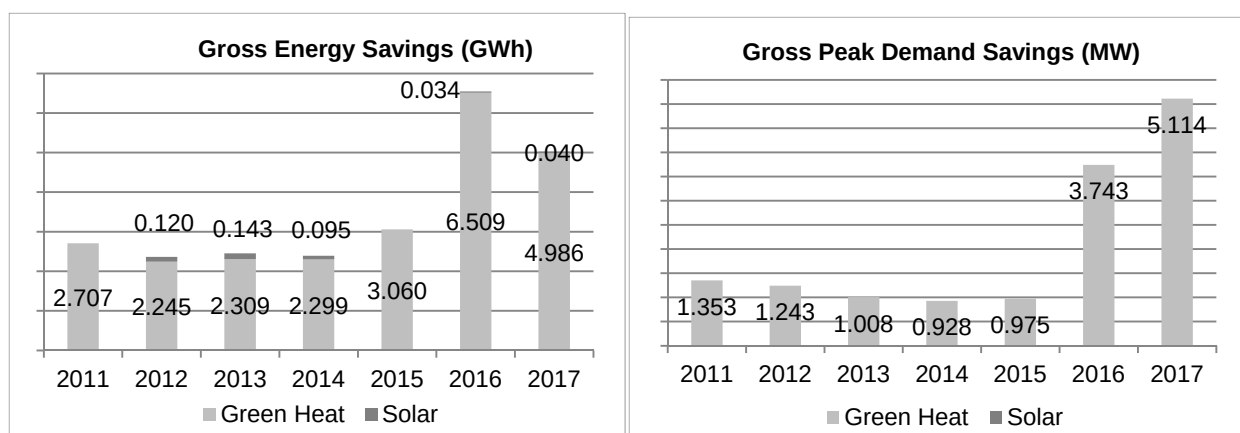
In 2017, a total of 1,829 measures were installed through Green Heat, which represented an increase over the previous year throughout which a total of 1,018 measures were installed. In August 2017, participants no longer needed to be pre-approved, which might explain the increased participation in Green Heat. Moreover, again this year, MSHPs are the most commonly installed measure. In addition, this measure is now offered to non-electrically heated homes. Consequently in 2017, 1,288 MSHPs were installed in electrically heated homes and 303 MSHPs were installed in non-electrically heated homes. ASHPs were also offered to non-electrically heated homes for a few months in 2017, which resulted in a participation increase for this measure. Figure 9 breaks down all the measures installed through Green Heat since 2011 by measure type.

Figure 9: Summary of Participation in Green Heat, 2011-2017



Green Heat achieved 5.026 GWh in gross energy savings and 5.114 MW in peak demand savings. Despite the large increase in participation, gross savings were lower in 2017 than in 2016, as illustrated by Figure 10 below. This is essentially due to the lower average energy savings obtained for MSHPs and ASHPs as a result of the billing analyses conducted in 2017. However, peak demand savings increased similarly to participation levels since they were not affected by billing analysis findings.

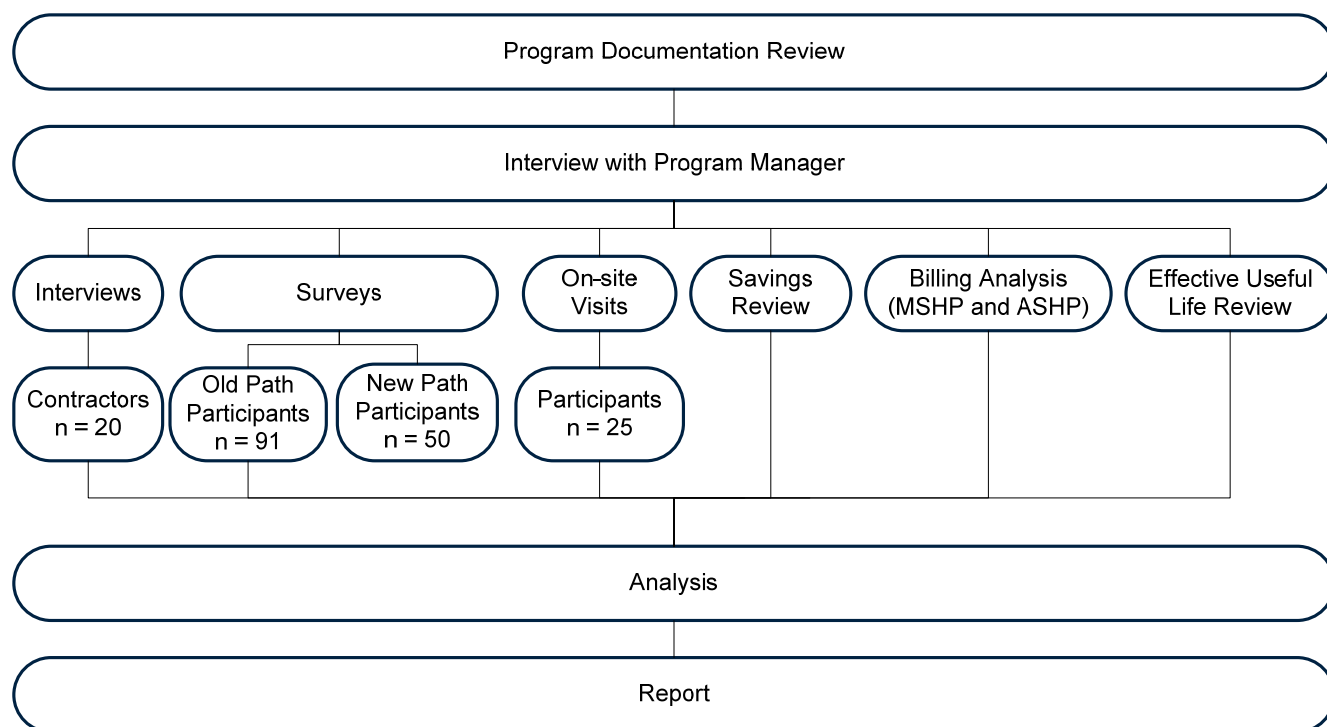
Figure 10: Summary of Gross Savings for Green Heat, 2011-2017



6 GREEN HEAT EVALUATION METHODOLOGY

This section presents the methodology used and the activities carried out for the 2017 Green Heat evaluation. Figure 11 illustrates the various data collection activities carried out for the evaluation.

Figure 11: Methodological Model



The Evaluator first reviewed program component documentation and then met the program manager in August 2017 to verify the implementation status of the previous evaluation recommendations and learn about the changes implemented in 2017. Based on the information obtained from this meeting, a list of questions and topics to be included in the data collection instruments was prepared.

After the meeting with the program manager and the documentation review, specific evaluation activities were undertaken as described in the following subsections.

For evaluation activities that yield quantitative results based on a sample, the Evaluator aimed to achieve a maximum margin of error of 10 percent at a confidence level of 90 percent. This means that if measurements were conducted many times with different samples, the data would be within 10 percentage points above or below the percentage reported 90 percent of the time. Thus, the margin of error indicates the relative level of precision³⁴ of the measurement, while its associated confidence level indicates the probability of a measure falling within this margin of error.³⁵

As part of this evaluation, the Evaluator calculated the margin of error for survey samples, net-to-gross ratios and billing analysis results where applicable. The margins of error are presented alongside the results in the relevant sections further below. An example of the calculation used to establish the margin of error for survey samples is also presented in Appendix II of 2017 DSM Programs Evaluation Executive Summary.

Contractor Interviews

In October and November 2017, Research Into Action conducted 20 interviews with contractors. The term contractor refers to distributors and retailers who sell to and/or install rebated equipment for end users. These interviews were used to understand, among other things, the involvement of contractors in Green Heat, the outreach and delivery processes, barriers to participation, as well as to determine contractor perception and satisfaction with Green Heat and ENS.

The guide used for the contractor interviews is presented in Appendix VIII. All appendices are presented in the Existing Residential Program – Appendices.

Participant Surveys

In November 2017, CRA conducted two telephone surveys using computer-assisted telephone interviewing technology with 91 old path³⁶ and 50 new path³⁷ participants. The new path participant survey only included participants who installed MSHP units because these constituted the vast majority of systems installed under the new path at the time the survey was conducted. Hence, this was the only measure for which meaningful results could be obtained from the new path survey. The average duration of the surveys was 17 minutes for the old path and 19 minutes for the new path. The questionnaires and complete survey results are presented in Appendices IX, X, XI and XII.

³⁴ Precision refers to how reproducible a set of measurements is. It does not take into account, however, how close the measured values are to the true values since this refers to accuracy.

³⁵ As part of this evaluation, the confidence level and the margin of error only take random sampling errors into account; they do not reflect non-sampling errors or biases such as data entry errors, inaccurate responses from respondents or the inability to contact certain people.

³⁶ For the old path survey, interviews were conducted with 51 participants who installed mini-split heat pumps, 24 participants who installed air-source or ground-source heat pumps and 16 participants who installed another type of equipment.

³⁷ For the new path survey, interviews were conducted with 29 electrically heated households and 21 non-electrically heated households.

The participant surveys were meant to collect feedback on the following aspects of Green Heat:

- › Participation motivations
- › Usage of the old and new equipment installed
- › Free-ridership (including the cross-influence from ENS promotion and other program components)
- › Satisfaction with Green Heat and the equipment installed
- › Participant price sensitivity relative to the equipment purchased (Van Westendorp analysis³⁸)
- › MSHP purchasing context
- › Recommendations for program component improvements
- › Demographics

For the old path survey, a random sample of 91 participants from a total number of 730 participants³⁹ yields a margin of error of 8.1 percent at a 90 percent confidence level. For the new path survey, a random sample of 50 participants from a total number of 878 participants⁴⁰ yields a margin of error of 11.4 percent at a 90 percent confidence level. The margin of error for the new path is higher than target because only a small portion of the 878 new path participants had taken part in this path at the time of sampling.

On-site Visits

In October and November 2017, 25 on-site visits were conducted by Equilibrium Engineering at participant homes, including three visits for solar thermal measures, four visits for biomass measures and 18 visits for heat pump measures. These visits served to confirm whether the new equipment had been installed and was working properly, collect information on the previous space heating and hot water systems, and gather data on the use of the different energy sources available in these homes. The on-site visit sampling methodology and the protocol used to collect information are presented in Appendix XIII.

Savings Review

The Evaluator applied various methodologies to review the savings values presented in the tracking sheet for biomass, solar thermal and heat pump measures. For biomass and solar thermal measures, unitary savings values were reviewed based on a literature review. For heat pump measures, a literature review was performed to establish the baseline efficiency for standard heat pumps.

³⁸ The Van Westendorp's Price Sensitivity Meter (PSM) is a market technique for determining consumer price preferences. In this case, MSHP participants were asked what they considered to be the appropriate price of an MSHP using four categories: a price too cheap that the equipment quality is in question, a bargain, a price approaching too expensive, and a price viewed as not affordable.

³⁹ As part of Green Heat (old path), 730 participants (based on the unique phone numbers) installed 847 measures.

⁴⁰ As part of Green Heat (new path), 878 participants (based on the unique phone numbers) installed 982 measures.

Billing Analysis

A billing analysis was conducted for participants who had an MSHP or an ASHP installed in previous years to establish the average energy savings achieved. The billing analysis compared their energy consumption as a function of heating degree days (HDDs) for a one-year period prior to the new heat pump installation and for one heating season immediately following installation.

Effective Useful Life Review

As part of the 2017 evaluation, to examine the EUL values used by ENS to calculate lifetime energy savings, the Evaluator conducted a thorough literature review by consulting TRMs, evaluation reports and relevant studies.

7 GREEN HEAT PROCESS AND MARKET EVALUATION

The Evaluator administered a phone survey of 141 Green Heat participants to understand their perspectives on both program component paths. The survey included 91 respondents that participated in the old path and 50 respondents from the new path. The survey gauged their decision-making processes in purchasing the equipment, satisfaction and concerns with Green Heat, appropriate pricing for purchased equipment, awareness of the MSHP market, and recommendations for improvements.

The Evaluator interviewed 20 contractors about their understanding of the new and old paths, their use of Green Heat in sales, and their satisfaction with ENS and Green Heat. Additionally, contractors provided perspectives on the successes the program component achieved, as well as the challenges and opportunities of the program component.

The sections below provide an overview of contractor and participant findings combined with results from the interview with the program manager. Participant survey results aggregate the old and new path participants except when statistically significant differences exist.

7.1 Background on August 2017 Green Heat Change

Green Heat transitioned from a program component that required ENS approval before measure installation to a mail-in rebate program in August 2017. That change took place to make the program component less burdensome on contractors, participants, and ENS. According to ENS staff, the Green Heat market actors (contractors and participants) experienced three key interrelated problems with the old path:

- › Projects took a long time for a relatively simple transaction. From project initiation to receiving an incentive often took 90 to 100 days.
- › Each actor had to complete a step in the process before the next actor could proceed. Each actor had to have completed a set of tasks before the next actor could begin their set of tasks. This created confusion and led, in part, to long project durations. For example, participants had to wait for ENS to pre-approve their project before installing equipment, which constituted a particular burden when it was an emergency replacement. Furthermore, contractors could not make sales immediately if participants elected to participate because they first had to seek pre-approval.
- › Confusion about the pre-approval requirement led to some dissatisfaction. A notable number of homeowners applied for rebates after the equipment was installed. This happened in some cases when during certain times of year homeowners had immediate need for a heat source and were unwilling to wait for pre-approval.

The new path aimed to resolve the three key problems by requiring fewer actions by the market actors and removing the pre-approval stage. This has had the effect of removing ENS from involvement in the initial stages of a project. ENS now receives applications, determines whether to approve the installed measures, and mails rebates to participants.

The interview with the Green Heat program manager revealed that ENS is hopeful that the concrete steps taken by staff to recraft Green Heat will result in an easier and better process for all market actors. Participants can have their heat pumps installed quickly, contractors only have to complete a simple form for participants or leave it to the participant to complete, and ENS staff are less burdened with pre-qualifying equipment and processing applications.

Additionally, the new path expands which participants are eligible to participate. The old path only allowed people to participate if they had electrically heated homes. With the new mail-in approach, ENS allows people to install MSHPs no matter their pre-existing heating fuel type.⁴¹

7.2 Overview of Respondents

The majority of participants in both paths reported having a college or university education; two thirds (67%) reported having a college or university certificate. Over one third (35%) reported an annual income greater than \$80,000, while roughly one quarter (24%) reported a household income lower than \$50,000. Most respondents (74%) were 45 years or older (Table 22).

⁴¹ From August 1 to November 20, 2017, incentives for centrally ducted heat pumps, air-to-water heat pumps and ground-source heat pumps were offered to non-electrically heated participants. Those measures were no longer offered to non-electrically heated participants after November 20, 2017.

Table 22: Overview of Participant Characteristics

Characteristic	Percent (n=141)
Education	
High school or less	23%
Trades certificate or diploma	8%
College certificate or diploma	21%
University certificate or diploma	46%
Refused	3%
Household Income	
Less than \$24,999	4%
\$25,000 - \$49,999	20%
\$50,000 - \$79,999	23%
\$80,000 or more	35%
Refused	17%
Age	
18 to 24	2%
25 to 34	6%
35 to 44	15%
45 to 54	25%
55 to 64	22%
65 or over	27%
Refused	3%
Gender	
Male	66%
Female	34%

New path participants took advantage of the program component change that allowed non-electrically heated homes to participate. Fifty-eight percent of new path participants used electricity as their heating type and 42 percent used non-electric sources for heating. Per old path guidelines, all old path participants used electrical heat.

Most (87%) participants resided in a detached single-family home with a household size of two or fewer (64%). Twenty-eight percent reported three or four occupants living in their home, and 7 percent had a household size of five or more. Almost two thirds (65%) of participants reported having a two or three-bedroom home, while 33 percent reported four or more bedrooms.

The majority of interviewed contractors sold heat pumps and had at least several years of experience with Green Heat. Of the 20 contractors interviewed, 18 sold and installed heat pumps directly to homeowners, two sold solar equipment, and four reported selling wood or pellet stoves. The majority (85%) of contractors reported working with Green Heat for at least two years.

How contractors became aware of Green Heat varies. The most common source of Green Heat awareness reported by contractors was through NSP (5 of 20 contractors). Four other contractors reported they became aware of Green Heat through an industry source such as a supplier or wholesaler. Another four contractors (20%) listed ENS as their source of awareness, either through staff or online advertisement, while another fifth (20%) found out about Green Heat through participants.

A notable minority of contractors were not aware of the new path. About one third of contractors (35%) were unfamiliar with the new Green Heat path, while two thirds (65%) reported being aware of the Green Heat change in August 2017. A few contractors noted that they found out about the program component change from participants (see Table 23).

Table 23: Overview of Green Heat Contractor Respondents

Respondent Characteristics	Percent (n=20)
Measures Offered*	
Heat Pump	90%
Wood/Pellet	20%
Solar	10%
Years Aware of Green Heat	
5 or more	50%
About 2	35%
1 year or less	5%
Don't know	10%
Green Heat Awareness Source**	
NSP	25%
Industry, suppliers or wholesalers	20%
ENS Source (contact, outreach, advertisement)	20%
Participants	20%
Other	10%
Don't know	10%
New Green Heat Path Awareness	
Aware	65%
Not Aware	35%

*Three contractors sold both heat pumps and/or solar equipment and wood stoves.

**One contractor reported two awareness sources: contacts through NSP and ENS

7.3 Green Heat Outreach and Delivery

Contractors stated promoting Green Heat to participants, and ENS and NSP marketing efforts have supported contractor promotion efforts. Seventeen of 20 contractors reported they are typically the source of information about Green Heat for participants, and they typically provide the information in their initial interaction. Seven contractors elaborated that they have integrated informing participants about Green Heat eligibility into their sales consultation process. One quarter of the contractors reported that participants sometimes or frequently bring up Green Heat rebates before they do.

Green Heat staff agreed that contractors are an important source of knowledge about the program component for participants, along with word-of-mouth and marketing efforts. NSP's Heat Pumps Set Me Free marketing campaign and ENS's social media campaigns were particularly noted as key efforts that have driven participants to the program.

Despite contractor promotion, word-of-mouth was the primary source of awareness of MSHPs among interviewed MSHP participants. Of those who installed an MSHP, over half (54%) reported they became aware of the technology from a friend, acquaintance, or family member (see Table 24). Additionally, more new path respondents became aware from advertisements (28%) than their old path counterparts (10%) (z-test, <.05).

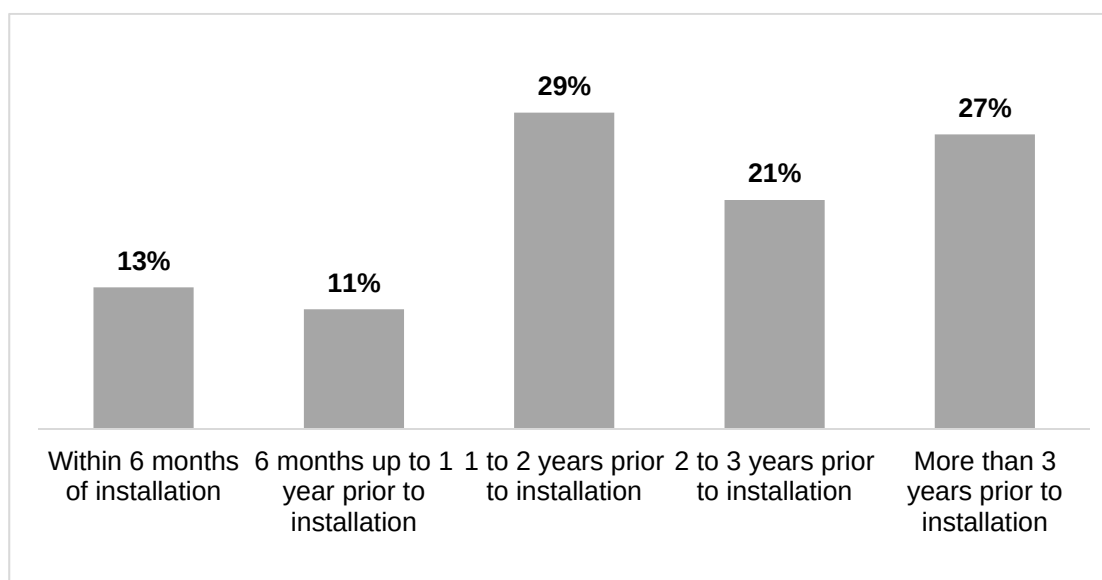
Table 24: Awareness Source of MSHP

Source	Percent (n=101)
Via a friend, acquaintance, or family member	54%
Saw an advertisement*	19%
Through a contractor, retailer, distributor	6%
Online*	5%
Through work	4%
At a home show	2%
Other	7%
Don't know	3%

*Statistically significant (z-test <.05) difference between old and new path participants.

Participants were generally aware of MSHPs before installing the technology. All but 13 percent of MSHP respondents were aware of MSHPs at least six months prior to installing a unit (see Figure 12).

Figure 12: When Participants First Became Aware of MSHPs (n=101)



Outreach efforts by contractors have not changed much as a result of the new path. Of the 13 contractors aware of the new path, seven noted no change in outreach efforts, five indicated a more streamlined approach to conducting outreach because of the elimination of the pre-approval process, and one reported now targeting oil heat participants.

Highlighting the long-term money and energy savings of Green Heat qualified equipment is the most effective approach to selling energy efficient products according to contractors and participants. Most contractors (75%) reported reducing electricity bills due to lower energy use and subsequently lowering operating costs as the primary benefits they communicate to participants. Additionally, almost half (9 out of 20) reported mentioning non-energy benefits of energy efficient equipment, such as equipment reliability and quality, comfort, and the environmental benefits of energy conservation. Contractors who sell and install wood or pellet stoves mentioned the use of wood stoves for heat during power outages.

Half of the interviewed contractors suggested that Green Heat and incentives offered are not the strongest selling points for energy efficient equipment. These contractors elaborated that participants typically opt for energy efficient systems because of the lower costs in the long term rather than the incentive amount provided upfront. That being said, several contractors reported Green Heat rebates are sometimes an influential factor or perceived as a bonus among participants who opt for energy efficient equipment, which elevates participant satisfaction with the service, thus increasing the likelihood of referrals.

Saving on energy costs was the most commonly reported reason participants installed Green Heat rebated equipment, especially among new path participants. New path participants (70%) were motivated by saving energy or money more than old path participants (50%). About one tenth (11%) of respondents reported they were interested in installing new energy efficient equipment because their old system was not working properly or they wanted air conditioning (11%). Other reasons reported by participants were to make homes more energy efficient or increase comfort (Table 25).

Table 25: Reasons Participants Decided to Install Energy Efficient Equipment

Reason	Percent (n=141)
Save energy and money*	57%
Old system wasn't working properly	11%
Wanted air conditioning	11%
Make home more energy efficient	6%
Comfort	4%
To have a backup heating source	3%
To replace another heat source	2%
Convenience/ease of use	1%
To help the environment	1%
Other	4%

*Statistically significant (z-test <.05)⁴² between old and new path participants.

7.4 Barriers and Participant Concerns

For participants who had previously considered installing an MSHP, cost was the most prominent barrier hindering these participants from installing one in the past. Of those that considered installing an MSHP in the past, 45 percent considered them too expensive and postponed installation. To assess price perceptions of energy efficient equipment, the Evaluator asked all MSHP participants to report what they considered to be the appropriate price of an MSHP using four categories: a price too cheap that the equipment quality is in question, a bargain, a price approaching too expensive, and a price deemed not affordable. The results suggest that participants perceive MSHP systems priced at \$4,070 as a bargain and \$6,250 as expensive. These values represent the price range that most surveyed participants said they were willing to pay for an MSHP. This price range can help determine the appropriate level of incentive to be offered to spur a potential participant to act. Table 26 displays the range and average MSHP prices reported by participants across the four price categories.

⁴² The Z-Test of Proportions is used to assess response differences between two groups when data are nominal. The Evaluator used a significance level of .05, so a *p* value of .05 or lower indicates a statistically significant difference in this analysis.

Table 26: Mean and Range of MSHP Price Categories

Scenarios	Count	Range	Mean
Too cheap	81	\$500-\$8,000	\$2,870
Bargain	83	\$1,500-\$10,000	\$4,070
Getting expensive	85	\$1,000-\$12,000	\$6,250
Not affordable	85	\$1,000-\$16,000	\$7,600

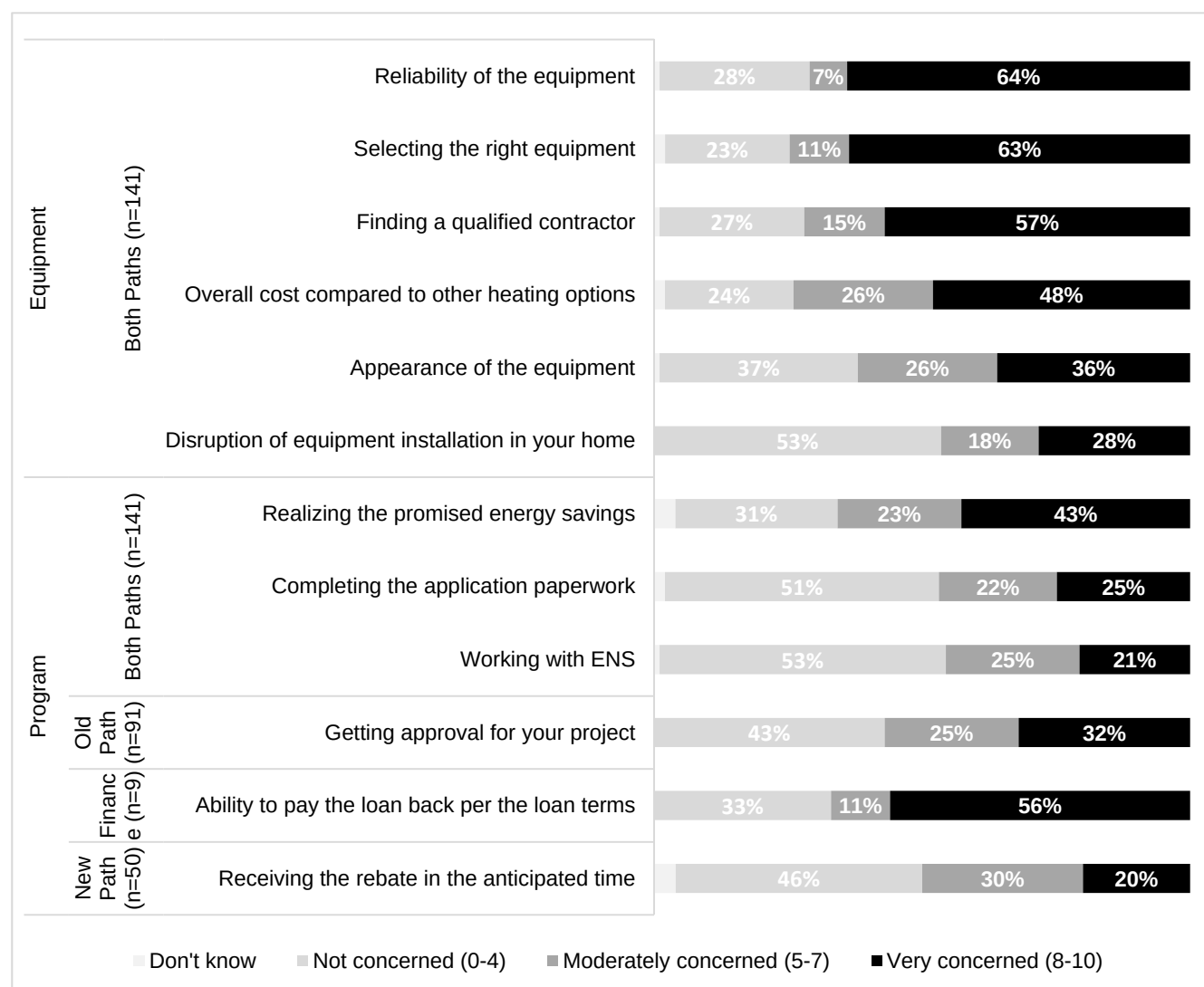
Other reasons cited for not installing a heat pump earlier included the fact that participants determined their existing heating system was still in adequate condition (9%) or because they lacked detailed information about the equipment (9%). Additional reasons reported by participants, though with lower frequency, included concerns about the reliability and energy savings of heat pumps.

On average, participants expressed more concern with issues related to equipment, such as reliability and selecting the right equipment, rather than concern with the program component. Almost two thirds (64%) of participants reported being very concerned with equipment reliability when they began considering installation; a similar proportion (63%) of respondents reported being concerned with selecting the right equipment. Participants were least concerned with disruption resulting from equipment installation in their home (see Figure 13 below).

As for the program component, participants were most concerned with realizing the promised energy savings of the installed equipment. Over two fifths (43%) of all respondents reported being very concerned with the promised energy savings. Fewer were concerned with completing the application paperwork and working with ENS (see Figure 13 below).

Participants under the old path reported some concern with getting their project approved and those that used the financing option reported a relatively high level of concern with their ability to pay the loan back (see Figure 13).

Figure 13: Participant Concerns with the Program Component and Installed Equipment



In addition to the rating questions on participation concerns, about one third (29%) of all participants expressed concerns with their Green Heat experience in open-ended comments. Responses revealed that participants were most commonly concerned with the performance of the equipment, primarily whether the system would provide enough heat for their home (44%). One fifth of participants who reported other concerns were also apprehensive about the size and location of the equipment in their home. Other concerns described by participants included the timing of either the installation or the application process (12%), as well as eligibility and application requirements (10%) (see Table 27).

Table 27: Other Concerns of Green Heat Participants

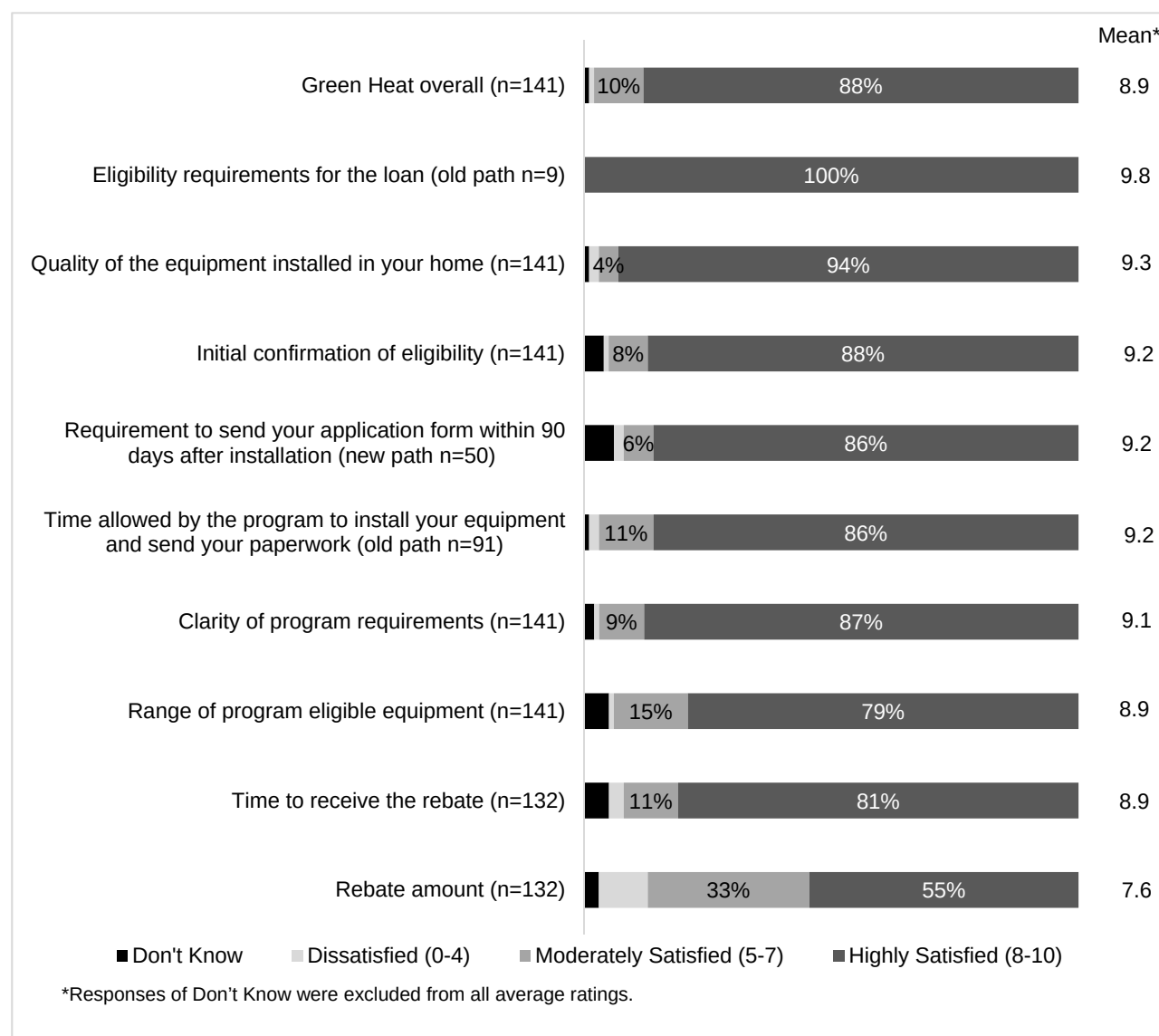
Concerns with...	Percent (n=41)*
Equipment performance: if it would provide enough heat	44%
Logistics of the equipment installation (size and location)	20%
Timing of the project	12%
Eligibility requirements	10%
Return on investment	7%
Range of eligible equipment	5%
Other	17%

*Open-ended responses were coded into multiple responses.

7.5 Satisfaction with Green Heat

Participants were largely satisfied with all elements of Green Heat, except the rebate amount which received lower satisfaction scores. Respondents were most satisfied with the quality of the equipment installed (94%), and all respondents from the old path who used the financing option reported being highly satisfied with the eligibility requirements for the loan. Participants in the rebate option were least satisfied with the rebate amount; over two fifths (43%) reported low to moderate satisfaction with the amount of the rebate. Participants who reported moderate or low satisfaction with Green Heat overall later elaborated they were not satisfied because either the rebate amount was too low, the application process involved too much paperwork, or the eligible equipment requirements were confusing (see Figure 14). Participants appear equally satisfied with the old and new paths (average ratings of 9.0 and 8.8 respectively).

Figure 14: Participant Satisfaction with Green Heat Elements



The financial aspects of participation were the most helpful elements of Green Heat reported by participants. Despite the relatively low satisfaction with the rebate amount, over half (54%) of all participants cited the monetary benefits of the program component as the most helpful aspects of Green Heat in open-ended comments, as follows: 40 percent reported the rebate as the most helpful because it lowered installation costs; 9 percent reported the energy savings from the efficient heating device; and 5 percent reported the financing option. This discrepancy could mean respondents would prefer a higher rebate but still found the existing rebate helpful. About one third (32%) reported at least one item related to programmatic assistance (see Table 28) as the most helpful aspect of Green Heat. Most of these respondents reported education and information provided about the efficient equipment as most helpful (see Table 28).

Table 28: Most Helpful Aspects of Green Heat

Aspect	Percent (n=141)
Financial Aspects	54%
Lower installation cost	40%
Energy savings/efficient heating device	9%
Financing option	5%
Programmatic Assistance	32%
Information provided/providing education about efficient equipment	21%
Easy application process	6%
Assistance finding installer	3%
Good/knowledgeable representatives	2%
Other	6%
Don't know	7%

Contractors like the new path. Of the 13 contractors familiar with the new path, 12 perceived the change as beneficial and one described it as challenging.

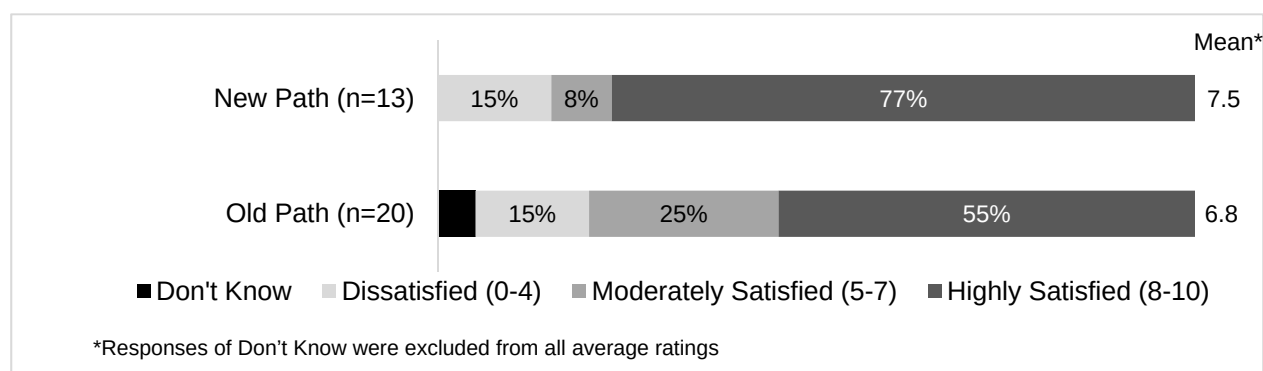
The most common benefit mentioned was a streamlined and quicker process for both contractors and participants resulting from the elimination of the pre-approval requirement. Benefits described by the twelve satisfied contractors were:

- › The elimination of pre-approval decreased processing time; participants do not have to be as involved in the program component (5 mentions).
- › Overall process is easier, simpler, and more streamlined for contractors and participants (4 mentions).
- › Expansion of participant eligibility requirements that allow non-electric heat participants to install MSHPs has increased sales because more homeowners now qualify (3 mentions).

Of the remaining seven contractors unaware of the new path, two anticipated the change in process would be beneficial, while the remaining five were unsure.

Contractors appear to be more satisfied with the new path compared to the old path. The large majority (92%) of contractors familiar with the change in process reported it as beneficial. Overall, satisfaction with the new path is higher (77%) than with the old path (55%) (see Figure 15 below). Of the 13 contractors familiar with the new and old paths, five reported their satisfaction has increased, one reported their satisfaction decreased, and seven reported their satisfaction had not changed compared to the old path. Of these seven contractors, all were already highly satisfied with Green Heat.

Figure 15: Contractor Satisfaction with Green Heat by Path



7.6 Interactions with ENS

Interactions between contractors and ENS are occasional. Most contractors reported irregular interactions with ENS staff; 80 percent reported interacting with ENS about Green Heat every few months or less frequently. The remainder (4 contractors) reported at least one monthly interaction with ENS; these were high-volume contractors who had completed at least five Green Heat rebated projects in 2017.

A notable minority of contractors reported difficulty reaching ENS staff. Of the 16 contractors who reported having a working relationship with ENS, over half (56%) reported that staff have been able to answer their questions in a timely manner. Two contractors (12%) reported ENS staff are sometimes timely in their communication, while the remaining third (31%) reported that staff are not prompt in returning calls or emails, making them hard to reach. One of these contractors, the sole contractor to report dissatisfaction with the new path, noted that the new path has been time consuming and frustrating for participants. The contractor specified that it has been difficult to get answers from ENS since Green Heat changed.

Contacting ENS by phone was the most common communication mode reported by contractors (65%), while 40 percent of contractors mentioned email. Contractors reported communicating with ENS mainly about Green Heat clarification questions, calling on behalf of participants to get answers about applications, their rebate status, and other eligibility inquiries.

A majority of contractors would like ENS to assist with outreach for Green Heat. Of the 15 respondents that provided suggestions for Green Heat improvement, over half (60%) reported additional outreach and promotion are needed to help them sell more Green Heat projects (see Table 29 below). Two contractors aware of the new path explained that a simple, easy-to-understand, one-page document that outlines the application steps, eligibility, and benefits of Green Heat would be useful to hand out during the consultation process. Additionally, eight contractors (53%) indicated that ENS should expand the list of rebate-qualified equipment.

The majority of contractors expressed moderate or high satisfaction with the service and support ENS provided them to deliver Green Heat rebated equipment. Almost two thirds (65%) reported high satisfaction and one fifth (20%) reported moderate satisfaction. One contractor (5%) was dissatisfied with the service and support provided by ENS and the remaining two contractors did not report their satisfaction.

Table 29: Service or Support Needed From ENS

Suggestions by Contractors	Percent (n=15)
Outreach support, forms, brochures, general advertising	60%
Expand list of rebate-qualified products and services	53%
Improvements in clarity and accessibility of customer service	20%
More referrals	13%
Vetting process to ensure contractor qualifications	13%
Restore financing option	13%
Other	20%

The majority (75%) of contractors reported being a member of the Efficiency Trade Network (ETN).⁴³ Of these 15 contractors, eight reported benefiting from their association with the network. Of these eight, six described benefits while two did not elaborate on benefits. Benefits noted were referrals (n=3), increased exposure to potential participants (n=2), and updates about ENS programs (n=1).

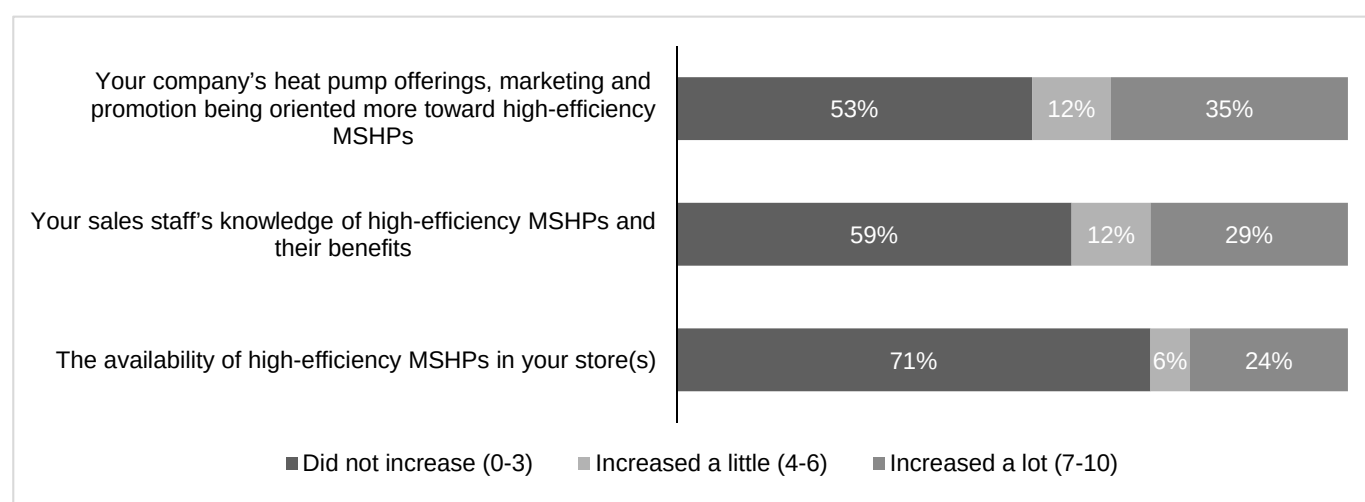
Four contractors desired changes to the ETN list. Specifically, three contractors expressed concern with the level of expertise of firms on the list and suggested auditing service installations to ensure quality. It was unclear if these respondents were aware of ENS vetting efforts. In addition, one high volume contractor suggested revising the contractor list to display the specializations of listed contractors. It was unclear if this respondent was aware of the ETN list search capabilities currently provided that allow one to see specializations.

⁴³ When the Evaluator compared responses to the ETN list online, three contractors reporting ETN membership were not listed.

7.7 Influence of Green Heat

Roughly a quarter to a third of contractors indicated that Green Heat influenced an element of their business. A minority of contractors reported that Green Heat has helped increase their company's knowledge and offerings of energy-efficient MSHPs. Nearly a quarter (24%) reported an increase in the availability of high-efficiency models in their stores as a result of Green Heat and almost 30 percent noted an increase in sales staff knowledge of MSHPs. More than a third (35%) noted that Green Heat has increased their company's heat pump offerings and promotion of high-efficiency equipment (see Figure 16).

Figure 16: Green Heat Influence on Contractors (n=17)



Almost half of contractors noted that Green Heat has helped their business. Forty-five percent of contractors reported that Green Heat has marginally increased their sales due to heightened awareness and demand for energy-efficient heating systems. The other 55 percent of contractors reported that Green Heat has neither helped nor hindered their business.

Contractors were asked to provide some perspective on the influence of Green Heat on participant decision-making. Six contractors responded that the program component is most effective at encouraging participants who had already decided on installing an MSHP to select the most efficient model. Four contractors responded that Green Heat is equally effective at encouraging both participants who have already made the decision to install an MSHP to purchase a high-efficiency model and those who have not yet decided to install an MSHP. Four contractors responded that Green Heat had little influence and four contractors either could not provide an answer or did not respond.

"People have already made up their minds; they want a quote on a ductless mini-split. They're all more efficient than oil or electric. It's just that the more efficient ones will get you the rebate, but they're more expensive. [...] The rebates help offset the cost of the more expensive ones."

“I’d say most in that the ones that are already going to a mini-split heat pump will opt for the more efficient one because of the rebate. And the ones that aren’t looking for a mini-split, the program will help motivate them to purchase a mini-split.”

7.8 Green Heat Challenges and Opportunities for Improvement

New path program component requirements may be difficult for some potential participants.

Despite the improved ease and simplification of the application process, three contractors were concerned that Green Heat is burdensome for the elderly or participants with disabilities; the technicalities and requirements of the application form have been challenging. For example, one contractor reported that the photo requirement in the application process has caused difficulties for some participants who do not have the technology or ability to easily take a photo of a heat pump located in a difficult spot. A different contractor described a situation in which an elderly participant ultimately decided to not change his heat pump because of the demands of the application process and a confusing interaction he had with ENS staff.

According to program staff, the new path should work well for MSHP participants, but there is some concern about the path working well for non-MSHP participants such as those who purchase rebated ASHPs. MSHP participants have a list of eligible heat pumps to select from whereas non-MSHP participants likely have to rely on their contractor to determine eligibility based on the technical specifications of the equipment. This means more room for error in determining if a participant will actually receive an incentive.

To improve Green Heat, participants most commonly reported the need to advertise it more or in a better way. The most common recommendation made by participants was to improve advertising, and this seemed particularly salient to new path participants (52%) compared to old path participants (27%) (z-test, $p < .05$). Other recommendations included ensuring awareness of the eligibility requirements, as well as improving communication between participants and ENS (Table 30).

Table 30: Participant Recommendations for Improving Green Heat

Improvements	Old Path (n=44)	New Path (n=23)
Advertise the program component more or in a better way*	27%	52%
Offer more information and flexibility on the eligibility requirements	25%	39%
Improve communication	9%	26%
Offer additional equipment eligible for rebates	20%	22%
Simplify program component application, forms and associated paperwork	11%	9%
Provide more information on qualified contractors	7%	4%
Speed up the process	7%	4%
Increase the time given to complete the upgrades	7%	0%
Other	14%	17%

*Statistically significant (z-test <.05) difference between old and new path participants.

8 GREEN HEAT IMPACT EVALUATION

The objective of the 2017 Green Heat impact evaluation is to determine the gross and net electrical energy and peak demand savings achieved.

8.1 Gross Savings

Gross savings correspond to the change in energy consumption that results from actions taken by participants regardless of their reasons for participating.⁴⁴ To review the gross savings tracked by ENS, the Evaluator not only conducted on-site visits for biomass, heat pump and solar measures, but also performed a unitary savings review of all measures and a billing analysis for MSHPs and ASHPs.

Both the energy savings and peak demand savings calculations were reviewed. The peak demand savings period for 2017 is defined as the coldest days (with an on-peak temperature estimated at -15 °C) on a non-holiday weekday between 5 p.m. and 7 p.m. from December to February.

8.1.1 On-site Visits

The Evaluator conducted 25 on-site visits as part of the 2017 Green Heat impact evaluation to assess the energy savings of installed measures as summarized in Table 31 below. The number of visits for MSHP measures reflects the large number of measures installed in this category compared to the other categories of measures installed in 2017. No visits were performed for the solar air space heating system measure category since no such installations had been performed by the time the on-site visits were conducted in November. Similarly, no on-site visits were conducted for HPWHs given the limited quantity installed.

The on-site visits served to verify energy savings by confirming that the rebated equipment was properly installed and operating. Additional information was collected to validate the primary and secondary heating systems, as well as confirm how the new equipment was used by participants.

⁴⁴ Definition adapted from National Renewable Energy Laboratory, *The Uniform Methods Project Chapter 23: Estimating Net Savings: Common Practices*, September 2014, p. 3

Table 31: On-site Visits by Measure Category

Measure Category	Measure	Number of On-site Visits
Biomass	Wood stove	2
	Pellet stove	1
	Wood Furnace or Boiler	1
Heat Pump	Air-source heat pump	5
	Ground-source heat pump	1
	Mini-split heat pump	12
	Heat pump water heater	0
Solar	Domestic hot water solar system	3
	Solar air space heating system	0

Biomass Measures

The results of the four visits confirmed that the new biomass equipment was the primary heating source at each site and that electrical consumption was offset in all cases. In three cases, electrical baseboards were the old primary heat sources and in the fourth, the new pellet stove replaced a failed primary biomass system that included electrical baseboards as backup. Participant declarations indicated the new biomass systems provided heat to most of the living spaces, with electric baseboards acting as the secondary heat source, thus confirming the assumption on which unitary savings are based. These installations were performed by Wood Energy Technology Transfer certified professionals, as required by Green Heat, and participants indicated no issues with the new biomass heating systems.

Heat Pump Measures

The Evaluator confirmed that the new heat pumps were used as the primary heat source in 15 of 18 homes, while one participant declared that the heat pumps heated 50 percent of the space and two participants stated 30 percent coverage. Four homes had non-electrical secondary heating systems and all four participants declared 10 percent or less of the building heat emanated from these secondary systems. One participant had two heat pumps installed, one on the main floor and one in the basement. The primary basement heat source was the new heat pump, but the primary heat source on the main floor was the existing wood stove which provided 90 percent of the heating load with the heat pump acting as the secondary heat source. Since all visited participants were from the old path, which only allowed mainly electrically heated participants to participate in Green Heat, the heat pump installed on the main floor would not have been considered eligible under the program component. The Evaluator, however, noted that the application form and the follow-up correspondence between ENS and this participant clearly indicated that the main existing heating system was electrical baseboards, so this issue was not an ENS oversight.

The on-site visits revealed that the GSHP and MSHPs were installed and operating correctly. Conversely, three of the five ASHP visits revealed installation issues. In two cases, the issues had been resolved by the installer before the Evaluator visited or were in the process of being resolved by the installer at the time of the visit. The third ASHP had had problems since installation and did not adequately heat the building to the required temperature in the morning after a nighttime setback being applied to the thermostat. In addition, the participant commented that the ASHP blows cool air into the home while in heating mode. The installer has returned several times to troubleshoot the heat pump; however, the issue was still unresolved at the time of the on-site visit. In summary, the Evaluator has noticed over the years that ASHPs tend to have more installation issues than MSHPs simply because of the higher installation complexity and that installation issues are not due to any specific installer.

In preparation for the GSHP site visit, the Evaluator could not find a model number for the new unit in either the project application, or the tracking sheet. ENS requested that the participant email the model number, but did not receive it. Therefore, ENS chose the most conservative of the three possible model numbers associated with the information found on the invoice. With the information collected on site, the Evaluator later confirmed that the GSHP model installed met Green Heat performance requirements.

Solar Thermal Measures

The results of the three visits confirmed that the solar thermal equipment was properly installed at all locations. Collector orientation was optimal for the provided site characteristics and solar exposure, resulting in maximum solar energy harvest. All three systems were flat plate collector types with indirect connections to solar preheat tanks. The pipe insulation was inspected and was in accordance with Green Heat requirements. All participants confirmed that the systems have been operating consistently since installation. In one project, the tracking sheet indicated that four panels were installed. During the visit however, the Evaluator found that five panels were installed. The participant explained that the number of panels differed because the orientation of the installation had been changed.

The on-site visits confirmed that electricity consumption was offset in two projects. However, for one project, the DHW heating source was oil. All participants eligible for solar thermal rebates must use electricity as the DHW heating source. Therefore, the solar thermal equipment installed for this project should not have been eligible under the program component. ENS was aware of this issue, but made an exception for customer service reasons.

8.1.2 Savings Review of Biomass Measures, Solar Measures and Hybrid Heat Pump Water Heaters

The Evaluator reviewed the savings methodologies and calculation values for all biomass and solar measures as well as hybrid HPWHs installed under Green Heat in 2017.

For biomass and solar measures, the Evaluator used the same savings methodologies for both the old and new paths since Green Heat requires that homes offset electrical resistance heating for both paths, resulting in a common savings calculation methodology for both paths. Similarly, the Evaluator used the same savings calculation methodology for HPWHs installed under both paths since they both require that the new equipment replace existing electrical resistance water heaters.

Wood and Pellet Stoves

Tracked Savings

ENS uses unitary savings values to track the energy and peak demand savings associated with wood and pellet stoves. The unitary savings values are based on HOT2000 energy models created for the 2013 evaluation. The baseline of the models used electrical resistance heating as the primary heat source and was calibrated to account for historical electrical consumption.

During the 2016 evaluation, it was noticed that some of the participants had ASHPs as their primary heating system. Therefore, the unitary savings values for those participants were calculated by dividing the unitary savings value by a COP of 2.1 based on the TRM⁴⁵ of the Pennsylvania Public Utility Commission.

With respect to peak demand savings, it was assumed that existing ASHPs operated exclusively on the electrical resistance backup in the air handler, and thus the peak demand savings for wood and pellet stove measures with an ASHP baseline were identical to the peak demand savings with an electrical resistance baseline. Therefore, the unitary peak demand savings value was not adjusted.

The modification to the unitary energy savings value resulted in two distinct baselines within the wood and pellet stove category. One set of values was applied to the electrical resistance baseline and one set to the ASHP baseline; these values are listed in Table 32.

⁴⁵ Pennsylvania Public Utility Commission (PUC), *Technical Reference Manual*, June 2015, Section 2.2 – HVAC.

Table 32: Tracked Unitary Savings Values for Wood and Pellet Stoves

Category of Equipment	Tracked Energy Savings Value (kWh/year)	Tracked Peak Demand Savings Value (kW)
Wood Stove with Electrical Resistance Baseline	10,443	4.0
Pellet Stove with Electrical Resistance Baseline	8,959	4.0
Wood Stove with ASHP Baseline	5,222	4.0
Pellet Stove with ASHP Baseline	4,480	4.0

Revised Savings

As in previous years, the Evaluator performed a literature review in search of updated or recently released technical references and metering studies that could be used to refine the unitary savings methodologies for wood and pellet stoves. The literature review did not identify any additional resources that were based on metered studies or billing analyses in comparable climates. Therefore, the calibrated energy simulations remain the most representative source for the unitary savings values.

However, one small adjustment was applied to the two unitary savings values used for participants with an ASHP as the baseline to account for a calculation error in the 2016 evaluation report.⁴⁶ Thus, a revised unitary savings value of 4,973 kWh for wood stoves with an ASHP baseline and a revised unitary savings value of 4,266 kWh for pellet stoves with an ASHP baseline were used.

Wood and Pellet Boilers and Furnaces

Tracked Savings

The tracked unitary savings values for wood and pellet boilers and furnaces are based on the 2010 Residential Fuel Substitution Program Review carried out by Dunskey Energy Consulting.⁴⁷

The energy savings values were adjusted using a billing analysis and HOT2000 energy modelling to reflect the typical annual heating consumption values of actual 2012 program component participants. These values, listed in Table 33, have been used since 2013.

Table 33: Tracked Unitary Savings Values for Wood and Pellet Furnaces and Boilers

Category of Equipment	Tracked Energy Savings Value (kWh/year)	Tracked Peak Demand Savings Value (kW)
Wood Furnace or Boiler	13,804	7.66
Pellet Furnace or Boiler	13,765	7.75

⁴⁶ Unitary savings values with electrical resistance should be divided by a COP of 2.1 rather than 2.0.

⁴⁷ Dunskey Energy Consulting, *Residential Fuel Substitution Pilot Program*, Final Report, December 2010.

Revised Savings

A literature review focused on identifying updated technical references, metering studies and/or comparable billing analyses was carried out for wood and pellet boilers and furnaces in 2017. The Evaluator found no updated references or studies that were more representative and therefore recommends that the current unitary savings values be maintained. This is further supported by the fact that only four Green Heat participants have installed wood and pellet furnaces and boilers in the last two years. The revised savings listed in Table 33 are thus maintained.

Solar Domestic Hot Water and Solar Air Heaters

Tracked Savings

Currently, the tracked energy savings values for solar DHW and solar air heaters are based on RETScreen energy models. ENS creates the energy models for each participant using manufacturer technical specifications for the given equipment and a set of defined operating variables. The modelling variables are based on recommendations from the 2012 evaluation.

Peak demand savings for both solar domestic water and solar air heaters are tracked as zero because the sun is set during the peak demand period. Hence the solar equipment is unable to generate heat.

Revised Savings

The Evaluator carried out a literature review to determine if any recent studies supported adopting another approach than energy modelling. Results did not uncover any detailed metering studies or billing analyses that would improve the accuracy of the calculated energy savings values. Therefore, the Evaluator recommends that ENS continue using the RETScreen energy models to determine unitary savings.

Heat Pump Water Heaters

Tracked Savings

The unitary savings value for HPWHs was established in 2016 using nine calibrated HOT2000 energy models considered representative of typical Nova Scotia housing stock. The nine homes were each modelled using two different electrical heating system baselines as the primary heating source (electrical radiant baseboards and a MSHP) and a standard electrical resistance water heater. Then, the same homes were modelled with a HPWH. The savings were determined by calculating the average difference in the total modelled energy consumption values between the homes equipped with a standard water heater and those same homes equipped with an HPWH.

The unitary peak demand savings were determined using the on-peak demand-to-energy ratio developed by Navigant in the 2016-2018 DSM Plan. Navigant used local data to establish a DHW ratio of 0.162 W in demand reduction for every kWh of energy saved. Using the unitary energy savings value of 2,183 kWh, a unitary peak demand savings value of 0.354 kW was obtained. These values are listed in Table 34.

Table 34: Tracked Unitary Savings Values for Heat Pump Water Heaters

Category of Equipment	Tracked Energy Savings Value (kWh/year)	Tracked Peak Demand Savings Value (kW)
Heat Pump Water Heaters	2,183	0.354

Revised Savings

The Evaluator reviewed the existing unitary savings value and concluded that the methodology is still adequate. It is recommended that ENS continue using the values in Table 34.

8.1.3 Savings Review of Mini-split Heat Pumps

In August 2017, Green Heat underwent a series of changes related to the incentive structure and eligibility criteria. These changes especially impact savings generated by MSHPs. Unlike the old path which only allowed electrically heated participants, the new path allows all MSHP participants regardless of their primary heating source. The new path therefore includes both electrically and non-electrically heated households.

Tracked Savings

Electrically Heated Households

ENS uses the same methodology to calculate energy and peak demand savings for all participants from the old path and participants in electrically heated households from the new path.

The MSHP energy savings values are the results of a billing analysis carried out by the Evaluator in the previous evaluation. The average annual savings value of 0.232 kWh per Btu/h of nominal installed heating capacity, are tracked by ENS for each electrically heated household.

Since a peak coincident demand savings factor could not be determined through the billing analysis, MSHP peak demand savings are calculated for each installed MSHP system for electrically heated households using the general heat pump peak demand savings algorithm below, which is a modified version⁴⁸ of the Pennsylvania PUC TRM for air source heat pumps of less than 65,000 Btu/h. The peak demand savings calculations are performed using the variables defined and listed in Table 35 below.

$$Peak\ Demand\ Savings_{kW} = \left(\frac{HC_{min}}{3.412} \right) * \left[\frac{1}{COP_{base\_min}} - \frac{1}{COP_{ee\_min}} \right]$$

Table 35: Definition of the Parameters and their Numerical Values - MSHP

Acronym	Unit	Variable	Value/Source
HC_{min}	kBtu/h	Rated heating capacity of the new heat pump at outdoor air temperature of -15 °C	Specification data for each installed system
COP_{base_min}	kW/kW	COP for the assumed base case of electrical resistance	Resistance heater has a COP of 1
COP_{ee_min}	kW/kW	COP for the new heat pump at -15 °C	Specification data for each installed system

Non-electrically Heated Households

For non-electrically heated households, tracked MSHP energy savings are currently calculated based on a slightly modified version of the Pennsylvania PUC TRM⁴⁹ for air source heat pumps under 65,000 BTU/hr. The modifications made to the equation included an adjustment for a cooling penalty for participants that did not previously have air conditioning in the home.

The modified energy savings calculations are performed for each MSHP system installed in non-electrically heated households using the following equation and the variables are defined in Table 36 below.

$$Energy\ Savings_{kWh} = Heating\ Savings + Cooling\ Savings\ or\ Penalty$$

$$= \left(\left(\frac{HC}{1000} * \left[\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{ee}} \right] * EFLH_h \right) + \left(\frac{CC}{1000} * \left[\frac{1}{SEER_{base}} * AC - \frac{1}{SEER_{ee}} \right] * EFLH_c \right) \right)$$

For peak demand savings, ENS currently uses a deemed value of 0 kW for all MSHPs installed in non-electrically heated homes.

⁴⁸ The algorithm was changed so that the peak demand savings calculation uses the rated heating capacity and the COP at -15 °C, which corresponds to the design temperature during the peak period.

⁴⁹ Pennsylvania Public Utility Commission (PUC), *Technical Reference Manual*, June 2015, Section 2.2 – HVAC.

Table 36: Definition of the Variables and their Numerical Values – MSHP

Acronym	Unit	Variable	Value/Source
HC	Btu/h	Rated heating capacity of the new heat pump	Specification data for each installed system (Air conditioning, Heating and Refrigeration Institute [AHRI] Certified Value)
HC_{min}	Btu/h	Rated heating capacity of the new heat pump at an outdoor air temperature of -15 °C	Specification data for each installed system
CC	Btu/h	Rated cooling capacity of the new heat pump	Specification data for each installed system (AHRI Certified Value)
$HSPF_{base}$	Btu/W·h	Heating seasonal performance factor (Region V) for the baseline equipment	Non-electrical system: 7.13 (PUC TRM)
$HSPF_{ee}$	Btu/W·h	Rated heating seasonal performance factor (Region V) for the new heat pump	Specification data for each installed system (AHRI Certified Value)
$SEER_{base}$	Btu/W·h	Seasonal energy efficiency ratio for existing AC system	PUC TRM ⁵⁰ DHP/ASHP: 14 Central AC: 13 Room AC: 11.3
$SEER_{ee}$	Btu/W·h	Seasonal energy efficiency ratio for the new equipment	Specification data for each installed system (AHRI Certified Value)
$EFLH_h$	h/year	Full heating load hours	2,280 (Minnesota TRM)
$EFLH_c$	h/year	Full cooling load hours	213 (Minnesota TRM)
AC	Unitless	Cooling penalty modifier	AC in baseline = 1 No AC in baseline = 0

Revised Savings

Since energy and peak demand savings vary depending on the old heating sources prior to installing MSHPs, the Evaluator developed distinct savings calculation methodologies for electrically heated (fully⁵¹ or mainly) households and non-electrically heated households.

Electrically Heated Households

To revise the gross savings of participants with electrical heating, the Evaluator conducted another billing analysis in 2017 with old path participants. This analysis includes more participants and longer post-installation periods after the installation of the MSHP than the billing analysis conducted as part of the 2016 evaluation. This new analysis included all 2015 participants as well as participants who installed an MSHP between January 2016 and June 2016. The methodology described below is similar to that of the first billing analysis.

⁵⁰ Pennsylvania Public Utility Commission (PUC), *Technical Reference Manual*, June 2015, Section 2.2 – HVAC.

⁵¹ Fully electrically heated households correspond to households that are 100 percent electrically heated.

The electrical consumption billing data provided by NSP for the selected participants were analyzed for both the pre-installation and post-installation periods. For the pre-installation periods, data from seven billing periods (corresponding to approximately 14 months) were reviewed in order to include the entire winter preceding MSHP installation. For the post-installation, data from a minimum of five billing periods (approximately 10 months) was necessary to cover the entire winter that followed installation without excluding too many participants. The initial sample included 350 participants and was reduced to 292 participants based on the above criteria.

The objective of the billing analysis was to compare the electrical energy consumption of the sampled participants before and after the installation of their MSHPs. To do so, a regression model based on the Princeton Scorekeeping Method was used. This standard statistical method calculates a regression specific to each participant instead of analyzing the data as a whole. The linear regression model is expressed in the following equation:

$$CONS = A + B \times HDD$$

Where:

- › CONS is the average daily consumption
- › A is the daily base consumption constant
- › B is the unitary consumption coefficient per HDDs
- › HDD is the average daily HDDs

The daily base consumption constant (Constant A) represents the everyday electrical consumption not related to outdoor temperature or the HDDs. End uses in the daily base consumption constant include lights, appliances, DHW and electronic devices. Conversely, the unitary consumption coefficient (Coefficient B) corresponds to the electrical consumption that varies according to outdoor temperature; it mainly includes space heating consumption, but also a portion of other end uses that tend to increase consumption during colder months, such as lighting and DHW.

The pre-installation and post-installation billing data of each participant were analyzed using the linear regression model presented above. The analysis was focused on variable electricity consumption, which was obtained by multiplying the Coefficient B and normalized annual HDD⁵² to establish MSHP energy savings. The normalized HDD values were used to compare the two periods on the same basis and establish the average savings that are not specific to a particular year. By isolating variable electricity consumption, the Evaluator limited the impacts of changes made to houses that might have occurred during the pre-installation and post-installation periods and that would have had an effect on base consumption.

⁵² Government of Canada, *Station Results - 1981-2010 Climate Normals and Averages*, <http://climate.weather.gc.ca>. These data are updated every 10 years.

Participants who had a heat pump as their old primary heating system were removed from the analysis. Though Green Heat requires that existing heat pumps be non-functional to be eligible, the Evaluator could not identify the moment when the heat pump stopped working for four participants who were consequently removed from the analysis.

The statistical significance of the regression model described above was used as a discriminating criterion to define which results should be retained. The analysis was strictly based on statistical observations using the following criteria:

- › Having a significant level of correlation for both the pre and post-installation Coefficients B (75 participants removed)
- › Having a positive daily base consumption Constant A (five participants removed)
- › Having a coefficient of determination (R^2) above 0.65 (28 participants removed)
- › Having a savings-per-installed-capacity value within two standard deviations of the average (10 participants removed)

Of the 292 participants available at the beginning of the analysis, 170 were thus retained for the final analysis.

A billing analysis performed on an extended sample⁵³ after the 2016 evaluation cycle demonstrated that the presence of secondary non-electrical heating systems decreases the savings generated by MSHPs. Therefore, the impact of this variable was considered in the 2017 billing analysis. Of the 170 participants used in the billing analysis, 31 percent had a secondary non-electrical heating system. Therefore, the Evaluator calculated distinct energy savings values for fully electrically heated households and mainly electrically heated households (i.e. those with a secondary non-electrical heating system).

For fully electrically heated households, billing analysis results revealed an energy savings value per unit of installed capacity of 0.179 kWh/Btu/h, while a value of 0.060 kWh/Btu/h was obtained for mainly electrically heated households. These unitary savings values per installed capacity are used to calculate energy savings of participants from the old path as well as participants in electrically heated households from the new path.

Table 37 summarizes the average savings per installed capacity, as well as the error calculations for each category of participant.

⁵³ Hamelin, M. C. et al., "Accounting for Real-Life Conditions in Mini-Split Heat Pump Savings: Findings from a Billing Analysis" in *Proceedings of the 2017 International Energy Program Evaluation Conference*, Baltimore, MD, 2017.

Table 37: Average MSHP Energy Savings and Energy Savings per Installed Capacity

	Fully Electrically Heated Households		Mainly Electrically Heated Households	
	Energy Savings	Energy Savings per Installed Capacity	Energy Savings	Energy Savings per Installed Capacity
Number of Observations	118	118	52	52
Mean	3,336 kWh	0.179 kWh/Btu/h	1,328 kWh	0.060 kWh/Btu/h
Absolute Margins of Error*	± 420 kWh	± 0.022 kWh/Btu/h	± 773 kWh	± 0.034 kWh/Btu/h
*The absolute margins of error are calculated with a confidence interval of 90 percent.				

The Evaluator also calculated the heating equivalent full load hours (EFLH) value resulting from the billing analysis of energy savings. To do so, the EFLH variable was isolated from the general heat pump energy savings algorithm below.

$$Energy\ Savings_{kWh} = \left(HC * \left[\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{ee}} \right] * EFLH_h \right)$$

Where:

- › HC is the heat pump nominal heating capacity [kBtu/h]
- › $HSPF_{base}$ is the heating seasonal performance factor (Region V) for the baseline equipment [Btu/W·h]
- › $HSPF_{ee}$ is the heating seasonal performance factor (Region V) for the new heat pump [Btu/W·h]
- › $EFLH_h$ are the annual heating equivalent full load hours [h]

$$EFLH_h = \frac{ES_{kWh}}{HC * \left[\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{ee}} \right]}$$

Distinct EFLH values were obtained for fully and mainly electrically heated households. The average energy savings values (ES_{kWh}) presented in Table 37 above were used in the EFLH calculation. The average rated heating capacity (HC) for fully electrically heated households was 19.6 kBtu/h and mainly electrically heated households was 20.0 kBtu/h. The capacity-weighted average $HSPF_{ee}$ for installed MSHPs was 10.72 Btu/W·h for fully electrically heated households and 10.89 Btu/W·h for mainly electrically heated households. The $HSPF_{base}$ was 3.412 Btu/W·h (equivalent to 100% efficient electrical resistance heating). Therefore, EFLH values of 852 hours and 330 hours were established for fully electrically heated households and mainly electrically heated households respectively. The average EFLH value for all participants included in the billing analysis (118 fully electrically heated household and 52 mainly electrically heated households) is 668 hours.

The Evaluator compared the EFLH values with values obtained from either billing analyses or metering studies in other jurisdictions. Only a few jurisdictions have conducted metering studies to estimate MSHP energy savings. Massachusetts derived EFLH for MSHPs from a metering study of 152 homes over two consecutive winters.⁵⁴ This metering study of both non-cold climate and cold climate units found that EFLH were lower than expected when compared to other means of estimating EFLH mainly because some units were not used regularly during each heating season, operating coincidentally with other systems or not operating at all. The findings of this study revealed that EFLH for cold climate heat pumps specifically (526 hours in winter 2015 and 420 hours in winter 2016) are of the same magnitude as the average value of 668 hours obtained through this billing analysis.

The significant impact of secondary non-electrical heating systems on average savings (decrease of 60% in savings in this billing analysis) was also observed in a billing analysis conducted by Ecotope for the Northwestern United States (Washington, Oregon, Montana, and Idaho), which included 3,899 participants who had installed an MSHP to displace heat from a zonal electrical system.⁵⁵ The study revealed a decrease in energy savings of 73 percent for participants with a secondary heating system; savings of 2,718 kWh were measured for fully electrically heated households and 747 kWh for households with a secondary heating system. The similar conclusions obtained by both aforementioned studies suggest that the billing analysis results presented herein are representative of the real savings associated with the MSHPs installed through Green Heat.

Again in 2017, the billing analysis did not provide any information for estimating peak demand savings. Consequently, the Evaluator used the same general heat pump peak demand savings algorithm as that used to calculate tracked peak demand savings. This algorithm is considered valid because the heat pump system will operate at maximum capacity on the coldest days of the year unless the unit is significantly oversized.

Non-electrically Heated Households

This section presents the methodology used to calculate the revised savings for non-electrically heated households under the new path. The billing analysis results could not be used for these participants since the basecase electricity consumption for this category cannot be measured using electrical billing data prior to the installation of the heat pump.

⁵⁴ The Cadmus Group, Inc., *Ductless Mini-Split Heat Pump Impact Evaluation*, Prepared for the Electric and Gas Program Administrators of Massachusetts and Rhode Island, December 30, 2016.

⁵⁵ Ecotope. *Ductless Heat Pump Impact & Process Evaluation: Billing Analysis Report* (Report #13-262), 2013.

Basecase Scenarios

The Evaluator first considered the basecase over which energy savings shall be calculated for non-electrically heated households. The Evaluator relied on the participant survey to establish the basecase scenario, i.e. which of the following actions participants would have taken in the absence of the program component:

- › Would have purchased a heat pump
- › Would have switched to electrical resistance heating
- › Would have preserved non-electrical heating

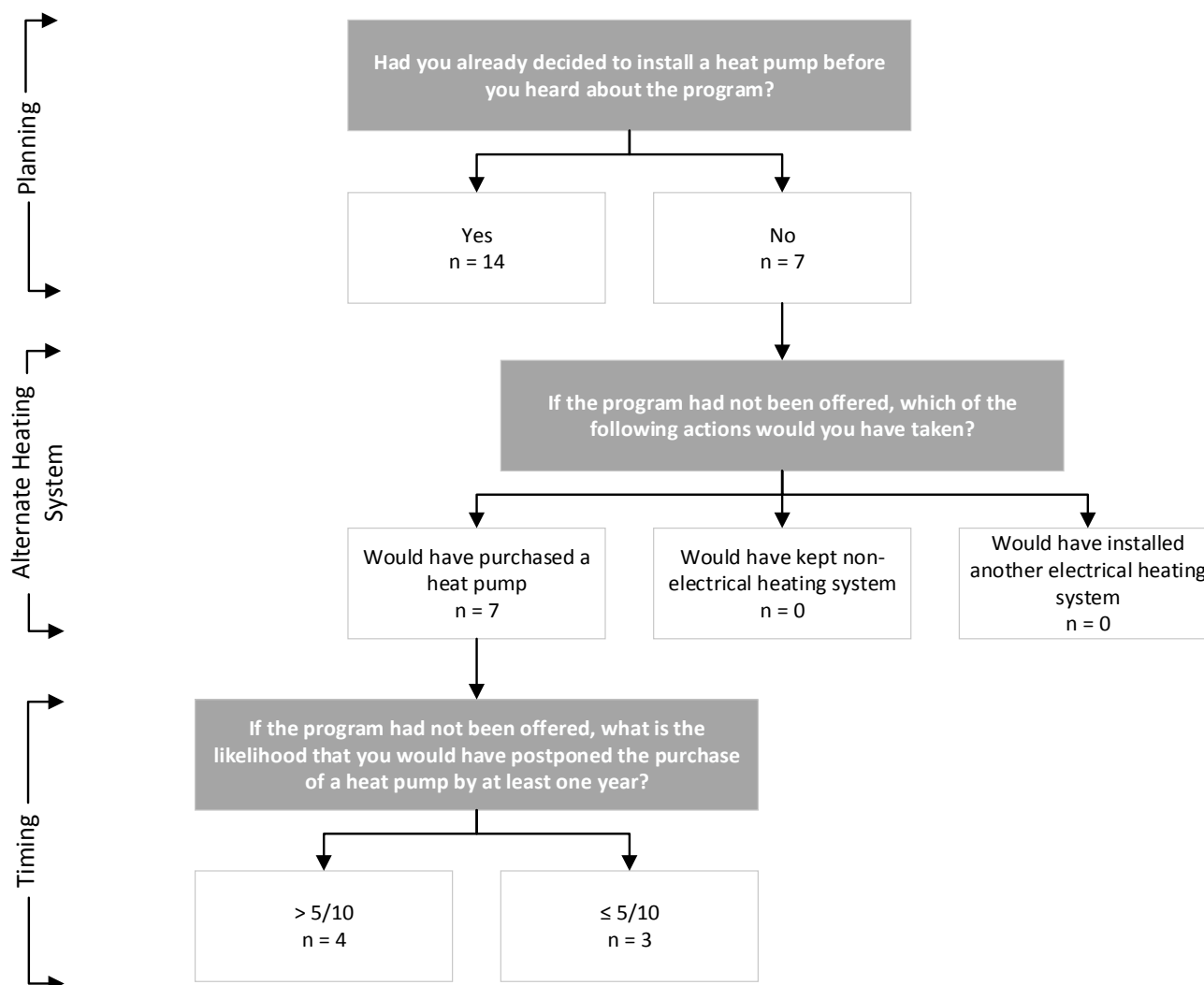
In the case of non-electrically heated households, the basecase equipment can have a significant impact on the energy savings associated with Green Heat:

- › If participants intended to purchase a heat pump or switch to electrical resistance heating in the absence of the program, then the purchase of a high-efficiency heat pump results in less electricity consumption and therefore positive electricity savings.
- › If participants intended to keep their non-electrical heating system in the absence of the program, then the purchase of a high-efficiency heat pump results in increased electricity consumption and therefore negative electricity savings.

For the basecase scenario, the decision to purchase a heat pump, an alternate heating system or keep the existing system is used. Once the basecase scenario is established, then the decision to purchase a high-efficiency heat pump rather than a regular heat pump is used to assess free-ridership (see Subsection 8.2.1).

Table 38 presents the survey answers which allowed the Evaluator to establish an adequate basecase for non-electrically heated households.

Table 38: Survey Answers About the Decision to Purchase a Heat Pump for Non-electrically Heated Households



The results of the survey must be used with caution since the sample size of 21 non-electrically heated households is small; the sample was small because of the low number of non-electrical participants who took part in the program component at the time of the survey, in October 2017. The Evaluator recommends that this survey be conducted with a larger sample as the total number of participants increases in 2018 and in following years. Regardless, this survey demonstrates that all participants either had decided to purchase a heat pump or were more likely to purchase a heat pump than keep their non-electrical heating system or purchase another type of electrical heating system. For this reason, the Evaluator considered that a standard heat pump was an adequate basecase for non-electrically heated households.

There is, however, the possibility that a small number of participants might have purchased a heat pump sooner than anticipated because of influence from Green Heat since four participants indicated a probability of at least 6/10 that they would have postponed their purchase in the absence of Green Heat. In these cases, savings for the first few years might be negative since the baseline for those years would be the non-electrical heating system (in other words, the heat pump is an added load to the electrical grid). To better estimate this impact and take it into account in the savings calculations, more questions would need to be asked and a larger sample would be necessary. Since more research is required to determine if participants are purchasing heat pumps sooner than anticipated because of Green Heat, the Evaluator did not make adjustments to account for the change in timing due to Green Heat influence for the 2017 evaluation.

The Evaluator conducted a sensitivity analysis to estimate the impact that negative savings might have on average savings for non-electrically heated households. The average first-year unitary savings, using the parameters defined below, were calculated at 434 kWh if the basecase is a standard heat pump, and -1,004 kWh if the basecase is a non-electrical heating system. It was therefore established that 30 percent of participants with non-electrical heating would have to have a non-electrical basecase for the first year (i.e. have purchased their heat pump at least one year earlier because of Green Heat) for their negative savings to cancel out the positive savings achieved by the remaining 70 percent of participants. Among the small sample of 21 participants, four (or 19%) mentioned they would have likely waited before purchasing a heat pump in the absence of Green Heat – this preliminary result is below the threshold of 30 percent where average first-year savings would be nil (i.e. the overall energy savings impact from non-electrical participants would be positive if only 19% of participants would have waited to purchase their heat pump in the absence of Green Heat).

The Evaluator also considered the impact that this would have on lifetime energy savings. Assuming that some participants with non-electrical heating purchased a heat pump one year earlier because of Green Heat, their lifetime energy savings are still positive. Using an EUL of 18 years and positive savings of 434 kWh after the first year, average lifetime energy savings are 6,378 kWh. Based on the assumption that all participants using non-electrical heating would have purchased their heat pump one year sooner because of Green Heat, the lifetime energy savings would be reduced by 23 percent. For lifetime energy savings to be nil for participants who purchased their heat pump earlier because of Green Heat, participants would have to accelerate their purchase by more than five years.

Significant uncertainty remains about the magnitude of any savings decrease associated with these effects and there is no evidence that negative savings outweigh positive savings at this point. The Evaluator recommends that the impact of negative savings be quantified with greater precision in future years.

Savings Equations

For all non-electrically heated households, the Evaluator used the previously defined general heat pump energy savings algorithms to calculate annual energy savings and peak demand savings, as follows:

$$\text{Energy Savings}_{kW h} = \left(HC * \left[\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{ee}} \right] * EFLH_h \right)$$

$$\text{Peak Demand Savings}_{kW} = \left(\frac{HC_{min}}{3.412} \right) * \left[\frac{1}{COP_{base\_min}} - \frac{1}{COP_{ee\_min}} \right]$$

Capacities and Efficiency Level of MSHPs

For energy savings, the heating capacity (HC) and the efficiency of the MSHP ($HSPF_{ee}$) are specific to each installed system model. Similarly, for peak demand savings, the minimum heating capacity (HC_{min}) and the minimum COP (COP_{ee_min}) are specific to each installed system.

Baseline Efficiency

The Evaluator performed a literature review to determine the efficiency level that corresponds to a standard heat pump.

The literature review revealed that the baseline technology used in MSHP measures of other jurisdictions was almost exclusively an MSHP that met the minimum federal efficiency requirements. In Canada, minimum efficiency standards for ASHPs (including MSHPs) are in effect under the federal Energy Efficiency Regulations.

Consequently, the Evaluator used a baseline HSPF Region V of 7.1 that corresponds to the energy efficiency regulation for split system heat pumps.⁵⁶

For peak demand savings, the COP of the baseline scenario at -15 °C is assumed to be 1 since the standard MSHP is expected to either operate at a COP near unity or in electrical resistance mode at such a low temperature.

⁵⁶ Natural Resources Canada, *Single-Phase and Three-Phase Split-System Central Air Conditioners and Heat Pumps*. <http://www.nrcan.gc.ca/energy/regulations-codes-standards/products/6895>, (Last accessed December 4, 2017).

EFLH Value

To determine the usage conditions of the MSHPs installed in non-electrically heated households, the Evaluator surveyed these participants about their use of other heating systems in addition to the newly installed MSHP. The survey results revealed that:

- › 62 percent of surveyed participants still use their old non-electrical heating system in addition to the MSHP
- › 19 percent use another electrical heating system in addition to the MSHP
- › 19 percent only use the MSHP

The Evaluator interpreted these results as follows: 62 percent of the participants who had previously used non-electrical heating installed an MSHP in a now mainly electrically heated home, since they are still using their old non-electrical system along with their MSHP; 38 percent of the participants now live in a completely electrically heated home and use only their MSHP or a mix of the MSHP and another electrical system. Therefore, the Evaluator established an EFLH value of 528 based on an average of the EFLH values obtained from the billing analysis for mainly (330 hours) and fully (852 hours) electrically heated households weighted by the survey results.

Revised Parameters Summary

Table 39 summarizes the parameters used in the energy and peak demand savings equations for MSHPs installed in non-electrically heated households.

Table 39: Parameters Used for Savings Calculations of MSHPs in Non-electrically Heated Households

Acronym	Unit	Value	Source
HC	Btu/h	Specific to each installed model	Tracking sheet (AHRI Certified Value)
HC_{min}	Btu/h	Specific to each installed model	Tracking sheet
$HSPF_{base}$	Btu/W·h	7.1	Energy efficiency regulations for split systems
$HSPF_{ee}$	Btu/W·h	Specific to each installed model	Tracking sheet (AHRI Certified Value)
$EFLH_h$	h/year	528	Billing analysis
COP_{base_min}	kW/kW	1	Assumption
COP_{ee_min}	kW/kW	Specific to each installed model	Tracking sheet

8.1.4 Savings Review of Central Air-source, Air-to-water and Ground-source Heat Pumps

Central Air-source and Air-to-water Heat Pumps

The central air-source heat pump category under Green Heat currently includes centrally ducted (air-to-air) ASHPs and AWHPs. In accordance with the 2016 evaluation, both ASHP and AWHP savings were calculated using the same energy performance criteria and equivalent full load operating hours. As the Green Heat Program Manual defines AWHPs as a sub-category of central heat pumps, and since they are not commonly installed, they are referred to as ASHP throughout the remainder of this report.

Tracked Savings

Tracked energy savings for ASHPs are calculated using a modified version of the Pennsylvania PUC TRM⁵⁷ savings algorithm (as presented further below) for each system, based on their specific performance metrics. All the calculations are performed using AHRI-certified heating and cooling capacities which are obtained directly from the AHRI website or from equipment manufacturer specifications. The baseline seasonal energy efficiency ratio (SEER) and HSPF values depend on the participant's existing equipment. For non-mainly electrically heated households under the new path, ENS uses an HSPF Region V value of 7.13 based on the Pennsylvania PUC TRM value for standard ASHPs.⁵⁸ The heating and cooling EFLH of 2,280⁵⁹ and 213 hours per year are based on the values for Northern Minnesota retrieved from the 2017 State of Minnesota TRM⁶⁰ which obtained these results through energy modelling.

$$\begin{aligned} \text{Energy Savings}_{kWh} &= \text{Heating Savings} + \text{Cooling Savings or Penalty} \\ &= \left(\left(\frac{HC}{1000} * \left[\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{ee}} \right] * FLH_h \right) + \right. \\ &\quad \left. \left(\frac{CC}{1000} * \left[\frac{1}{SEER_{base}} * AC - \frac{1}{SEER_{ee}} \right] * FLH_c \right) \right) \end{aligned}$$

Peak demand savings are calculated using a unitary peak demand savings value of 3.04 kW drawn from the 2015 evaluation. This unitary value was determined using the available performance data for a sample of fifteen ASHPs installed in 2015. The capacity tables for those fifteen ASHP units were used to extract heating capacities and COPs at a temperature of -15 °C. Using the performance data and the algorithm below, the peak demand savings were calculated for each of the fifteen ASHPs and then averaged to yield the 3.04 kW value.

⁵⁷ Pennsylvania Public Utility Commission (PUC), *Technical Reference Manual*, June 2015, Section 2.2 – HVAC.

⁵⁸ Pennsylvania Public Utility Commission (PUC), *Technical Reference Manual*, June 2015, Section 2.2 – HVAC.

⁵⁹ The value in the Minnesota TRM is actually 2,280 hours. A value of 2,208 was mistakenly used by the Evaluator in 2016 due to a transcription error in the 2016 Evaluation Report.

⁶⁰ Minnesota Department of Commerce – Division of Energy Resources, *State of Minnesota Technical Reference Manual for Energy Conservation Improvement Programs – Version 2*, Effective January 1, 2017.

$$Demand Savings_{kW} = \left(\frac{HC_{min}}{1000 * 3.412} \right) * \left[\frac{1}{COP_{base}} - \frac{1}{COP_{ee\_min}} \right]$$

Table 40 further defines the variables used in determining tracked energy and peak demand savings.

Table 40: Definition of the Parameters and their Numerical Values - ASHP

Acronym	Unit	Variable	Value/Source
HC	Btu/h	Rated heating capacity of the new heat pump	Specification data for each installed system (AHRI Certified Value)
HC_{min}	Btu/h	Rated heating capacity of the new heat pump at an outdoor air temperature of -15 °C	Specification data for each installed system
CC	Btu/h	Rated cooling capacity of the new heat pump	Specification data for each installed system (AHRI Certified Value)
$HSPF_{base}$	Btu/W·h	Heating seasonal performance factor (Region V) for the baseline equipment	Electrical resistance: 3.412 Functioning ASHP: 7.13 (PUC TRM) Non-electrical system: 7.13 (PUC TRM)
$HSPF_{ee}$	Btu/W·h	Rated heating seasonal performance factor (Region V) for the new heat pump	Specification data for each installed system (AHRI Certified Value)
$SEER_{base}$	Btu/W·h	Seasonal energy efficiency ratio for existing AC system	PUC TRM ⁶¹ DHP/ASHP: 14 Central AC: 13 Room AC: 11.3
$SEER_{ee}$	Btu/W·h	Seasonal energy efficiency ratio for the new equipment	Specification data for each installed system (AHRI Certified Value)
FLH_{heat}	h/year	Full heating load hours	2,280 (Minnesota TRM)
FLH_{cool}	h/year	Full cooling load hours	213 (Minnesota TRM)
AC	Unitless	Cooling penalty modifier	AC in baseline = 1 No AC in baseline = 0
HC_{min}	Btu/h	Rated heating capacity of the new heat pump at an outdoor air temperature of -15 °C	Specification data for each installed system
COP_{base}	kW/kW	Coefficient of performance for the baseline equipment	Electrical resistance: 1
COP_{ee_min}	kW/kW	Coefficient of performance for the new heat pump at an outdoor temperature of -15 °C	Specification data for each installed system

⁶¹ Pennsylvania Public Utility Commission (PUC), *Technical Reference Manual*, June 2015, Section 2.2 – HVAC.

Revised Savings

Electrically Heated Households

A billing analysis was performed in the 2017 evaluation to more accurately estimate ASHP energy savings for all previously mentioned scenarios. All participants from 2013 to 2016 who installed an ASHP were included in the analysis. The same linear regression model and the same methodology as the MSHP billing analysis were used. The initial sample included 197 participants of whom 142 had sufficient data for both the pre-installation and post-installation periods. For the former period, data from seven billing periods were reviewed, while for the latter, data from a minimum of four billing periods were necessary to consider the winter period following the installation without excluding too many participants. A total of 64 participants were removed from the analysis since their old primary heating system was also a central air-source heat pump (ASHP).

Similar to the MSHP billing analysis, the statistical significance of the regression model was used as a discriminating criterion to define which results should be retained. The analysis was strictly based on statistical observations using the following criteria:

- › Having a significant level of correlation for both the pre and post-installation Coefficient B (22 participants removed)
- › Having a positive daily base consumption Constant A (two participants removed)
- › Having a coefficient of determination (R^2) above 0.65 (nine participants removed)
- › Having an available installed capacity (three participants removed)
- › Having a savings-per-installed-capacity value within two standard deviations of the average (three participants removed)

The 37 remaining participants were categorized based on type of heating system:

- 1 Fully electrically heated with no secondary system
- 2 Mainly electrically heated (with a non-electrical secondary system)
- 3 Fully electrically heated with a secondary heat pump

Table 41 presents the savings for each category, as well as for categories 1 and 3 combined.

Table 41: Average Energy Savings per Installed Capacity per Participant Category

	Category 1	Category 2	Category 3	Categories 1 and 3	All Participants
Number of Observations	21	4	12	34	37
Mean (kWh/Btu/h)	0.140	-0.099	0.026	0.101	0.094
Absolute Error (kWh/Btu/h)	0.078	0.321	0.072	0.044	0.043

Given the small sample sizes, it is difficult to establish distinct unitary savings for any of these categories. However, it seems that participants who do not have a secondary heating system have greater unitary savings than other categories. It would be useful to broaden the billing analysis sample size in future years to verify whether unitary savings differences become statistically significant. Considering the low savings for participants with secondary heat pumps (category 3) and the large proportion of participants in the tracking sheet who are in this category, the Evaluator recommends further investigating this type of participant, possibly by making it the focus of on-site visits in 2018. It is possible that secondary heat pumps in fact provide a large portion of the home's heat and that the displaced heating load by the new heat pump does not originate from electrical resistance heating; these assumptions could be validated by careful on-site analysis of secondary heating systems.

The Evaluator further studied the results for ASHPs installed in homes with no secondary heating systems (category 1) to compare them to other studies. Since these participants had an average installed heating capacity of 34,546 Btu/h, they obtained annual energy savings of 4,838 kWh. By isolating the EFLH variable from the energy savings algorithm and using the energy savings of 4,838 kWh and the average HSPF of 7.89 in the algorithm below, EFLH are estimated at 842 hours.

$$EFLH_h = \frac{ES_{kWh}}{HC * \left[\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{ee}} \right]}$$

This means that heat pumps operate in heat pump mode for 842 hours rather than in electrical resistance mode when the heat pump generates no energy savings compared to the electrical resistance baseline. It is difficult to find comparable ELFH values in the literature because the EFLH values used in other jurisdictions are often obtained from energy modelling or an analysis of heating degree days. However, the Independent Electricity System Operator (IESO) conducted a billing analysis with ASHPs replacing electrical heating systems in Ontario⁶² and obtained very similar conclusions. For the 43 central ASHPs included in the IESO billing analysis, average energy savings were estimated at 4,139 kWh. ASHPs were installed across Ontario, essentially between Windsor and Ottawa, with a few installations in Sudbury and North Bay. As a point of reference, HDDs for Toronto stand at 4,066 degree days, while Halifax has 4,263 degree days. Both climates are therefore comparable. IESO also surveyed billing analysis participants and asked them about their supplemental heat usage: 17 percent of ASHP participants said that they use supplemental heat “very often” or “all the time”; the fact that those participants were included in the 4,139 kWh might explain why savings were marginally lower in Ontario than for the fully electrically heated participants in the present study.

⁶² Cadmus and IESO, *Evaluation of Verifying Cold Climate Air Source Heat Pumps in Electrically Heated Residential Homes in Ontario*, Canada, Poster presented at the 2017 International Energy Program Evaluation Conference, Baltimore, MD, 2017, available at <http://www.cadmusgroup.com/papers-reports/evaluation-of-verifying-cold-climate-air-source-heat-pumps-in-electrically-heated-residential-homes/>. (Last accessed December 4, 2017).

The Evaluator also analyzed the effect of cooling on electrical consumption by adding cooling degree days (CDD) values in the linear regression model. The results revealed that only seven participants had a significant level of correlation for both the pre and post-installation coefficient associated with CDD. It was therefore concluded that the CDD were generally not a good predictor of energy consumption and that no adjustment to energy savings should be made based on this variable.

In conclusion, the Evaluator used the unitary savings value for categories 1 and 3 combined, 0.101 kWh/Btu/h, to establish the revised savings for ASHPs. The small sample size for participants with non-electrical heating systems did not allow outliers to be identified, and therefore it was considered best to exclude those results from the sample. By considering participants of categories 1 and 3, EFLH were established at 604 hours.

Like the MSHP billing analysis, the ASHP billing analysis did not provide any information for estimating peak demand savings. Since no information was provided in the tracking sheet on the heating capacity and the COP at -15°C for ASHPs, the Evaluator relied on the unitary peak demand savings value of 3.04 kW from the 2015 evaluation. This value of 3.04 kW was calculated based on the information found for a small number of ASHP models (15 models). Considering that the number of ASHPs has significantly increased in the past several years (from 52 in 2015 to 143 in 2017),⁶³ the Evaluator strongly suggests that ENS start tracking the ASHP parameters at -15°C to increase the accuracy of the peak demand savings calculations.

Non-electrically Heated Households

This section presents the methodology used to calculate the revised savings for ASHPs installed in non-electrically heated households.

Similar to the MSHP approach used for non-electrically heated households, the Evaluator chose to consider three scenarios which represent actions that participants would have taken in the absence of the program component:

- › Would have purchased a heat pump
- › Would have switched to electrical resistance heating system
- › Would have kept their non-electrical heating system

⁶³ 142 centrally-ducted air-to-air heat pumps and one centrally-ducted air-to-water heat pump in 2017.

For each scenario mentioned above, energy savings are calculated differently since the basecase equipment is not the same:

- › If participants intended to purchase a heat pump in the absence of the program, then the basecase is a standard ASHP. The minimum HSPF (Region V) allowed by the federal regulation is 7.1; consequently, the Evaluator chose to use this HSPF value of 7.1. Therefore, the electrical savings for these participants are positive but very minor.
- › If participants intended to replace a non-electrical heating system with electrical resistance heating system, then the baseline equipment is an electrical resistance heating system. Therefore, the unitary savings value per installed capacity of 0.101 kWh/Btu/h obtained from the ASHP billing analysis can be used and the electrical savings are positive.
- › If participants intended to keep their non-electrical heating system, then the purchase of an ASHP results in increased electricity consumption and therefore electricity savings are negative.

No survey could be conducted for participants who installed an ASHP in a non-electrically heated household because of the very low number of such participants at the time the survey was conducted. Additionally, these participants no longer qualify for the program component as of the end of 2017. It will thus not be possible to survey them. Since no information was available for these participants' intentions, the Evaluator decided to consider the three scenarios equally. Therefore, an average unitary energy savings value was established based on the savings calculated for each scenario. For peak demand savings, the Evaluator also calculated an average unitary savings value based on the three possible scenarios.

The Evaluator used an average heating capacity of 30.751 kBtu/h based on a simple mean of the capacities documented in the tracking sheet for all non-electrically heated households. Similarly, the Evaluator used a weighted average efficient HSPF value of 7.96 based on nominal capacities and HSPF values in the tracking sheet.

The EFLH value of 604 hours previously established in the billing analysis was used to calculate the energy savings of the ASHPs installed in non-electrically heated households. For the minimum heating capacity and the minimum COP, the Evaluator relied on the parameters from the 2015 evaluation used to determine the unitary peak demand savings value of 3.04 kW since such parameters were not tracked in 2017.

Table 42 presents the unitary savings values obtained for each category, as well as the average unitary savings value.

Table 42: Unitary Savings Values Calculations for ASHPs in Non-electrically Heated Households

Scenario in the Absence of Green Heat	Energy Savings Equation	Energy Savings Value (kWh)	Peak Demand Savings Equation	Peak Demand Savings Value (kW)
Would have purchased a heat pump	$HC \times \left[\frac{1}{HSPF_{base}} - \frac{1}{HSPF_{ee}} \right] \times EFLH_h$	283	Unitary savings value from 2015 Evaluation	3.04
Would have switched to electrical resistance heating system	$HC \times 1000 \times 0.101 \frac{kWh}{\frac{Btu}{h}}$	3,106	Unitary savings value from 2015 Evaluation	3.04
Would have kept their non-electrical system	$HC * \left[0 - \frac{1}{HSPF_{ee}} \right] * EFLH_h$	-2,333	$\left(\frac{HC_{min}}{3.412} \right) * \left[0 - \frac{1}{COP_{ee,min}} \right]$	-2.89

Thus, an average unitary energy savings value of 352 kWh and an average unitary peak demand savings value of 1.06 kW were used to calculate savings generated by ASHPs installed in non-electrically heated households.

Ground-source Heat Pumps

GSHPs installed under Green Heat are required to be Canadian GeoExchange Coalition certified.

Tracked Savings

The tracked energy and peak demand savings for GSHP measures installed in 2017 were established using the standardized engineering algorithms defined further below. These algorithms are based on the 2016 Pennsylvania PUC TRM. The algorithms use performance data specific to each installed system (heating and cooling capacity and COP) and several defined variables listed in Table 43 below to calculate energy and peak demand savings. Similar to ASHPs, the baseline EER and HSPF values depend on the participant's existing equipment. For mainly non-electrically heated households under the new path, ENS uses an HSPF Region V value of 7.13 based on the Pennsylvania PUC TRM value for standard air-source heat pumps.⁶⁴ The heating and cooling EFLH of 2,280⁶⁵ and 213 hours per year are based on the values for Northern Minnesota retrieved from the 2017 State of Minnesota TRM⁶⁶ which was obtained through energy modelling.

⁶⁴ Pennsylvania Public Utility Commission (PUC), "Technical Reference Manual", June 2015, Section 2.2 – HVAC.

⁶⁵ This value should have been 2,280 hours as for ASHPs. This is also due to the transcription error in the 2016 Evaluation Report.

⁶⁶ Minnesota Department of Commerce – Division of Energy Resources "State of Minnesota Technical Reference Manual for Energy Conservation Improvement Programs – Version 2" Effective January 1, 2017.

If equipment specifications are not documented, then deemed savings values of 15,531 kWh and 7.29 kW are used.

$$\begin{aligned}
 \text{Energy Savings}_{kWh} &= \text{Heating Savings} + \text{Cooling Savings or Penalty} \\
 &= \left(\frac{HC}{1000} \times \left(\frac{1}{HSPF_{base}} - \frac{1}{COP_{ee} \times DRF \times GSOP} \right) \times FLH_{heat} \right) \\
 &\quad + \left(\frac{CC}{1000} \times \left(\frac{1}{SEER_{base}} \times AC - \frac{1}{EER_{ee} \times DRF \times GSER} \right) \times FLH_{cool} \right) \\
 \\
 \text{Demand Savings}_{kW} &= \left(\frac{HC}{3412 \frac{Btu/hr}{kW}} \times \left(\frac{1}{COP_{base}} - \frac{1}{COP_{ee} \times DRF} \right) \right)
 \end{aligned}$$

Table 43: Definition of the Parameters and their Numerical Values - GSHP

Acronym	Unit	Variable	Value/Source
<i>HC</i>	Btu/h	Heating capacity of installed system	Specification data for each installed system
<i>CC</i>	Btu/h	Cooling capacity of installed system	Specification data for each installed system
<i>HSPF_{base}</i>	Btu/W·h	Heating seasonal performance factor for the baseline equipment	Electrical resistance: 3.412 Functioning ASHP: 7.13 (PUC TRM) Non-electrical system: 7.13 (PUC TRM)
<i>COP_{base}</i>	kW/kW	Coefficient of performance for the baseline equipment	Electrical resistance: 1
<i>COP_{ee}</i>	kW/kW	Coefficient of performance for the new heat pump	Specification data for each installed system
<i>DRF</i>	Unitless	Derating factor from PUC TRM	0.885
<i>GSOP</i>	Btu/W·h	Factor to determine the HSPF of a GSHP based on its COP	3.412
<i>GSER</i>	Unitless	Factor used to determine the SEER of a GSHP based on its EER	1.02
<i>EER_{base}</i>	Btu/W·h	Energy efficiency ratio for existing AC system	PUC TRM ⁶⁷ DHP/ASHP: 14 Central AC: 13 Room AC: 11.3
<i>EER_{ee}</i>	Btu/W·h	Energy efficiency ratio for the new heat pump	Specification data for each installed system
<i>FLH_{heat}</i>	h/year	Full heating load hours	2,280 (Minnesota TRM)
<i>FLH_{cool}</i>	h/year	Full cooling load hours	213 (Minnesota TRM)
<i>AC</i>	Unitless	Cooling penalty modifier	AC in baseline = 1 No AC in baseline = 0

⁶⁷ Pennsylvania Public Utility Commission (PUC), "Technical Reference Manual", June 2015, Section 2.2 – HVAC.

Revised Savings

To update the savings for GSHPs, the Evaluator first conducted a literature review to determine if updated TRMs, metering studies or billing analyses had been published since 2016. The results of the literature review did not reveal any new studies that could be specifically applied to GSHPs. The Evaluator also considered relying on the results of the ASHP billing analysis presented herein since ASHPs and GSHPs might operate similarly, both being centrally ducted heat pumps. However, the EFLH values obtained from the billing analysis demonstrated that ASHPs operate much less than anticipated. The Evaluator believes that these values might not be representative of GSHP operating conditions; one major difference is that GSHPs run at a constant capacity and efficiency independently of outside air temperature. Despite this, the value of 2,280 hours seems too high for two main reasons:

- › This savings value is based on a heating capacity of about 3 tons, which is representative of the GSHPs installed through Green Heat. Using the EFLH value of 2,280 hours which was used to calculate savings, the space heating output of GSHPs is estimated at 24,000 kWh. This is significantly above the average 14,600 kWh⁶⁸ space heating load determined through a billing analysis of 100-percent electrically heated Green Heat households in the 2013 evaluation.
- › The ASHP billing analysis demonstrated that the energy savings of centrally ducted heat pumps are significantly impacted by secondary heating systems (either electrical or non-electrical). Since five of the nine GHSP participants in 2015 to 2017 had a secondary heating system, it would be overly optimistic to consider that all the space heating load is covered by the GSHP.

The Evaluator therefore analyzed the electricity consumption in both the pre-installation and post-installation periods for nine participants who installed a GSHP during 2015 to 2017 with the objective of determining the amount of energy savings for this measure.

The Evaluator calculated the difference in electricity consumption between the pre-installation and post-installation periods. The Evaluator also analyzed the annual electricity consumption prior to GSHP installation.

Electricity savings were obtained for five of the nine participants, while results were not statistically significant for other participants. This could be due to the fact that many participants already had central heat pumps prior to installing a GSHP. Since participants who already have a central system heat pump are eligible only if the existing heat pump has ceased to function and must be fully replaced, it can be assumed that sometime during the pre-installation period the heating system efficiency changed, which could affect the consistency of the electricity consumption regression. The results presented in Table 44 below were therefore analyzed with a focus on the four participants who did not have a central heat pump prior to installing a GSHP (identified in bold).

⁶⁸ Econoler, *Green Heat 2013 DSM Evaluation for Efficiency Nova Scotia Corporation*, February 21, 2014, p. 23.

Table 44: Analysis of Electricity Consumption for Participants who Installed GSHPs

Participant	Existing Heating Systems		Existing Central HP	Average Annual Consumption Before Installation (kWh)	Annual Energy Savings as per Billing Analysis (kWh)
	Primary Heating System	Secondary Heating Source			
1	Forced Hot Air Furnace	None	No	27,728	9,887
2	Electric Baseboards	MSHP	No	14,847	N/A
3	Electric Baseboards	Wood/Pellet Stove	No	14,337	-3,842
4	Electric Baseboards	None	No	N/A	N/A
5	GSHP	Electric Baseboards	Yes	26,140	N/A
6	ASHP	Electric Baseboards	Yes	22,052	N/A
7	Forced Hot Air Furnace	GSHP	Yes	20,669	-3,464
8	GSHP	Wood/Pellet Stove	Yes	16,778	1,171
9	GSHP	Natural Gas	Yes	47,422	4,284

It was not possible to obtain annual energy consumption or savings for one of the fully-electrically heated households because sufficient data was not available. For another participant, the energy savings could not be calculated due to statistically insignificant regressions. Despite this, it should be noted that for two of the participants, the annual energy consumption was lower than the energy savings value of 15,531 kWh used by ENS, which demonstrates that the latter value is too high. For the electrically-heated participant who had the highest annual energy consumption (27,728 kWh), the calculated savings are 9,887 kWh, which is substantial but still significantly below the ENS value of 15,531 kWh. The other participant for whom annual energy savings could be calculated resulted in negative savings of 3,842 kWh; this could be due to lower usage of the existing non-electrical secondary heating system or different occupancy patterns, among other factors.

This analysis seems to confirm that the energy savings currently used for this measure are too high. To avoid overestimating the savings of this measure, the Evaluator suggests using an ELFH value of 1,384 hours, which corresponds to the number of hours a three-ton GSHP would need to operate to meet a heating load of 14,600 kWh.

For peak demand savings, the Evaluator used the same methodology as for tracked savings.

8.1.5 Interactive Effects

Interactive effects occur in a home when the implementation of energy-efficiency measures has an impact on the energy consumption of other elements such as heating and cooling. In the case of Green Heat, the energy efficiency measures implemented are high-efficiency heating measures that do not result in an increase or decrease of the heating or cooling loads needed to maintain the desired indoor comfort conditions. The only exception is HPWHs; interactive effects are already included in the energy simulation for this measure. Therefore, no additional interactive effects factor is applied to the savings.

8.1.6 Effective Useful Life

As part of the 2017 evaluation, the Evaluator reviewed the EUL values used by ENS in the calculations of both energy savings that will last over time.

For Green Heat, the EUL values of all eligible measures were reviewed based on the findings of the literature review. When establishing the EUL for a given measure, the Evaluator considered the most common values found in TRMs, evaluation reports or relevant studies. Sources that based their EUL estimates on measured data or other reliable methods were preferred when possible.

Table 45 presents the tracked and revised EUL values by measure category.

Table 45: Summary of Effective Useful Life Values by Measure Category

Measure	ENS Tracked EUL	Revised EUL	Reference
Wood and Pellet Stoves	18	18	GDS Measure Life Report, Table 1: value for retrofit heating and cooling systems
Wood and Pellet Furnaces and Boilers	18		
Centrally Ducted Heat Pumps	18	18	GDS Measure Life Report, Table 1: value for retrofit heating and cooling systems
Mini-split Heat Pumps	18		
Air-to-water Heat Pumps	18		
Ground-source Heat Pumps	25	25	United States DOE: value for geothermal heat pumps inside components ⁶⁹
Hybrid Heat Pump Water Heater	13	10	DEER 2014 EUL Table: value for heat pump water heaters
Solar Hot Water System	15	20	ENERGY STAR, Save Money and More with ENERGY STAR Qualified Solar Water Heaters ⁷⁰
Solar Air Heating System	10	20	

⁶⁹ United States Department of Energy, Geothermal Heat Pumps | Department of Energy, <http://energy.gov/energysaver/articles/geothermal-heat-pumps> (Last accessed February 28, 2018).

⁷⁰ ENERGY STAR, Save Money and More with ENERGY STAR Qualified Solar Water Heaters, https://www.energystar.gov/products/water_heaters/water_heater_solar/benefits_savings.

A literature review of various TRMs revealed that most jurisdictions refer to the GDS Associates Measure Life Report⁷¹ for estimating the measure life of residential heating measures. This report was published in 2007 and aimed to provide a set of EUL values that could be consistently used across New England States. The EUL values documented in that report were obtained through a literature review and stakeholder consultations.

Since very few TRMs document the specific EUL of biomass measures, the Evaluator continued using the EUL value documented in the GDS report for residential retrofit heating measures. This value is consistent with the value suggested by the ASHRAE⁷² for furnaces (18 years) and the value suggested by the Database for Energy Efficiency Resources (DEER)⁷³ for boilers and furnaces (20 years).

For air-source heat pumps, which include central ducted heat pumps, MSHPs and AWHPs, the literature review revealed that the EUL value is between 15⁷⁴ and 18 years.⁷⁵ Two sources were commonly used by TRMs, namely the DEER (EUL of 15 years) and GDS Report (EUL of 18 years). These EUL values are consistent with other sources such as ASHRAE which documents the measure life of residential air-to-air heat pumps at 15 years, as well as NRCan⁷⁶ which suggests a service life between 15 and 20 years. Since most jurisdictions use 18 years for air-source heat pumps, the Evaluator considered that the value of 18 years already used by ENS was appropriate.

For GSHPs, the literature review revealed that the EUL value is higher than air-source heat pumps because the compressor is protected from weathering and undergoes less mechanical and thermal stress.⁷⁷ The EUL values documented in TRMs range between 18 and 30 years. Some jurisdictions refer to the GDS report for residential heating measures (18 years for retrofit or 25 years for new construction), while others refer to the United States DOE⁷⁸ (EUL of 25 years). NRCan also recommends a range of 20 to 25 years. The Evaluator decided to not change the EUL value at 25 years since this value is in line with the literature review findings.

⁷¹ GDS Associates, Inc., *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*, Report prepared for the New England State Program Working Group, June 2007, Table 1, pp. 1-3, https://energy.mo.gov/docs/default-source/energy_division/measure-life-report-2007.pdf.

⁷² ASHRAE, *ASHRAE Equipment Life Expectancy Chart*, http://www.culluminc.com/wp-content/uploads/2013/02/ASHRAE_Chart_HVAC_Life_Expectancy%201.pdf.

⁷³ Database for Energy Efficiency Resources (DEER), *DEER2014 EUL Table*, 2014, https://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwig3cq25e_UAhUBVz4KHTc-CjsQFggnMAA&url=http%3A%2F%2Fwww.deeresources.com%2Ffiles%2FDEER2013codeUpdate%2Fdownload%2FDEER2014-EUL-table-update_2014-02-05.xlsx&usq=AFQjCNH2stM_7JBIJbqBDBKHnEdml-AvpQ.

⁷⁴ EUL value used in the following consulted TRMs: Pennsylvania, New York, California, Oregon, and Idaho.

⁷⁵ EUL value used in the following consulted TRMs: Maine, Vermont, Massachusetts, Rhode Island, Mid-Atlantic, Illinois, Minnesota, Connecticut, and Wisconsin.

⁷⁶ Natural Resources Canada (NRCan), *Air-Source Heat Pumps*, Updated March 27, 2017, <http://www.nrcan.gc.ca/energy/publications/efficiency/heating-heat-pump/6831>. [Accessed November 9, 2017].

⁷⁷ Natural Resources Canada (NRCan), *Ground-Source Heat Pumps (Earth-Energy Systems)*, Updated March 27, 2017, <http://www.nrcan.gc.ca/energy/publications/efficiency/heating-heat-pump/6833>. [Accessed November 9, 2017].

⁷⁸ United States Department of Energy, <https://energy.gov/energysaver/geothermal-heat-pumps>.

For hybrid HPWHs, most jurisdictions refer to either the DEER (EUL of 10 years for HPWHs) or the DOE (EUL of 13 years for gas-fired, electrical, and oil-fired storage water heaters). Since the DEER documented a value specifically for HPWHs, the Evaluator decided to use an EUL value of 10 years rather than the tracked value of 13 years. Only few jurisdictions document the EUL value of DHW solar systems. Since ENERGY STAR presents an EUL value specifically tailored to DHW solar measures of 20 years, the Evaluator decided to revise the EUL value to 20 years. As for solar air heating systems, the Evaluator assigned an EUL value of 20 years to this measure since very little information was found in the literature with respect to this type of solar heating system. The Evaluator considers that the EUL of solar air heating systems is at least equivalent to that of solar DHW systems because solar air heating has very few mobile mechanical components.

8.1.7 Summary of Savings Values

Table 46 and Table 47 list the tracked and revised savings values for each measure installed under Green Heat.

Table 46: Tracked and Revised Unitary Savings Values for Biomass, Solar and DHW Measures

Measure	Tracked Unitary Energy Savings (kWh)	Revised Unitary Energy Savings (kWh)	Tracked Unitary Peak Demand Savings (kW)	Revised Unitary Peak Demand Savings (kW)
Wood Stove	10,443 ⁷⁹	10,443 ⁸⁰	4.0	4.0
Pellet Stove	8,959 ⁸¹	8,959 ⁸²	4.0	4.0
Wood Furnace and Boiler	13,804	13,804	7.66	7.66
Pellet Furnace and Boiler	13,765	13,765	7.75	7.75
Solar DHW	N/A	N/A	0.0	0.0
HPWH	2,183	2,183	0.354	0.354

⁷⁹ Excluding participating homes with an existing heat pump as the baseline, where the savings are 5,222 kWh.

⁸⁰ Excluding participating homes with an existing heat pump as the baseline, where the savings are 4,973 kWh.

⁸¹ Excluding participating homes with an existing heat pump as the baseline, where the savings are 4,480 kWh.

⁸² Excluding participating homes with an existing heat pump as the baseline, where the savings are 4,226 kWh.

Table 47: Tracked and Revised Unitary Savings Values by Heat Pump Measure Type

Measure	Energy Savings per Capacity (kWh/Btu/h)		Average Unitary Energy Savings (kWh)		Average Unitary Peak Demand Savings (kW)	
	Tracked	Revised	Tracked	Revised	Tracked	Revised
MSHP – Fully Electrically Heated	0.232	0.179	4,139	3,130	2.51	2.47
MSHP – Mainly Electrically Heated	0.232	0.060	4,261	1,080	2.69	2.63
MSHP – Non-electrically Heated	N/A	N/A	1,989	406	0.06	2.50
ASHP and AWHP – Electrically Heated	N/A	0.101	10,722	3,364	2.74	3.04
ASHP and AWHP – Non-electrically Heated	N/A	N/A	885	352	0.0	1.06
GSHP	N/A	N/A	17,196	11,544	7.79	8.70

8.1.8 Revised Gross Savings

Table 48 below outlines the revised total gross savings at the generator, which were calculated using a residential line loss factor of 1.099 between the meter and the generator. This value comes from a weighted average of the line loss factors of Green Heat participants according to their rate code (the residential rate code corresponds to a line loss factor of 10.0%, the municipal rate code 4.6%, and the commercial rate code 9.5%).

Overall, the total gross energy and peak demand savings at the generator are estimated at 5.026 GWh and 5.114 MW respectively.

Table 48: Revised Gross Energy and Peak Demand Savings for Green Heat

Measure Category	Wood Stove	Pellet Stove	Wood Furnace/ Boiler	Pellet Furnace/ Boiler	Solar DHW	HPWH
Energy Savings						
Number of Units	50	20	2	0	14	3
Tracked Energy Savings (GWh)	0.484	0.171	0.028	0.000	0.036	0.007
Adjustment Ratio for Energy Savings	N/A	N/A	N/A	N/A	1.000	N/A
Revised Unitary Energy Savings (kWh)	10,443	8,959	13,804	13,765	N/A	2,183
Gross Energy Savings – at the Meter (GWh)	0.511	0.170	0.028	0.000	0.036	0.007
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099
Gross Energy Savings – at the Generator (GWh)	0.562	0.187	0.030	0.000	0.040	0.007
Effective Useful Life (years)	18	18	18	18	20	10
Gross Lifetime Energy Savings – at the Generator (GWh)	10.113	3.359	0.546	0.000	0.793	0.072
Peak Demand Savings						
Tracked Peak Demand Savings (MW)	0.200	0.080	0.015	0.000	0	0.001
Adjustment Ratio for Peak Demand Savings	N/A	N/A	N/A	N/A	1	N/A
Revised Unitary Peak Demand Savings (kW)	4.00	4.00	7.66	7.75	0	0.354
Gross Peak Demand Savings – at the Meter (MW)	0.200	0.080	0.015	0.000	0	0.001
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099
Gross Peak Demand Savings – at the Generator (MW)	0.220	0.088	0.017	0.000	0	0.001

Revised Gross Energy and Peak Demand Savings for Green Heat (Continued)

Measure Category	MSHP – Fully Electrical	MSHP – Mainly Electrical	MSHP – Non-electrical	ASHP and AWHP – Electrical	ASHP and AWHP – Non-electrical	GSHP	Total
Energy Savings							
Number of Units	947	341	303	82	61	6	1,829
Tracked Energy Savings (GWh)	3.919	1.453	0.603	0.879	0.054	0.103	7.737
Adjustment Ratio for Energy Savings	0.756	0.253	0.205	0.314	N/A	0.671	-
Revised Unitary Energy Savings (kWh)	N/A	N/A	N/A	N/A	352	N/A	-
Gross Energy Savings – at the Meter (GWh)	2.964	0.368	0.124	0.276	0.021	0.069	4.573
Line Loss Factor	1.100	1.100	1.100	1.100	1.100	1.100	-
Gross Energy Savings – at the Generator (GWh)	3.257	0.405	0.136	0.303	0.024	0.076	5.026
Effective Useful Life (years)	18	18	18	18	18	25	-
Gross Lifetime Energy Savings – at the Generator (GWh)	58.632	7.282	2.445	5.457	0.425	1.903	91.027
Peak Demand Savings							
Tracked Peak Demand Savings (MW)	2.380	0.916	0.019	0.225	0.000	0.047	3.883
Adjustment Ratio for Peak Demand Savings	0.982	0.978	40.890	N/A	N/A	1.117	-
Revised Unitary Peak Demand Savings (kW)	N/A	N/A	N/A	3.04	1.06	N/A	-
Gross Peak Demand Savings – at the Meter (MW)	2.338	0.896	0.757	0.249	0.065	0.052	4.653
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099	-
Gross Peak Demand Savings – at the Generator (MW)	2.570	0.984	0.832	0.274	0.071	0.057	5.114

8.2 Net-to-gross Ratio

The NTGR serves to determine net savings, i.e. the savings that can be reliably attributed to a program component. More precisely, the NTGR includes effects, such as free-ridership and spillover, that positively or negatively affect the energy savings generated by a program component. In the case of Green Heat, only one effect is considered, namely free-ridership.

8.2.1 Free-ridership

For Green Heat, free-ridership occurs when participants would still have installed the heating system in the absence of the program component. The free-ridership level was assessed using a self-reporting approach which involved asking sampled participants to respond to a set of questions during a telephone survey. Four different sets of questions were asked depending on the type of measures installed and path: (1) fuel-switching measure, i.e. biomass or solar heating system; (2) central heat pump measure; (3) an MSHP measure under the old path; and (4) an MSHP measure under the new path. The questionnaire considers all the applicable variables of the decision-making process, including planning, efficiency, timing and cost.

The feedback collected from this participant survey was converted into an overall free-ridership level using algorithms presented in Appendix XIV.

Fuel-switching Measure

For biomass or solar heating systems, the questionnaire assessed the likelihood of participants replacing their electrical system with a non-electrical system in the absence of the program component. Additional questions were used to determine whether participant decisions to install the measures had been influenced by previous participation in one of ENS's energy efficiency program components or ENS efforts to raise awareness about energy efficiency.

Using this approach, the free-ridership level was established at 36 percent for biomass and solar measures, which is the same as 2016's results (36%).

Central Heat Pump Measure

For centrally ducted heat pump measures, the questionnaire assessed the likelihood of participants, in the absence of Green Heat, replacing their electrical heating system with a central heat pump of the same efficiency level as the unit installed under the program component. Additional questions were used to determine whether participant decisions to install the measures had been influenced by previous participation in one of ENS's energy efficiency program components or ENS efforts to raise awareness about energy efficiency.

Using this approach, the free-ridership level was established at 44 percent for central heat pumps, which is similar to 2016's results (43%).

MSHP Measure

For MSHPs, which are by far the most popular Green Heat measures, the Evaluator assessed free-ridership separately for old and new path participants. The Evaluator significantly changed last year's questionnaire to assess free-ridership using two factors: (1) a first series of questions regarding the participant decision to install a heat pump instead of installing another type of heating system or simply keeping the existing system (type-of-system factor); and (2) a second series of questions regarding the participant decision to install a high-efficiency heat pump rather than a regular heat pump (high-efficiency factor).

Participants who installed MSHPs were also asked questions to determine whether their decisions to install the measures had been influenced by previous participation in one of ENS's energy efficiency program components or ENS efforts to awareness about energy efficiency.

For the new path, the survey included questions specific to the decision-making process of participants who had an existing non-electrical heating system. As mentioned in the Savings Review section, non-electrically heated households indicated that they had the intention of purchasing a heat pump in the absence of the program component. Consequently, their gross savings are based on the difference between a standard and a high-efficiency heat pump. Thus, the free-ridership level for these participants is calculated for the high-efficiency factor only. Using this approach, free-ridership for non-electrically heated households under the new path was established at 33 percent, the lowest of all Green Heat measures. This was expected since this free-ridership level only reflects the probability of purchasing a high-efficiency heat pump in the absence of the program component.

Free-ridership for electrically heated households under the new path was established at 51 percent. The Evaluator believes that this high free-ridership level is a result of the participation process since new path participants may submit their rebate application up to 90 days after purchasing an MSHP. This increases the probability of people participating who have not been influenced by the program component. The limited paperwork also makes participation more attractive for people who would not have bothered to fill out the pre-approval form in the previous version of the program component. Free-ridership for electrically heated households under the old path was established at 35 percent, compared to 39 percent in 2016. The small decrease, although not statistically significant, is most likely explained by the changes made to the free-ridership algorithm used in 2016.

Table 49 summarizes the average free-ridership level by measure category.

Table 49: Average Free-ridership Level by Measure Category

Measure Category	Average Free-ridership Level	Sample Size	Population Size	Margin of Error
Biomass and Solar Measures	36%	16	86	4.9%
Central Heat Pumps	44%	24	149	5.1%
MSHPs		101	1,591	
Old Path	35%	51	742	7.7%
New Path Electrically Heated	51%	29	546	10.6%
New Path Non-electrically Heated	33%	21	303	10.9%

Because no HPWHs were included in the survey sample and this product does not fall under any of the previously mentioned categories, the Evaluator applied a nil free-ridership level to the three HPWH measures installed in 2017, considering their high costs and the fact that the technology was only recently introduced.

For MSHPs, the Evaluator used the survey results for new path and old path participants to determine the average free-ridership levels for the three different categories of participants: mainly electrically heated; fully electrically heated; and non-electrically heated. Calculations are presented in Table 50.

Table 50: Average Free-ridership Level by MSHP Category

MSHP Category	Proportion Old Path	Proportion New Path	FR Old Path	FR New Path	Average Free-ridership Level
Fully electrically heated	54%	46%	35%	51%	42%
Mainly electrically heated	67%	33%	35%	51%	40%
Non-electrically heated	0%	100%	-	33%	33%

8.2.2 NTGR Calculation

The NTGR was calculated using the following equation:

$$NTGR = (1 - \% \text{ free-ridership})$$

Using the free-ridership levels established for each measure type, the NTGR value was established at 0.58 for MSHPs in fully electrically heated households, 0.60 for MSHPs in mainly electrically heated households, 0.67 for MSHPs in non-electrically heated households, 0.56 for central heat pumps, 0.64 for biomass and solar measures, and 1.00 for HPWHs.

8.3 Net Savings

Net savings are defined as the energy use reductions specifically attributable to Green Heat. Net savings were estimated by applying the NTGR listed above to the evaluated gross savings, using the following equation:

$$\text{Net Savings} = \text{Gross Evaluation Savings} \times \text{NTGR}$$

The total net energy savings were established at 2.980 GWh at the generator, while the total net peak demand savings were established at 3.073 MW at the generator. Using the Nova Scotia-specific factor for GHG emissions generated by electricity production, 0.6531 kg CO₂ eq/kWh, the net energy savings resulted in an estimated 1,946 tonnes of avoided CO₂ eq annually. Based on the average EUL of 18.10 years, the net lifetime energy savings were established at 53.925 GWh.

The detailed results are summarized in Table 51.

Table 51: Evaluated Net Energy and Peak Demand Savings for Green Heat

Measure Category	Wood Stove	Pellet Stove	Wood Furnace/ Boiler	Pellet Furnace/ Boiler	Solar DHW	HPWH
Energy Savings						
Revised Gross Energy Savings – at the Meter (GWh)	0.511	0.170	0.028	0.000	0.036	0.007
NTGR	0.64	0.64	0.64	0.64	0.64	1.00
Net Energy Savings – at the Meter (GWh)	0.327	0.109	0.018	0.000	0.023	0.007
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099
Net Energy Savings – at the Generator (GWh)	0.360	0.119	0.019	0.000	0.025	0.007
Effective Useful Life (years)	18	18	18	18	20	10
Net Lifetime Energy Savings – at the Generator (GWh)	6.472	2.150	0.350	0.000	0.508	0.072
Peak Demand Savings						
Revised Gross Peak Demand Savings – at the Meter (MW)	0.200	0.080	0.015	0.000	0.000	0.001
NTGR	0.64	0.64	0.64	0.64	0.64	1.00
Net Peak Demand Savings – at the Meter (MW)	0.128	0.051	0.010	0.000	0.000	0.001
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099
Net Peak Demand Savings – at the Generator (MW)	0.141	0.056	0.011	0.000	0.000	0.001

Evaluated Net Energy and Peak Demand Savings (Continued)

Measure Category	MSHP – Fully Electrical	MSHP – Mainly Electrical	MSHP – Non-electrical	ASHP and AWHP – Electrical	ASHP and AWHP – Non-electrical	GSHP	Total
Energy Savings							
Revised Gross Energy Savings – at the Meter (GWh)	2.964	0.368	0.124	0.276	0.021	0.069	4.573
NTGR	0.58	0.60	0.67	0.56	0.56	0.56	-
Net Energy Savings – at the Meter (GWh)	1.719	0.221	0.083	0.154	0.012	0.039	2.711
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099	-
Net Energy Savings – at the Generator (GWh)	1.889	0.243	0.091	0.170	0.013	0.043	2.980
Effective Useful Life (years)	18	18	18	18	18	25	-
Net Lifetime Energy Savings – at the Generator (GWh)	34.006	4.369	1.638	3.056	0.238	1.066	53.925
Peak Demand Savings							
Revised Gross Peak Demand Savings – at the Meter (MW)	2.338	0.896	0.757	0.249	0.065	0.052	4.653
NTGR	0.58	0.60	0.67	0.56	0.56	0.56	-
Net Peak Demand Savings – at the Meter (MW)	1.356	0.537	0.507	0.140	0.036	0.029	2.796
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099	-
Net Peak Demand Savings – at the Generator (MW)	1.491	0.591	0.557	0.153	0.040	0.032	3.073

Table 52 compares the energy and peak demand savings established through this evaluation to those calculated in the tracking sheet.

Table 52: Comparison of Tracked and Evaluated Savings at the Generator

	Initial Gross Savings	Adjusted Gross Savings	NTGR	Net Savings
Energy Savings				
ENS Tracked Savings	8.510 GWh	8.510 GWh	0.61	5.170 GWh
Evaluation Results	8.510 GWh	5.026 GWh	0.59	2.980 GWh
Peak Demand Savings				
ENS Tracked Savings	4.271 MW	4.271 MW	0.61	2.604 MW
Evaluation Results	4.271 MW	5.114 MW	0.60	3.073 MW

The evaluated gross energy savings are 41 percent below the tracked gross energy savings. This is mainly due to the decrease in the unitary savings for MSHPs and ASHPs. The evaluated net energy savings are 42 percent below the tracked value. This difference is due to the slight decrease in the NTGR resulting from the higher free-ridership level mainly for new path participants with electric heating who installed MSHPs.

The evaluated net peak demand savings are 18 percent higher than those tracked by ENS. This difference mainly results from the adjustment made for participants who installed an MSHP or an ASHP in non-electrically heated households, for which ENS had tracked nil peak demand savings.

9 GREEN HEAT MARKET EVOLUTION

As part of the 2016 Evaluation, Econoler conducted interviews with contractors of biomass measures and heat pumps who reported that the market for MSHPs had changed significantly in the last few years. The 2016 Evaluation for Green Heat therefore recommended that ENS gather information to better understand how the market for MSHPs is evolving and to what extent the market has transformed in order to adapt the program component offerings (eligible products and rebate amounts) to this ever-changing environment. The aim of the following subsection is to determine appropriate market indicators and examine how the MSHP market is evolving, particularly in the context of recent changes to the Green Heat MSHP offering.

It should be noted that while this section provides insights on the evolution of the market for MSHPs, the Evaluator was unable to provide an indication of MSHP market adoption on the theoretical curve of technology diffusion as further data is required to fully assess the transformation of the MSHP market in Nova Scotia.⁸³

9.1 Background

Until 2012, ENS provided rebates for ductless MSHPs through EnerGuide for Existing Houses (former HEA program component). However, in April 2012, ENS incentives on heating and cooling equipment systems, except for ductless MSHPs, were transferred into a new program component called Fuel Substitution, and MSHPs were no longer eligible for incentives. ENS continued to recommend the implementation of MSHPs through some of its residential programs, although without the rebate.

In October 2015, Green Heat, the successor to Fuel Substitution, was expanded to include ductless MSHPs and hybrid water heaters. The addition of MSHPs to Green Heat boosted participation considerably and MSHPs constituted 87 percent of all Green Heat installations as of 2017.

In the last year, Green Heat has undergone a series of changes. Starting in August 2017, Green Heat was relaunched as a mail-in rebate program, thereby eliminating the pre-approval process. This modification also included new eligibility criteria for cold-climate MSHPs and a change in the incentive structure for four of the five heat pumps incented by the program, including MSHPs. Additionally, MSHPs are now offered to both electrically and non-electrically heated homes, whereas only electrically heated homes qualified for this incentive prior to August 2017.

⁸³ Everett M. Rogers, *Diffusion of Innovations – Fifth Edition*, August 16, 2003

9.2 Market Indicators

The Evaluator analyzed available market data to understand the state of the MSHP market in Nova Scotia, looking at the market share of heat pumps as a primary heating source, the number of MSHPs incented by Green Heat, the sales of efficient MSHPs compared to non-efficient products among participating contractors, and efficient MSHP prices.

9.2.1 Market Share of Heat Pumps

As presented in Table 53, the market share of heat pumps has grown considerably since 2013. In 2015, 11 percent of Nova Scotia homes had heat pumps as their primary heating source, up from 6 percent in 2013. Electric baseboard heaters constituted 28 percent of the market in 2015, down slightly from 2013. Note that while MSHPs are often used as secondary systems, data for secondary systems was not available.

Table 53: Share of Primary Heating Systems in Nova Scotia

	2013	2015
Forced Air Furnaces	31%	24%
Electric Baseboard Heaters	29%	28%
Heating Stoves	7%	6%
Boilers with Hot Water or Steam Radiators	23%	24%
Electric Radiant Heating	3%	2%
Heat Pumps	6%	11%
Other	N/A	6%

Source: Statistics Canada. Table 153-0145 - Households and the environment survey, primary heating system, Canada, provinces and census metropolitan areas (CMA), every 2 years (percent), CANSIM. (Accessed: January 8, 2018)

9.2.2 Green Heat MSHPs

Green Heat incentes participants to purchase an eligible high-efficiency MSHP. As discussed above, the program component rules were changed in August 2017 such that only a subset of high-efficiency MSHPs would be eligible, specifically single zone systems with a HSPF greater than 9.565 in Region V and multi-zone systems with an HSPF greater than 8.696 (i.e. new path).⁸⁴ By narrowing eligibility criteria, the program component targets a subset of high-efficiency MSHPs that provide the greatest savings.

⁸⁴ Systems with an HSPF below 9.565 may still be admitted to the program if equipped with a drain pan heater.

Table 54 provides the number of Green Heat incented systems since 2015. In 2017, participants with non-electrically heated homes became eligible for the program component. The number of incented systems for electrically heated homes in 2017 increased by 33 percent above 2016 levels. The remainder of the growth in incented systems in 2017 came from participants with non-electrically heated homes.

Table 54: Green Heat Incented High-efficiency MSHP Systems

	2015*		2016		2017	
	Electrical	Non-electrical	Electrical	Non-electrical	Electrical	Non-electrical
Number of MSHP systems**	111	0	861	0	1,286	306
Average HSPF of units	10.86		10.48		10.27	

*In 2015, MSHPs were only offered in the last three months of the year.

** MSHP systems include all indoor and outdoor units per participant (i.e. the number of participants equals the number of systems).

The efficiency of the MSHP units has not increased significantly since 2015, with the average HSPF decreasing from 10.86 in 2015 to 10.27 in 2017. The maximum efficiency MSHP sold through Green Heat in 2017 was an HSPF of 13.04, whereas in 2015 and 2016 the maximum efficiency was an HSPF of 12.34. The top tenth percentile of efficiency remained an HSPF of 12.174 from 2015-2017. Therefore, while the maximum efficiency of units incented through Green Heat has increased somewhat over time (from 12.34 to 13.04), there is very little change in the overall efficiency of the incented units over the period.

9.2.3 Market Share of High-efficiency MSHPs

The Evaluator interviewed contractors who sell and install HVAC products in Nova Scotia to gain a deeper understanding of their high-efficiency and standard MSHPs sales. To identify respondents, ENS provided the Evaluator with a list of Green Heat projects conducted in the first half of 2017. From that list, the Evaluator identified 110 contractors and conducted interviews with 20 HVAC contractors, of which 18 sold and installed MSHPs. Combined, these 18 contractors sold a total of 232 incented MSHPs in 2017.⁸⁵

Of the 18 contractors interviewed, eight sell only high-efficiency MSHPs, while 10 sell both standard and high-efficiency MSHPs. To obtain an overview of the market share of high-efficiency MSHPs in Nova Scotia, the contractors were asked the proportion of MSHPs sold in the first part of 2017 that qualified for Green Heat. It should be noted that these interviews began prior to the changes dated August 2017 in MSHP eligibility criteria, which impacts results. Overall, contractors reported that about 90 percent of their sales would have qualified for Green Heat. However, because of the changes in MSHP eligibility criteria, this proportion has likely been overestimated. In addition, since these contractors all participated in Green Heat, their answers may not be representative of the broader market. The majority of

⁸⁵ Source: 2017 ENS Green Heat Tracking Sheet

contractors selling non-efficient heat pumps report that cost is the primary reason that participants opt for a non-efficient heat pump.

As seen in Subsection 3.5, a third of the contractors think that the incentives offered through Green Heat had a positive influence on their MSHP offerings and almost half noted that Green Heat has helped their businesses.

Of the 18 contractors interviewed, seven reported that their MSHP sales have increased from two years ago when there was no rebate on MSHPs, four reported sales decreasing and five reported no change in sales (2 did not respond or did not know). Of those that reported sales staying the same or decreasing, market saturation and an increase in the number of contractors selling or installing MSHPs were cited as reasons.

9.2.4 MSHP Prices

Table 55 provides the average cost of incented units (not including incentive) and average incentive across cooling capacities. On average, the price of MSHPs has increased for cooling capacities of 12,000 Btu/hr and lower, while the price decreased slightly for units with cooling capacities above 12,100 Btu/hr. Average incentives have decreased across the range of units, reflecting changes to incentive levels made in 2017.

Table 55: Average Costs and Incentives of Program Component Units

Cooling Capacity (Btu/hr)	2016		2017	
	Average Cost	Average Incentive	Average Cost	Average Incentive
12,000 and below	\$4,462	\$335	\$5,028	\$256
12,100-24,000	\$6,510	\$428	\$6,335	\$351
Above 24,000	\$10,216	\$596	\$9,095	\$517

9.2.5 Codes and Standards

The ultimate indicator of market transformation is the adoption of more stringent codes and standards. The latest version of the building code for small residential buildings,⁸⁶ in effect since 2014, does not require heating systems to be more efficient than electric resistance heating. Also, heat pumps are not expected to become a requirement of the building code in Nova Scotia the near future. A minor increase to minimum heat pump energy efficiency levels was instituted as a result of Amendment 13 to the Energy Efficiency Regulations of Canada. Since this regulation now requires heat pumps to have an HSPF of 7.1 or greater in Region V, this had little impact on the market of high-efficiency heat pumps such as those rebated through Green Heat. No update to minimal energy performance standards for heat pumps are planned in upcoming Amendments 14 and 15 scheduled for pre-publication in early 2018 and the fall of 2018 respectively. The next regulatory update related to heat pumps is expected to be included in Amendment 16, which is planned for pre-publication in fall of 2019 and should therefore not be in effect until at least 2021.

9.2.6 Measured Free-ridership

No free-ridership was calculated specifically for MSHPs in 2015 since this product was incented only for the last three months of that year. Free-ridership was established at 39 percent for MSHPs in the 2016 Evaluation. In 2017, the free-ridership for the old path was slightly lower at 35 percent. The free-ridership for the new path (i.e. as of August 2017) was established at 33 percent for non-electrically heated homes and 51 percent for electrically heated homes.

As discussed in Subsection 8.2.1, the Evaluator believes that the higher free-ridership level for electrically heated homes in the new path is the result of the new participation process established in August 2017 and not an indication that the market has changed compared to the beginning of the year.

The Evaluator does not interpret the relatively high free-ridership rate for the MSHP component of Green Heat as an indicator that the market is approaching transformation. The free-ridership rate reflects that a large portion of participants would have bought a heat pump in the absence of Green Heat, but not necessarily a high efficiency unit. This free-ridership rate also does not provide any information about the remaining potential participants who have not yet been convinced of purchasing a heat pump through Green Heat.

9.3 Market Evolution Summary

In their recommendations on market transformation program planning, Rosenberg and Hoefgen (2009) identify a number of factors, presented in Table 56 below, to be analyzed to identify whether program component support should be withdrawn or reduced in light of changes observed in the market.⁸⁷

⁸⁶ Province of Nova Scotia, *Nova Scotia Building Code Regulation*, December 31, 2014.

⁸⁷ Rosenberg M. and Hoefgen L., 2009. Market Effects and Market Transformation: Their Role in Energy Efficiency Program Design and Evaluation. Prepared for California Institute of Energy and the Environment.

Table 56: Analysis of Key Factors in Program Component Planning

Factor	Results
Market share of heat pumps and efficient MSHPs	Heat pumps were the primary heating source in 11% of Nova Scotia homes in 2015, up from 6% in 2013. Data on secondary sources were unavailable. Participating contractors reported that efficient MSHPs (i.e. Green Heat qualified) made up about 90% of their 2017 MSHP sales prior to changes in eligibility requirements established in August 2017. Given eligibility changes, this share may decrease.
Recent trends in prices and availability	High-efficiency MSHPs are accessible to consumers. Of the 18 contractors interviewed, 8 sell only high-efficiency MSHPs, while the remainder sell both standard and high-efficiency MSHPs. The average price of high-efficiency MSHPs sold through Green Heat has increased slightly for MSHPs with a cooling capacity below 12,000 Btu/hr and decreased slightly for MSHPs with a cooling capacity above 12,000 Btu/hr. Contractors selling non-efficient heat pumps report that cost is the primary reason that participants opt for a non-efficient heat pump. New entrants continue to enter the MSHP market. Some contractors reported new entrants on the market as a reason for a decrease in their sales.
Likelihood of inclusion in a near-term code or standard	Electric resistance heating remains the minimal efficiency level as per building codes for small residential buildings. There are no major updates to requirements for heat pumps in the latest federal energy efficiency regulations and no known plans to make heat pumps mandatory.
Market readiness of more efficient substitute technology	Not applicable

The market for MSHPs continues to evolve. While high-efficiency MSHPs were reported as 90 percent of sales by interviewed contractors, this share is expected to shift downward with the new eligibility criteria established in August 2017 to push participants to buy even higher-efficiency MSHPs. In addition, since these contractors all participated in the Green Heat program, this result may not be representative of the broader market.

While the market indicators above provide some insight on the evolution of the market for MSHPs, a number of key data points either rely on information from participating contractors or were unavailable. The Evaluator was unable to provide an indication of MSHP market adoption on the theoretical curve of technology diffusion as further data is required to fully assess the transformation of the market for MSHPs in Nova Scotia.

10 EPI OVERVIEW

The following sections present the EPI evaluation results.

This section describes the EPI program component, follows up on the 2016 evaluation recommendations and gives an overview of its participation history.

10.1 Description

In January 2017, the former Rental Properties & Condos (RP&C) and Residential Direct Install (RDI) program components were merged together to form the EPI program component.

EPI provides participants with direct installation of energy-efficient products free of charge. ENS has contracted DAs to provide this service across the entire province. EPI is available to all residents of Nova Scotia with a priority given to low-income households. EPI encourages participants to also consider other ENS residential program components. EPI is available to both homeowners and renters.

The types of products installed through EPI in 2017 were the following:

- › LED lamps, including A-type, reflector and chandelier lamps
- › LED nightlights
- › Faucet aerators (for electrical DHW systems or non-electrical low-income households)
- › Low-flow showerheads (for electrical DHW systems or non-electrical low-income households)
- › Pipe insulation (for electrical DHW systems or non-electrical low-income households)
- › Hot water tank wraps (for electrical DHW systems)
- › Smart power controllers for audiovisual equipment
- › Nest thermostats (for non-electrically heated low-income households)
- › LED holiday lights (offered in exchange for incandescent holiday lights, during the months of November and December only)

EPI's funding comes from two sources: (1) the funding from electricity ratepayers is used for upgrades that reduce electricity consumption; and (2) the funding from the Province of Nova Scotia is used for upgrades that reduce the use of other fuels, but is only offered to low-income participants. This report only presents the evaluation results regarding the electricity ratepayer portion of EPI.

EPI aimed to achieve 24.4 GWh in net electricity savings and 3.6 MW in net peak demand savings at the generator for 2017.

10.2 Follow-up on 2016 Evaluation Report Recommendations

The RP&C and RDI program components were evaluated individually in 2016 and recommendations were made by the Evaluator for their improvement. Table 57 below provides a brief summary of the implementation status of each recommendation presented in the executive summary section of the 2016 evaluation report.

Table 57: Implementation Status of Recommendations in 2016 Executive Summary

2016 Recommendations	Status
2016 RP&C-R1. Start measuring spillover in 2017.	Implemented
2016 RDI-R1. Limit the number of smart power controllers installed to two per household.	Implemented
2016 RDI-R2. Conduct more on-site visits with participants who received smart power controllers.	Implemented

In 2016, the Evaluator assessed spillover for the RDI program component. Since the RP&C and RDI program components were merged to create EPI, the Evaluator has continued to measure spillover for EPI; thus, Recommendation 2016 RP&C-R1 has been implemented. EPI's level of spillover in 2017 is discussed in the Impact Evaluation Section.

To implement Recommendation 2016 RDI-R1, ENS made efforts in 2017 to determine the appropriate number of smart power controllers that should be installed in each household. Although the 2017 EPI tracking sheet indicates that 7 percent of the participants had more than two smart power controllers installed in their home (in comparison to 6 percent in 2016), ENS decided to limit the number of smart power controllers installed in each household to two, starting from January 15, 2018.

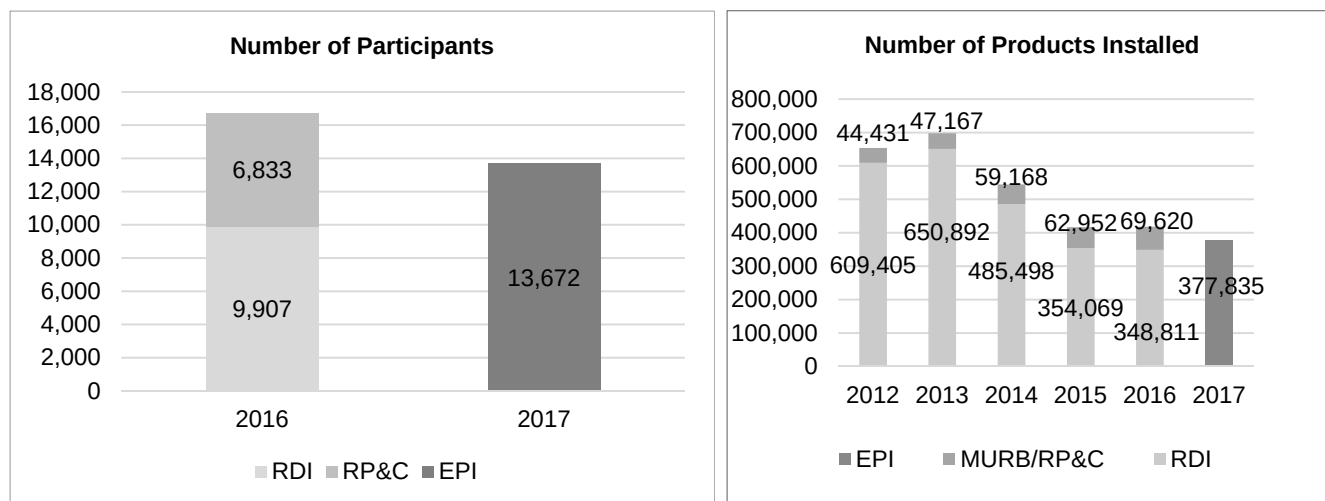
In 2017, to implement Recommendation 2016 RDI-R2 and get enough data needed for establishing an installation rate within an acceptable margin of error, the Evaluator conducted a higher number of on-site evaluation visits with participants who had received smart power controllers. The Evaluator contributed to this effort by increasing the number of on-site visits in homes with smart power controllers to 76 and thus succeeded in establishing an installation rate with an acceptable margin of error of 10.6 percent.

10.3 Participation History

As presented in Figure 17, there were a total of 13,672 EPI participants⁸⁸ in 2017, representing a level of participation 18 percent lower than that of RDI and RP&C combined in 2016. A total of 377,875 efficient products were installed in 2017, which was 10 percent less than in 2016.

⁸⁸ The number of EPI participants refers to the number of participants generating electrical savings and this number has been established based on the number of unique participant reference numbers.

Figure 17: Summary of Participation in RDI⁸⁹ and RP&C⁹⁰ and in EPI



Although a smaller number of households participated in EPI in 2017, the number of products installed per participant was higher (with a mean of 27.6 products in 2017, compared to a mean of 25 products in 2016). The higher number of installed products per participant is explained in part by a higher proportion of participants living in single-family homes, which typically have more installation opportunities due to the bigger size of their dwellings compared to apartments.

The Evaluator has noticed that the number of A-type lamp replacements in single-family homes decreased significantly in 2017, from 28 lamps with RDI in 2016 to 21 lamps with EPI in 2017. The Evaluator believes that this was largely due to the decreasing number of lighting sockets occupied by incandescent lamps⁹¹, since participants likely purchased other lighting technologies to replace their burned-out lamps. This finding is especially important, since A-type lamp replacements account for 62 percent of EPI's gross savings.

The participation levels have declined since RDI and RP&C were launched, mainly due to the decreasing pool of potential participants each year. However, the program component has contributed significantly to the growth of energy-efficient lighting products' penetration in Nova Scotia's market by providing direct installation of such products for over 100,000 participants since 2012.

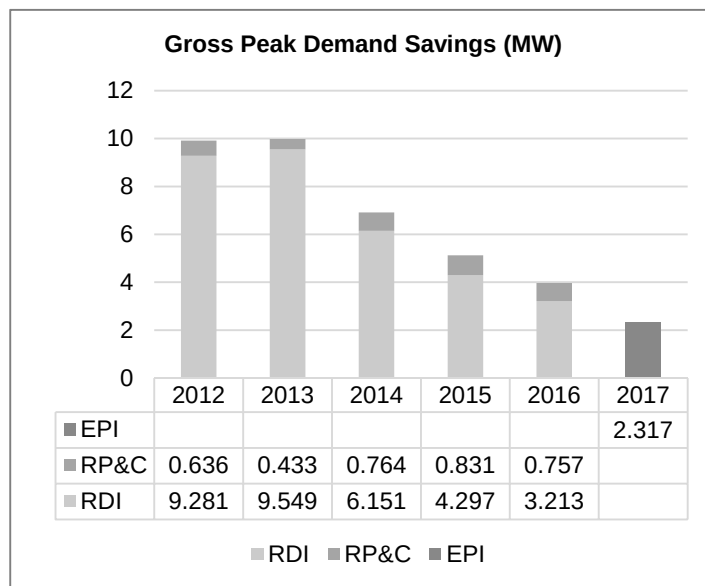
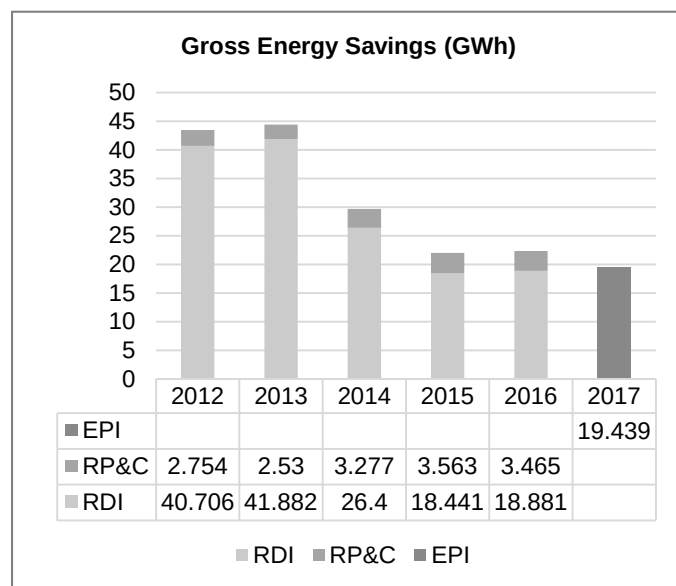
⁸⁹ The number of participants in RDI 2016 was revised to 9,907 to correct a transcription error made in the RDI 2016 evaluation report.

⁹⁰ The Multi-Unit Residential Building (MURB) program component became the RP&C program component in 2014.

⁹¹ EPI's guidelines require that all installed lighting products replace existing incandescent lamps.

As illustrated in Figure 18, EPI achieved 19.439 GWh gross energy savings in 2017, with the per-participant gross energy savings at 1.421 MWh. Gross energy savings generated in 2017 were slightly lower than those generated by RDI and RP&C combined in 2015 and 2016. As for gross peak demand savings, EPI achieved 2.317 MW in 2017, which was significantly less than the previous years. This decrease was mainly due to the refinement of the methodology used to establish peak demand savings.

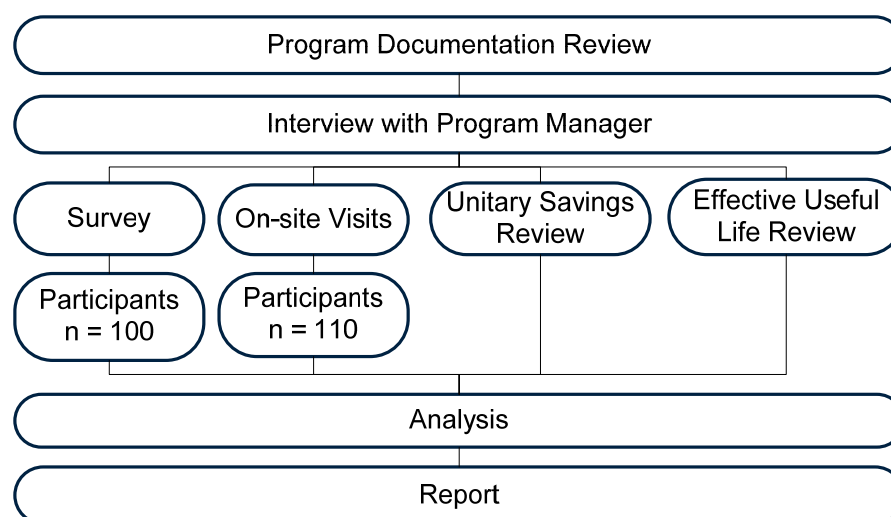
Figure 18: Summary of Gross Savings in RDI and RP&C and EPI



11 EPI EVALUATION METHODOLOGY

This section describes the methodology used and the activities carried out for the EPI 2017 evaluation. Figure 19 below shows the various data collection activities carried out for the evaluation.

Figure 19: Methodological Model



The Evaluator first reviewed the program component documentation and then held a meeting with the program manager in August 2017 to verify the implementation status of the previous evaluation recommendations and understand the program component changes made in 2017. Based on the information obtained from this interview, a list of questions and topics to be included in the data collection instruments were prepared.

Once the meeting with the program manager and the program component documentation review were completed, specific evaluation activities were undertaken, as described in the following subsections.

For evaluation activities that yield quantitative results based on a sample, the Evaluator aimed to achieve a maximum margin of error of 10 percent, at a confidence level of 90 percent. This means that if measurement was conducted many times with different samples, the data would be within 10 percentage points above or below the percentage reported 90 percent of the time. Thus, the margin of error indicates the relative level of precision⁹² of the measurement, while its associated confidence level indicates the probability of a measure falling within this margin of error.⁹³

⁹² Precision refers to how reproducible a set of measurements is. It does not take into account, however, how close the measured values are to the true values, as this would refer to accuracy.

⁹³ As part of this evaluation, the confidence level and the margin of error only take random sampling errors into account; they do not reflect non-sampling errors or biases such as data entry errors, inaccurate responses from respondents or the inability to contact certain people.

As part of this evaluation, the Evaluator calculated the margin of error for survey samples, free-ridership levels and installation rates. The margins of error are presented alongside the results in the applicable sections. Examples of calculations used to establish margins of error can be found in Appendix II of the 2017 DSM Programs Evaluation Executive Summary.

Participant Survey

In October 2017, CRA conducted a telephone survey with a total of 100 non-low-income participants, who were 63 owners and 37 tenants.⁹⁴ The average length of the survey was 18 minutes. The interviews were conducted using computer-assisted telephone interviewing technology. The questionnaire and the complete survey results are presented in Appendix XVI and Appendix XVII. All the appendices are presented in the Existing Residential Program – Appendices.

The participant survey was meant to collect feedback about the following aspects of EPI.

- › Installation of smart power controller(s) and satisfaction with the device(s)
- › Reasons for participation
- › Behavioural changes following participation in EPI
- › Satisfaction with EPI
- › Barriers to the installation of products
- › Recommendations for improvements
- › Free-ridership (including the cross-influence from ENS promotion and other program components)
- › Spillover
- › Demographics

The total number of EPI non-low-income participants was 7,625 for 2017. Drawing a random sample of 100 from a population of 7,625 yields a margin of error of 8.2 percent at a 90 percent confidence level.

On-site Visits

From August to November 2017, on-site visits were carried out by Equilibrium Engineering at the homes of EPI participants.

A total of 110 EPI participating households were visited. These on-site visits were conducted to validate the number of installed energy-efficient products recorded in the EPI tracking sheet and to determine the installation rates. During the on-site visits, useful technical information was also collected to help review and perform energy savings calculations.

The on-site visit sampling methodology and protocol are provided in Appendix XVIII.

⁹⁴ Low-income participants are usually assigned an NTGR of 1. All low-income participants were removed from the EPI survey sample so that the levels of free-ridership and spillover could be determined for EPI using the survey results.

Unitary Savings Review

As part of the impact evaluation of EPI, the Evaluator conducted a thorough literature review and performed engineering calculations to review the unitary savings values used in the tracking sheet for each product type installed through EPI. Unitary savings for single-family households and apartments were reviewed separately.

TRMs and public evaluation reports from jurisdictions similar to ENS were consulted and the most recent and relevant sources were selected as the basis of the unitary savings review.

Effective Useful Life Review

As part of the 2017 evaluation, to examine the EUL values used by ENS to calculate lifetime energy savings, the Evaluator conducted a thorough literature review by consulting TRMs, evaluation reports and relevant studies.

12 EPI MARKET EVALUATION

This section describes participant perspectives on the EPI component.

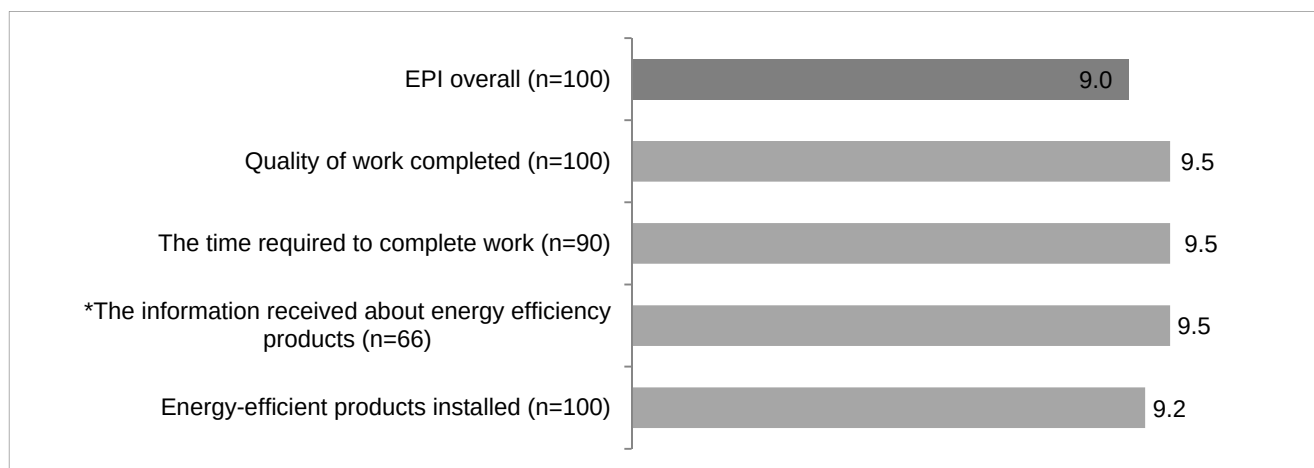
12.1 Participant Perspectives

A survey with 100 participants was conducted as part of the EPI evaluation. In addition to the questions designed for impact evaluation purposes, survey participants were asked questions regarding reasons for participation, behavioural changes, satisfaction and recommendations for improvements.

A number of reasons were cited by participants for agreeing to participate in the EPI service, with the primary one being to save energy or energy costs (67%), followed by wanting the energy-efficient upgrades (14%).

Satisfaction with EPI was very high, as indicated by an average rating of 9.0 on a 10-point scale, where 1 indicates “not at all satisfied” and 10, “completely satisfied”. The quality of the interaction with the installer who visited the home was the main reason cited for satisfaction with the service. As shown in Figure 20, satisfaction was also very high with various aspects of EPI, including the quality of work completed, the time required to complete the work, the information received about energy-efficient products, and the products installed.

Figure 20: Participant Satisfaction with EPI (Ratings on a 10-point Scale)



*Base: Respondents who received information during the visit from the installer about energy-efficient products

The small number of participants who were less satisfied (7 participants) indicated they expected more from the service, did not like the installer, or did not achieve any energy savings.

Over one in 10 participants (11%) reported problems with the products installed through the service, mostly with smart power strips and LED bulbs, followed by hot water tank wrap and showerheads. According to participants, the main problem with the smart power strips was that they kept turning the television off; they also mentioned that LED bulbs flickered.

Two in 10 participants started adopting or increased various energy-efficient actions after participating in the service, including unplugging items not in use (25%), reducing water consumption (23%), turning off lights (20%), setting the heating thermostat lower (18%), turning off appliances (18%), or setting the water heater lower (16%). In addition, nearly one half of the participants (47%) mentioned being more aware of power usage and energy savings following participation in EPI.

While many participants were unable to offer any recommendations on how to improve the service (62%), a small number mentioned the need for improved communication (9%), offering more information on the products installed (8%), or better advertising of the service (5%).

13 EPI IMPACT EVALUATION

The objective of the 2017 EPI impact evaluation is to determine the gross and net electrical energy and peak demand savings.

13.1 Gross Savings

This section reports on the gross unitary savings used by ENS in the 2017 tracking system and the revised gross unitary savings established by the Evaluator to accurately establish the savings associated with the products installed through EPI in 2017. The single-family households' and the apartments' unitary savings values are presented separately.

The tracked savings are generally based on the 2016 evaluation results, where RDI and RP&C savings are used for single family homes and apartments, respectively. For the sake of conciseness, the calculations are not described in detail if no major changes have been made since last year's evaluation. The complete details of calculations for establishing the revised savings of each product type are provided in Appendix XIX.

13.1.1 LED Lamps

Tracked Savings

The tracking sheet lists the number of LED lamps installed for each pairing of the old lamp wattage (35 W, 40 W, 50 W, 60 W, 70 W and 100 W) with the new lamp wattage (5 W, 7 W, 9 W, 9.5 W, 11 W and 18 W). Each of these pairings has a different displaced wattage, which is calculated based on the replaced lamp wattage information available in the tracking sheet.

In the tracking report, the actual wattage of replaced lamps are indicated for all the lamp types, except the G25 and E12 lamps, for which ENS assumes an old wattage value of 40 W.

This year, one LED lamp type previously not offered through RDI or RP&C is now being offered through EPI, namely 11 W LED lamps. The tracking sheet shows that 11 W lamps have been installed to replace 60 W lamps.

In addition to the LED lamps offered to participants living in existing residential buildings, in 2017, ENS started carrying out a new construction lighting pilot project. ENS worked with the developer of a new multi-unit residential building to install LED lamps during the construction period before occupancy. All the lamps installed through this pilot were 9 W LED lamps and ENS applied a unitary savings value of 50.3 kWh per year, with a displaced wattage of 51 W (9 W replacing 60 W).

The value of the daily hours of operation applied by ENS to the calculations is based on last year's evaluation, in which an average value of 2.7 hours per day was suggested according to the Northeast Residential Lighting Hours-of-Use Study (NERHOU) ⁹⁵ on all types of bulbs.

The following general lighting equation was used by ENS to calculate the tracked unitary savings values listed in Table 58.

$$\text{Annual Unitary Savings} \left[\frac{kWh}{yr} \right] = \frac{(\text{Old Wattage} - \text{New Wattage})[W] \times HOU \left[\frac{h}{day} \right] \times 365 \left[\frac{day}{yr} \right]}{1000 \left[\frac{W}{kW} \right]}$$

Table 58: Tracked Unitary Savings Values for Each Category of LED

Category of LED	Unitary Savings Value for Single-family Homes (kWh/year)	Unitary Savings Value for Apartments (kWh/year)
9 W replacing 40 W	30.6	30.6
9 W replacing 60 W	50.3	50.3
9 W replacing 100 W	89.7	89.7
9.5 W replacing 40 W	30.1	30.1
9.5 W replacing 60 W	49.8	49.8
9.5 W replacing 100 W	89.2	89.2
11 W replacing 60 W	48.3	48.3
18 W replacing 75 W	56.2	56.2
18 W replacing 100 W	80.8	80.8
7 W GU10 replacing 35 W	27.6	27.6
7 W GU10 replacing 50 W	42.4	42.4
7 W G25	32.5	32.5
5 W Chandelier E12	34.5	34.5

Revised Savings

To update the unitary savings values used by ENS, the Evaluator analyzed the displaced wattage calculations and reviewed the hours of operation.

⁹⁵ NMR Group Inc. and DNV GL, *Northeast Residential Lighting Hours-of-Use Study*, May 5, 2014, p. 69.

Displaced Wattage

As previously mentioned, the displaced wattage is defined as the difference between the real wattage value of the old lamp and that of the new LED lamp.

According to the specifications sheets, the 7 W GU 10 lamp has a light output equivalent to that of 50 W halogen lamp, and the LED 18 W LED lamp has an equivalent light output to replace a 100 W incandescent lamp. However, these lamps are also used to replace lamps having a lower or higher wattage than their equivalent-light-output wattage, resulting in significant light output difference for 12 percent of the lamps.

Regarding the new construction pilot project, the developer was in the process of installing 60 W lamps in all units before the pilot opportunity was brought to ENS's attention. Since it was clear that the developer was going to install 60 W bulbs throughout the building without the EPI incentive, the Evaluator considered the baseline of 60 W appropriate for the pilot.

The Evaluator concludes that all the displaced wattage values calculated by ENS for existing residential buildings are appropriate for this year's evaluation.

Hours of Operation

The Residential Lighting Evaluation Protocol of the Uniform Methods Project⁹⁶ recommends that each jurisdiction conduct a metering study to determine their specific hours of use. In 2016 and 2017, the Evaluator conducted a metering study among 75 households to assess the daily hours of operation. The overall average daily HOU was established at 2.48 hours/day with a margin of error of ± 0.24 hours/day. Since the NERHOU study was conducted on a much larger scope with 848 households and its data and findings fall within the Evaluator's metering study's margin of error, the Evaluator has decided that the value of 2.7 hours/day established by NERHOU for all types of bulbs is still the most appropriate value for the LED lamps installed through EPI. Furthermore, the Evaluator's metering study did not include any outdoor bulbs in its metered sample, but the NERHOU study's metered sample did include outdoor bulbs, which accounted for 4 percent of the sample; this percentage was also the proportion of outdoor lamps of all the LED bulbs installed through EPI. The detailed methodology and results are presented in the 2017 Residential Lighting Metering Study report, in Appendix XX.

The NERHOU study concluded that there was no difference between HOU of single-family homes and apartments. Thus, the HOU applied to obtain unitary savings for both types of dwellings in EPI are identical.

To sum up, the unitary savings values associated with LED lamps listed in Table 58 are still appropriate and correspond to the revised unitary savings.

⁹⁶ NREL, *Uniform Methods Protocol Chapter 6 : Residential Lighting Evaluation Protocol*, February 2014, pp. 6-20.

13.1.2 LED Nightlights

Tracked Savings

The tracked unitary savings value of LED nightlights installed through EPI in 2017 is 29.3 kWh per year for single-family homes and 28.5 kWh per year for apartments. These values were calculated by using the general lighting equation and by applying (1) an average LED nightlight wattage of 0.3 W and 0.5 W for single-family homes and apartments respectively, (2) a wattage of 7 W for the old incandescent nightlights and (3) hours of operation of 12 hours per day.

Revised Savings

The Evaluator considers the assumptions made for the hours of operation and the old wattage still appropriate. Based on the information collected from the site visits, the wattage of LED nightlights installed this year has been established at 0.5 W for both single-family homes and apartments.

Therefore, using the general lighting equation, the unitary savings associated with the installation of LED nightlights has been revised to 28.5 kWh per year.

13.1.3 LED Holiday Lights

Tracked Savings

Through EPI, ENS allows participants to exchange two sets of incandescent holiday lights for one set of LED holiday lights. Based on the evaluation results in the 2015 LED Holiday Light Exchange Report, ENS established the savings of each set of LED lights at 29.4 kWh in its tracking system.

Revised Savings

To update the unitary savings values used by ENS, the Evaluator reviewed the parameters used in the calculations by comparing the assumptions used in the 2015 evaluation report and the data collected by the DAs in 2017. The following paragraphs discuss the review of each of these parameters. Based on this review, the Evaluator established the unitary savings value at 43.6 kWh. Since no information was tracked regarding the type of dwelling and these values are considered valid for all home types.

The Number of Sets Replaced

ENS offers one set of LED lights in exchange for two sets of traditional incandescent lights with a limit of two sets of LED holiday lights per household. Consequently, the unitary savings value associated with each LED set exchanged is based on the assumption that, ultimately, participants will probably replace all returned sets with new LED sets.

This assumption is conservative because it assumes that each set of their old incandescent lights will ultimately be replaced even if the participant chooses to use only the new sets provided by ENS.

To validate this assumption for 2018 savings, the Evaluator suggests that participants be questioned through a participant survey or during on-site visits in 2018 if ENS offers this measure again in 2018.

The Proportion of Sets Replaced

New data collected in 2017 was used to update the proportion of each category of old incandescent sets participants exchanged. The 2017 proportions were determined based on information collected in the tracking report. The results are presented in Table 59 below.

Table 59: Proportions of Old Incandescent Sets by Category

Category of Incandescent Set	Number of Sets Returned	Proportion of Each Category
Long Large Incandescent Bulbs	489	37%
Long Mini Incandescent Bulbs	416	32%
Short Mini Incandescent Bulbs	414	31%
Total	1,319	100%

The Number of Lamps per Set

No data was collected about the number of bulbs per set of old incandescent lights replaced in 2017. The values used by the Evaluator are based on data collected by ENS during a light exchange event in 2014, as presented in Table 60. The Evaluator conducted a literature review in 2014 and found these values to be within the range of those used by other jurisdictions. No new studies have been found since. Since these numbers of bulbs per set are based on real data collected in the field, the Evaluator decided to use these numbers again this year.

Table 60: Average Number of Lamps on Each Set by Category

Category of Incandescent Set	Average Number of Lamps per Set
Long Large Incandescent Bulbs	35
Long Mini Incandescent Bulbs	50
Short Mini Incandescent Bulbs	20

Displaced Wattage

The lamp wattages used by ENS for both large and mini incandescent lamps remain unchanged in the revised savings. These values are based on a literature review conducted by the Evaluator in 2014. These values are 7 W for large incandescent bulbs and 0.4 W for mini incandescent bulbs.

The wattage value applied to the replacement set, namely the LED sets distributed, correspond to the wattage value of C-6 LED lights, with each set consisting of seventy 0.08 W lamps.

Hours of Operation

Based on the literature review conducted in 2015, an annual usage of 40 days is used. As for daily usage, the Evaluator considers an average of 5.8 hours per day, based on the results of a survey conducted among participants in 2013. The annual hours of use have been established at 232 hours per year.

Using the revised parameters mentioned above, the unitary savings values were calculated for the 2017 evaluation and are listed in Table 61 below.

Table 61: Revised Unitary Savings Value for Each Type of LED Light Set

Parameter	Value
Proportion of Old Large Incandescent Sets Returned (35 lamps per set)	37 %
Proportion of Old Mini Incandescent Sets Returned (50 lamps per set)	32 %
Proportion of Old Mini Incandescent Sets Returned (20 lamps per set)	31 %
Wattage of Old Large Incandescent Sets (35 lamps per set)	7 W/lamp × 35 lamps/set = 245 W/set
Wattage of Old Mini Incandescent Sets (50 lamps per set)	0.4 W/lamp × 50 lamps/set = 20 W/set
Wattage of Old Mini Incandescent Sets (20 lamps per set)	0.4 W/lamp × 20 lamps/set = 8 W/set
Average Old Wattage (incandescent sets)	$(37\% \times 245 \text{ W}) + (32\% \times 20 \text{ W}) + (31\% \times 8 \text{ W}) = 99.6 \text{ W/set}$
Wattage of New LED Sets (70 lamps per set)	0.08 W/lamp × 70 lamps/set = 5.6 W/set
Displaced Wattage (per exchange)	$(99.6 \text{ W} - 5.6 \text{ W}) = 94.0 \text{ W}$
Annual Hours of Operation	5.8 h/day × 40 days/yr = 232 h/year
Number of New LED Sets Used to Replace the 2 Old Sets Returned	2
Unitary Energy Savings Value (per exchange)	$2 \text{ sets} \times 94.0 \text{ W} \times 232 \text{ h/yr} = 43.6 \text{ kWh/year}$

13.1.4 Faucet Aerators

Tracked Savings

For all the faucet aerators installed in single-family homes (whether in the kitchen or the bathroom), ENS uses a unitary savings value of 103 kWh per year based on RDI's 2016 evaluation results. Similarly, ENS uses a unitary savings value of 122 kWh per year for faucet aerators installed in apartments based on RP&C's 2016 evaluation results.

These values were determined in last year's evaluation using a custom equation, which takes into account the reduction in the flow rate, the total DHW consumption and the number of faucet aerators per home. This algorithm was established in the 2014 evaluation report and was used again for the 2016 evaluation.

Revised Savings

The algorithm used in the three previous evaluations is still considered appropriate for determining the faucet aerator's unitary savings values, which are presented in Table 62, because the type of product installed has not changed. A change was made for the 2017 revised savings based on the average number of people occupying a home (determined based on the data from the tracking report), and the number of faucets. The average number of faucets for single-family homes was determined based on the data from the site visits. As for apartments, an assumption has been made that each of the apartments has an average of two faucets (one in the kitchen and the other in a bathroom) since the sample size of site visits to apartments was too small to allow for making a more accurate assessment of this average. The average number of people living in each home was 2.4 people for single-family homes and 1.4 people for apartments. The number of faucets was 3.3 faucets for single-family homes and estimated at 2 for apartments.

Table 62: Revised Unitary Savings Value for Faucet Aerators

Product	Unitary Savings Value for Single-family Homes (kWh/year)	Unitary Savings Value for Apartments (kWh/year)
Faucet Aerator	98	95

13.1.5 Low-flow Showerheads

Tracked Savings

As presented in Table 63, for single-family homes, ENS uses unitary savings values of 369 kWh, 553 kWh or 738 kWh for low-flow showerheads (or shower wands) with a flow reduction of 0.5 gpm, 0.75 gpm or 1.0 gpm respectively, based on the RDI 2016 evaluation. For apartments, ENS uses unitary savings values of 265 kWh, 398 kWh or 531 kWh for low-flow showerheads with a flow reduction of 0.5 gpm, 0.75 gpm or 1.0 gpm respectively, based on the RP&C 2016 evaluation.

These unitary savings values were calculated using a custom DHW consumption equation developed in the 2014 evaluation report and used in the 2016 evaluation. This equation takes into account the flow-rate reduction, the number of people per home, the percentage of hot water used in showers, the showering time and the number of showers per day per person.

Table 63: Tracked Unitary Savings Value for Low-flow Showerheads

Product Type	Unitary Savings Value for Single-family Homes (kWh/year)	Unitary Savings Value for Apartments (kWh/year)
Low-flow Showerhead with 0.5 gpm flow reduction	369	265
Low-flow Showerhead with 0.75 gpm flow reduction	553	398
Low-flow Showerhead with 1 gpm flow reduction	738	531

Revised Savings

The Evaluator modified the algorithm used by ENS to determine the unitary savings values in this year's evaluation. The new algorithm is based on last year's, but takes into account the number of showers in the home or apartment by dividing the original equation by this parameter of the number of showers. Because the original equation was based on the assumption that all occupants used the same shower (equipped with the low-flow showerhead), the associated savings were overestimated on the basis of a per-showerhead unitary savings value. The average number of showers in single-family homes (1.5 showers) was determined based on the data from the site visits conducted in 2017. The average number of showers for apartments has been determined based the assumption that most apartments have only one shower. The Evaluator, however, kept the values of the variables used in the algorithm because no changes were made to the types of products installed and the flow rate of the baseline products has remained the same.

Table 64 summarizes the revised unitary savings values for low-flow showerheads.

Table 64: Revised Unitary Savings Values for Low-Flow Showerheads

Product Type	Unitary Savings Value for Single-family Homes (kWh/year)	Unitary Savings Value for Apartments (kWh/year)
Low-flow showerhead with 0.5 gpm flow reduction	236	207
Low-flow showerhead with 0.75 gpm flow reduction	354	310
Low-flow showerhead with 1 gpm flow reduction	472	413

13.1.6 Pipe Insulation

Tracked Savings

For both building types, ENS uses a unitary savings value of 12.7 kWh per year per foot unit of pipe insulation from the 2015 evaluation report. This unitary savings value was found in the Ontario Power Authority (OPA) 2011 Measures List and Assumptions.⁹⁷

Revised Savings

The Evaluator reviewed the literature regarding pipe insulation and did not find any new relevant information that warrants changing the unitary savings value suggested by OPA in 2011. Therefore, the unitary savings value of 12.7 kWh for each foot unit of pipe insulation is still considered valid for the 2017 evaluation.

13.1.7 Hot Water Tank Wraps

Tracked Savings

The hot water tank wraps installed through EPI have a thermal resistance of 1.21 m²·°C/W. ENS uses a unitary savings value of 131 kWh per year for single-family homes and a value of 118 kWh per year for apartments.

These two unitary savings values have been determined using a custom algorithm developed in the 2014 RDI and the 2013 Multi-unit Residential Building (MURB) evaluations for determining heat transfer through an insulated cylinder and this algorithm was used in 2017.

⁹⁷ Ontario Power Authority (OPA), *OPA Prescriptive Measures and Assumptions List*, December 2010.

Revised Savings

The algorithm applied to this product type is still valid because the product installed through EPI was the same as in 2016 (through RDI and RP&C), although a change in thermal resistance was made for units installed in single-family homes because the value used by ENS was based on a blanket with a thermal resistance value of $0.90 \text{ m}^2 \cdot ^\circ\text{C/W}$.

Therefore, the unitary savings value associated with the installation of a hot water tank wrap is 159 kWh per year for single-family homes and 118 kWh for apartments.

13.1.8 Smart Power Controllers for Audiovisual Equipment

Tracked Savings

Since 2013, ENS has used a unitary savings value of 411 kWh per year for the installation of a smart power controller for audio-visual equipment.

This unitary savings value is based on a study conducted in 15 South African households representing a medium-level international audiovisual usage.⁹⁸ The first trial savings of 420 kWh per year were normalized to 411 kWh per year to represent the savings in an average home's audiovisual environment, as validated by an independent verification conducted by the Victorian State Government for use in the Victorian White Certificate Scheme.⁹⁹

Revised Savings

In the 2015 RDI and RP&C evaluations, the Evaluator conducted a literature review to find other studies on smart power controllers for audiovisual equipment and concluded that the unitary savings value of 411 kWh used by ENS was the most appropriate value. This year, the Evaluator did not find any more recent studies that could be used to validate the unitary savings associated with the installation of a smart power controller for audiovisual equipment.

As had been observed in 2016, the Evaluator noticed that 7 percent of all the participants in 2017 had more than two smart power controllers installed in their home. The studies covered in the literature review conducted in 2015 did not include homes with more than two smart power controllers installed. The Evaluator believes that in houses with more than two controllers installed, the savings generated by the smart power controllers could decrease, though the Evaluator does not have sufficient data to estimate the level of such a decrease. This further justifies the Evaluator's recommendation that the number of smart power controllers installed in each home should be limited to two.

⁹⁸ Karebo Systems, *Audiovisual Standby Power Controller: Energy Savings Field Trial, South Africa - June-August 2012*, Field trial data analysis, March 6, 2013.

⁹⁹ Embertec – Energy Efficiency Technologies, *Solution Provider Presentation, Maximum Savings – Zero Effort*.

13.1.9 Summary of Unitary Savings Values

Table 65 below lists the tracked and revised savings values for each type of product installed through EPI.

Table 65: Tracked and Revised Unitary Savings by Product Type and Building Type

Product Type	EPI – Single-family Homes		EPI – Apartments	
	Tracked Savings (kWh/yr)	Revised Savings (kWh/yr)	Tracked Savings (kWh/yr)	Revised Savings (kWh/yr)
LED Lamps				
9W Replacing 40W	30.6	30.6	30.6	30.6
9W Replacing 60W	50.3	50.3	50.3	50.3
9W Replacing 100W	89.7	89.7	89.7	89.7
9.5W Replacing 40W	30.1	30.1	30.1	30.1
9.5W Replacing 60W	49.8	49.8	49.8	49.8
9.5W Replacing 100W	89.2	89.2	89.2	89.2
11W Replacing 60W	48.3	48.3	48.3	48.3
18W Replacing 75 W	56.2	56.2	56.2	56.2
18W Replacing	80.8	80.8	80.8	80.8
GU10 7W Replacing 35W	27.6	27.6	27.6	27.6
GU10 7W Replacing 50W	42.4	42.4	42.4	42.4
7W G25	32.5	32.5	32.5	32.5
5 W Chandelier E12	34.5	34.5	34.5	34.5
LED Nightlights	29.3	28.5	28.5	28.5
LED Holiday Lights	29.4	43.6	29.4	43.6
Faucet Aerators	103	98	122	95
Low-flow Showerheads				
0.5 GPM	369	236	265	207
0.75 GPM	553	354	398	310
1.0 GPM	738	472	531	413
Pipe Insulation (per foot)	12.7	12.7	12.7	12.7
Hot Water Tank Wraps	131	159	118	118
Smart Power Controller for Audiovisual Equipment	411	411	411	411

13.1.10 Installation Rates

The Evaluator conducted 110 on-site visits at participating single-family homes and multi-family apartments to verify the number of products actually installed. The visits were carried out to determine the EPI installation rates for each product category; these rates are listed in Table 66 below. By comparing the recorded numbers of installed products and the actual numbers verified on site, installation ratios were calculated. A margin of error was calculated for each product category to confirm whether the results were within the acceptable limits of reliability.

Table 66 below lists the values used by the Evaluator to calculate the installation rates, which have been applied to the gross savings.

Table 66: Product Installation Rates

Type of Product	Quantity Installed – from Tracking Report	Quantity Installed – from On-site Visits	Percentage of Products Installed	Margin of Error ¹⁰⁰	Installation Rate Applied to Gross Savings
LED Lamps	3,087	3,032	98.2%	1.3%	98%
LED Nightlights	141	136	96.5%	4.8%	97%
Faucet Aerators	187	174	93.0%	3.9%	93%
Low-flow Showerheads	109	97	89.0%	5.1%	89%
Pipe Insulation (ft)	459	487	106.0%	9.0%	106%
Hot Water Tank Wrap	69	67	97.1%	4.2%	97%
Smart Power Controllers	99	56	56.6%	10.6%	57%

All the product types had an installation rate of at least 89 percent, except for smart power controllers. These results are comparable to the typical installation rates documented over the past few years, thus indicating that EPI's product installation rates have remained stable.

Like in previous years, the Evaluator identified some situations in which, though the total installed quantity matched the quantity verified on site, the actual wattage values of the lamps installed sometimes were different from the values recorded by the DA. No adjustments were made to the displaced wattage of LED lamps since there were only a small number of cases where the lamp wattage was incorrectly tracked.

¹⁰⁰ Calculated for a confidence interval of 90%.

The installation rate applied to gross savings corresponds to the percentage of products installed as observed during the site visits, except for pipe insulation. For pipe insulation, the Evaluator removed a single outlier from this product type's results because the DA appeared to have documented the number of pieces of insulation material instead of the total feet installed. The resulting installation rate for this outlier was 413 percent. In the gross savings calculation, the outlier installation rate was only applied to the savings of that specific case.¹⁰¹

Because the smart power controllers' results showed low installation rates in previous years with large margins of error, the Evaluator increased the number of participants sampled in 2017 to improve the margin of error. Even with the increased sample size, the result for the smart power controllers is consistent with the past years and shows a large variation between the number of products installed and the number of products still in use. The installation rate is 57 percent with a margin of error of 10.6 percent. The true installation rate is therefore between 46 percent and 68 percent. Although this product type showed a relatively wider range of possible installation rate values compared to other product types, the Evaluator believes that smart power controllers' true overall installation rate is well below 100 percent. This trend was documented in previous years, indicating that this technology is not being adopted effectively.

For those sampled participants who had a difference between the tracked number of smart power controllers and the number verified on site, the Evaluator identified three common reasons.

- › Participants did not like, or understand, how smart power controllers should operate and removed one or more of the products after the DA had installed them, which was the case for 24 participants.
- › The product had not been installed by the DA and had been left in the box for the participant to install, which was the case for 13 participants (mainly related to one particular DA). To find out whether this situation was widespread because of this particular DA, 10 additional site visits were conducted, leading to a total of 110 site visits. These 10 site visits were all conducted with those participants whose power smart controllers were installed by this DA. Although the inclusion of 10 additional visits for a particular DA would have usually required calculating a weighted average installation rate based on the proportions of installed smart power controllers respectively accounted for by each DA, the site visit results revealed similar installation rates for the over-sampled DA (56.1%) and the other DAs (57.6%), thus enabling the Evaluator to apply an overall installation rate of 57 percent to all smart power controllers installed through EPI.
- › In one case, there was a data entry error because the participant was told the DA would come back with a smart power controller, but the DA never provided one.

Overall, the results for the smart power controllers indicate that ENS should reconsider whether it should continue to offer this type of product through EPI.

¹⁰¹ The installation rate remained at 106% because the outlier's savings were small in comparison to the total savings of all the other pipe insulation projects.

For LED holiday lights, it is assumed that all lights were installed. Therefore, the Evaluator established the installation rate at 100 percent for this product type.

13.1.11 Peak Demand Savings

The peak demand savings correspond to the demand savings that coincide in time with the peak demand of the electricity system. The projected electricity-demand peak period in Nova Scotia is between 5 p.m. and 7 p.m. in the months of December to February on a non-holiday weekday. For all EPI products, except lighting products, the peak demand savings were calculated using the on-peak demand-to-energy ratios developed by Navigant in the 2016-2018 DSM Plan. These ratios were established for various measure categories, based on modelled system-coincident peak demand savings and energy savings for a projected deployment of measures. Navigant used local data to establish the ratios for 2017. The Evaluator considers the approach used by Navigant for establishing the on-peak demand-to-energy ratios still valid; therefore, these ratios were used to estimate peak demand savings for EPI, except for lighting products, for which measured data obtained from the Residential Lighting Metering Study was compared to values found in the literature.

The study analyzed the HOU values specifically for the peak demand period of the electricity system for each room type. The results showed that the peak-demand-to-energy ratio previously used for residential lighting (0.249 W/kWh) was overestimated, since the average value was established at $0.161 \text{ W/kWh} \pm 0.016 \text{ W/kWh}$. The Evaluator compared these results with those from the NERHOU study, which established a peak-demand-to-energy ratio of 0.162 W/kWh (with a PCF of 16% and 2.7 hours of use per day). The Evaluator recommends using this ratio because it is very close to the value of 0.161 W/kWh established by the Residential Lighting Metering Study. In addition, the margin of error in the NERHOU study was 1 percent, which is lower than the 10 percent in the Residential Metering study. Furthermore, the NERHOU sample also included outdoor lamps (with proportions similar to those in EPI), thus eliminating the need to make assumptions for calculating their specific peak-demand-to-energy ratio. Therefore, the Evaluator recommends applying the NERHOU ratio of 0.162 W/kWh to all indoor and outdoor lamps. Without specific data about LED nightlights, the Evaluator also applied the 0.162 W/kWh value to LED nightlights.

The Evaluator calculated the peak-demand-to-energy ratio for LED holiday lights. To evaluate the probability that the LED holiday lights are turned on during NSP's peak demand period, Econoler considered the probability of two events: (1) that the LED holiday lights are turned on between 5 p.m. and 7 p.m., and (2) that the LED holiday lights are in use on the day of the peak load, which occurs on a weekday in December, January or February. It was then assumed that the LED holiday lights are used on average 40 days per year throughout the entire month of December and the first nine days in January. Based on this assumption, the Evaluator evaluated the probability that the LED holiday lights were in use on the day of the peak load. NSP's peak load data¹⁰² for 2014 shows that in about 35 percent of cases, peak load occurred between 5 p.m. and 7 p.m. in December and over the first nine days in January. Since the peak demand period has not changed since 2014, the Evaluator considered that the methodology used in 2015 is still appropriate for 2017. Therefore, a peak coincidence factor of 35 percent was used in the peak demand savings calculations, and the peak-demand-to-energy ratio was established at 1.509 W/kWh.

Table 67 below lists the peak-demand-to-energy ratios established for each category of measure. These ratios are applicable to both single-family homes and apartments.

Table 67: Peak-demand-to-energy Ratios by Product Type

Type of Product	Peak-demand-to-energy Ratio	Peak-demand-to-energy Ratio Category
Lighting Products (LEDs and LED Nightlights)	0.162	Northeast Residential Lighting Hours-of-Use Study
LED Holiday Lights	1.509	Calculated by the Evaluator
Faucet Aerators	0.162	RES-Water Heat
Low-flow Showerheads	0.162	RES-Water Heat
Pipe Insulation (ft)	0.162	RES-Water Heat
Hot Water Tank Wrap	0.162	RES-Water Heat
Smart Power Controllers	0.000	RES-Plug Load-Controls

13.1.12 Interactive Effects

In a home, interactive effects occur when the implementation of energy-efficiency measures has an impact on the energy consumption of other elements, such as heating and cooling. In the case of EPI, replacing lighting products with LEDs causes an increase in the heating load during winter and a decrease in the cooling load during summer. The same effect occurs for hot water insulation measures.

¹⁰² Nova Scotia Power, Open Access Same-Time Information System, *Hourly Total Net Nova Scotia Load*, available at <<http://oasis.nspower.ca/en/home/oasis/monthly-reports/hourly-total-net-nova-scotia-load.aspx>> (Last accessed January 18, 2016).

For 2015's evaluation, the Evaluator performed a literature review of the interactive effects calculation methodology to update this methodology to include the latest studies and improve its precision by taking into consideration additional variables. The literature review showed that no reliable interactive effects study other than the one currently used by ENS was available. The literature review also indicated that most jurisdictions use separate interactive effects factors for energy savings and peak demand savings. As of 2016, ENS decided to apply different interactive effects factors to the peak demand savings and energy savings.

The interactive effects factors used by ENS for energy savings are based on a methodology developed by the Evaluator in 2015 and are still valid for 2017. As for peak demand savings, the Evaluator changed the methodology by deciding not to apply any interactive effects factors to those product types whose peak-demand-to-energy ratios have already accounted for the interactive effects. This change reflects the fact that the peak-demand-to-energy ratios established by Navigant are a ratio of the peak demand savings value to the energy savings values; both these two types of savings values already account for the interactive effects, since they have been established through whole-building energy modelling. Therefore, the interactive effects factors specific to peak demand savings were only applied to those product types whose peak-demand-to-energy ratios were not obtained through whole-building modelling, namely A-type and reflector LED lamps, LED nightlights and LED holiday lights. The peak-demand-to-energy ratios for those lighting products were adjusted so that they can be applied to gross energy savings with interactive effects and result in calculated peak demand savings including interactive effects. The adjusted peak-demand-to-energy ratios for lighting products are presented in Table 70 further below.

Another adjustment was made to the interactive effects factors: the percentages of LED products installed in homes that used electric heating, heat pump heating, and air-conditioning were used instead of the overall percentage of homes using electric heating, heat pump heating, and air-conditioning. The percentages were updated based on the information in the tracking sheet.

The information about the heating mechanical systems was included for participants in the EPI tracking sheet. The Evaluator took into account the participants who used a heat pump as a heating system in the interactive effects calculation. It was found that 27 percent of the participants who heated their homes primarily with electricity had an electric heat pump. Since the interactive effects calculation is based on a heating system efficiency of 100 percent, an adjustment was made by dividing the interactive effects factor for heating (-58.0%) by the COP of a heat pump. This COP was estimated based on a HSPF Region V of 7.1, which is the value for a standard split heat pump as defined by the federal Energy Efficiency Regulations.¹⁰³ The HSPF of a split system was used for heat pumps since the vast majority of participants had a ductless mini-split unit as their electric heat pump. As a result, the interactive effects factor for heating was first divided by a COP of 2.1 and, then added to the cooling only interactive effects factor of +3.6 percent, yielding an overall interactive effects factor of -24.0 percent for buildings electrically heated with a heat pump.

Table 68 lists the interactive effects factor calculation results for lighting products installed indoors.

Table 68: Interactive Effects Calculation Results for LED Products Installed Indoors

Parameter	% of LED Products ¹⁰⁴	Energy Interactive Effects Factor ¹⁰⁵	Peak Demand Interactive Effects Factor
Heat Pump Heating and Air-conditioning	13%	-24.0%	-90.0%
Electric Heating with Air-conditioning	8%	-54.4%	-90.0%
Electric Heating without Air-conditioning	24%	-58.0%	-90.0%
No Electric Heating with Air-conditioning	11%	3.6%	0%
With Neither Electric Heating nor Air-conditioning	44%	0%	0%
Weighted Interactive Effects Factor	100%	-17.7%	-40.4%

These interactive effects occur only when the products are installed inside the building. Since LED A-type lamps installed through the program component are also used for outdoor lighting, the interactive effects factor for these products was adjusted to take this into account, as shown in Table 69. The proportion for each category of lamp type was determined based on data from the 2017 EPI October tracking report. For LED holiday lamps, the proportions were determined based on the assumption that all sets replacing large incandescent sets are installed outdoors, and that 25 percent of the sets replacing mini incandescent sets are installed outdoors. For reflector and decorative LED lamps and LED nightlights, their interactive effects factors remain -17.7 percent for energy savings and -40.4 percent for peak demand savings, respectively.

¹⁰³ Minister of Justice, Canada, *Energy Efficiency Regulations*, 2016, <http://laws-lois.justice.gc.ca/PDF/SOR-2016-311.pdf>.

¹⁰⁴ The proportions of heating types and participants who use a heat pump or air-conditioning are taken from the 2017 EPI tracking report.

¹⁰⁵ ADS ASSOCIÉS, *Évaluations des effets énergétiques combinés des mesures d'économies d'énergie – résidence unifamiliale*, report presented to Hydro-Québec, 1992.

Table 69: Interactive Effects Factors for LED Lamps, LED Nightlights and LED Holiday Lights

Category of Product	% Indoor	% Outdoor	Energy Interactive Effects Factor	Peak Demand Interactive Effects Factor
A-type LED Lamps ¹⁰⁶	96%	4%	-16.9%	-38.7%
Reflector and Decorative LED Lamps ¹⁰⁷	100%	0%	-17.7%	-40.4%
LED Nightlights	100%	0%	-17.7%	-40.4%
LED Holiday Lights	47%	53%	-8.4%	-19.1%

The interactive effect factors were then applied to the peak-demand-to-energy ratios for lighting products, as shown in Table 70 below.¹⁰⁸

Table 70: Adjusted Peak-demand-to-energy Ratios by Lighting Product Type

Type of Product	Peak-demand-to-energy Ratio	Interactive Effects Factor for Energy Savings	Interactive Effects Factor for Peak Demand Savings	Adjusted Peak-demand-to-energy Ratio
A19 and A21 LED Lamps	0.162	-16.9%	-38.7%	0.120
Reflector and Decorative LED Lamps	0.162	-17.7%	-40.4%	0.117
LED Nightlights	0.162	-17.7%	-40.4%	0.117
LED Holiday Lights	1.509	-8.4%	-19.1%	1.333

¹⁰⁶ Including 9 W, 9.5 W, 11 W, and 18 W LED lamps.

¹⁰⁷ Including 7 W GU10, 7 W G25, and 5 W Chandelier E12 LED lamps.

¹⁰⁸ Adjusted peak-demand-to-energy ratio = peak-demand-to-energy ratio × (1 + interactive effects factor for peak demand savings) / (1 + interactive effects factor for energy savings)

In the 2015 RP&C evaluation, for the DHW measures' energy interactive effects factors, the Evaluator used engineering calculations to take into account the durations of the heating and cooling seasons, the efficiency of cooling and heating systems and the percentage of heat generated inside the heated portion of the building envelope. The methodology and the assumptions used in the previous evaluation are still considered appropriate for determining the energy interactive effect factors generated by the DHW measures.

Unlike the lighting interactive effects, the interactive effects calculations for DHW measures are different for apartments and single-family homes. The reason for this is that the locations of DHW tanks vary with the dwelling type. It is assumed that about half of DHW tanks are located in the basement or semi-conditioned spaces in single-family homes. The interactive effects during the cooling period are only considered for apartment buildings since DHW tanks are more likely to be in the air-conditioned living space than in single-family homes, where DHW tanks are more likely to be in the basement, where no air-conditioning is installed.

Table 71 lists the updated interactive effects factors for DHW products, based on the new proportions of heating and cooling systems found in the 2017 tracking report that had pipe insulation and hot water tank wraps installed. This year, the Evaluator established interactive effects for electric heating and heat pumps separately to refine the analysis.

Table 71: Interactive Effects Factors for Pipe Insulation and Hot Water Tank Wraps

Parameter	% of DHW Products	Energy Interactive Effects during Heating Period	Energy Interactive Effects during Cooling Period
Single-family homes, heat pump heating	12.1%	$-90\% \times 3.8/12 / 2.1 = -13.8\%$	$0\% \times 2/12 / 2.1 = 0.0\%$
Single-family homes, electric heating	26.4%	$-90\% \times 3.8/12 = -28.5\%$	$0\% \times 2/12 = 0.0\%$
Single-family homes, no electric heating	45.6%	$0\% \times 3.8/12 = 0.0\%$	$0\% \times 2/12 = 0.0\%$
Apartments, heat pump heating, with air-conditioning	0.3%	$-90 \times 8/12 / 2.1 = 28.5\%$	$40\% \times 2/12 = 6.7\%$
Apartments, electric heating, with air-conditioning	0.4%	$-90\% \times 8/12 = -60.0\%$	$40\% \times 2/12 = 6.7\%$
Apartments, electric heating, without air-conditioning	6.2%	$-90\% \times 8/12 = -60.0\%$	$0\% \times 2/12 = 0.0\%$
Apartments, no electric heating, yet with air-conditioning	2.3%	$0\% \times 8/12 = 0.0\%$	$40\% \times 2/12 = 6.7\%$
Apartments with neither electric heating nor air-conditioning	6.7%	$0\% \times 8/12 = 0.0\%$	$0\% \times 2/12 = 0.0\%$
Weighted Interactive Effect Factor	100%	-13%	0.18%
		-12.9%	

13.1.13 Effective Useful Life

As part of the 2017 evaluation, the Evaluator reviewed the EUL values used by ENS in the calculations of energy savings that are expected to persist over time.

For EPI, the EUL values of all the measures eligible for the program component were reviewed based on the findings of the literature review. When establishing the EUL for a given measure, the Evaluator considered the most common values found in TRMs, evaluation reports or relevant studies. The sources that based their EUL estimates on measured data or other reliable methods were preferred when available.

The EUL value found in the literature was then adjusted to account for the increased baselines throughout the EUL of the measure. This equivalent EUL therefore corresponds to the number of years by which the first-year savings estimate is multiplied to obtain the lifetime energy savings.

Table 72 below lists the tracked and the revised equivalent EUL values by measure. It should be noted that a single EUL value is applied to all EPI building types.

Table 72: Summary of Effective Useful Life Values by Measure Category

Measure	ENS Tracked EUL	Revised Equivalent EUL	Reference
LED A19 Lamps	16.7	7, 9 or 10	Analysis of EE regulations (see the explanation below)
LED Reflector Lamps	16.7	7	Analysis of EE regulations (see the explanation below)
LED Decorative Lamps	16.7	7	Analysis of EE regulations (see the explanation below)
LED Holiday Lights	16	25	Evaluator's assumption (see the explanation below)
LED Nightlights	16	23	Manufacturers' rated lifetime (see the explanation below)
Faucet Aerators	5	10	DEER 2014 EUL Table; value for faucet aerators ¹⁰⁹
Low-flow Showerheads	10	10	DEER 2014 EUL Table; value for low-flow showerheads
Pipe Insulation	15	15	GDS Measure Life Report, Table 1; value for residential pipe wrap ¹¹⁰
Hot Water Tank Wraps	5	7	DEER 2014 EUL Table; value for water heater wrap
Smart Power Controllers	4	4	Power Smart Engineering ¹¹¹

Based on the literature review findings, the Evaluator has concluded that the following measures' EUL values tracked by ENS are accurate since these values are used by most of the TRMs consulted:

- › Low-flow showerheads
- › Pipe insulation
- › Smart power controllers

¹⁰⁹ Database for Energy Efficiency Resources (DEER), *DEER2014 EUL Table*, 2014.

¹¹⁰ GDS Associates, Inc., *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*, Report prepared for the England State Program Working Group, June 2007, Table 1, pp. 1-3.

¹¹¹ PowerSmart Engineering, *Smart Strip Electric Savings Usability*, October 2008, p. 22.

The EUL value of faucet aerators was increased from five to 10 years based on the literature review findings, which revealed that most jurisdictions use an EUL value of 10 years based on the Database for Energy Efficiency Resources (DEER).

For hot water tank wraps, the Evaluator increased the EUL value to seven years. The Evaluator proposes this revised value, because it is commonly used by other jurisdictions. This value is based on the DEER and is in line with the EUL value proposed in the GDS report.

For LED lamps, the Evaluator first calculated the equipment life for each type of lamp, as shown in Table 73 below. The equipment life was calculated as the ratio between the manufacturers' rated lifetime hours for the most popular models of lamps installed under EPI, and the annual HOU value used for unitary savings values calculations.

Table 73: Equipment Life Value per LED Lamp Type

LED Lamp Type	Average Rated Lifetime Hours (Hours)¹¹²	Annual HOU (Hours/year)¹¹³	Equipment Life (Years)
LED A19 Lamps	25,000	986	25
LED Reflector Lamps	25,000	986	25
LED Decorative Lamps	15,000	986	15
LED Holiday Lights	30,000	232	129
LED Nightlights	100,000	4,380	23

¹¹² Based on the manufacturers' specifications sheets for the most popular models installed through EPI.

¹¹³ Based on the unitary savings review.

Driven by government regulations, the LED lamp market is evolving rapidly. LEDs installed today may eventually become the baseline since LED technologies are advancing fast and their prices are falling (i.e. a growing number of customers will choose to purchase LEDs over all other products). Some jurisdictions have already applied a reduced equivalent EUL value to their residential lighting savings by adopting a higher baseline to represent savings in future years. In other words, their baseline increases over the lifetime of a product, which in turn reduces the equivalent EUL value that is applied to the first-year savings to obtain the lifetime energy savings. That is the case for Illinois, where LED savings are considered nil after 10 years, and baselines are adjusted throughout the lifetime to match changes in the regulations; for instance, a 60 W incandescent baseline is revised to a 43 W halogen incandescent after the end of the incandescent's remaining useful life, and revised again to the minimum efficiency CFL level required by the Energy Independence and Security Act (EISA) that will come into force in 2021.¹¹⁴ Massachusetts also uses a similar methodology and has set the equivalent EUL value at eight to nine years for LED bulbs, which takes into account baseline increases that will occur because of EISA 2020.¹¹⁵

The Canadian market may change less quickly than the American market because Canadian regulations generally lag a few years behind the American ones; so, limiting the EUL value to 10 years, as done by Illinois, is too conservative. Consequently, the Evaluator used the equipment life of LED A19 lamps as the EUL, thereby avoiding capping since it is uncertain when LED lamps will become the baseline technology in the Canadian market. Like the approach used by Illinois and Massachusetts, the Evaluator applied a triple baseline for LED A19 lamps over their 25-year EUL to establish their equivalent EUL that accounts for the following factors:

- › The existing incandescent light bulbs replaced have an estimated remaining useful life of one year. Incandescent light bulbs have a typical rated life expectancy of 1,000 to 2,000 hours.¹¹⁶ The remaining useful life of replaced functional incandescent light bulbs is assumed to be half the rated life expectancy. By applying a remaining useful life of 1,000 hours and 2.7 hours of use per day, the period over which savings can be calculated with an incandescent baseline has been established at one year.
- › The current Canadian regulation bans the import of 60 W, 75 W and 100 W light bulbs, imposes a minimum efficiency to be achieved by “efficient” incandescent light bulbs (also called halogen incandescent light bulbs)¹¹⁷, and reflects the USA's federal legislation (as shown in the following table). After the first year over which incandescents remain the baseline, the baseline is increased to halogen incandescent lamps.

¹¹⁴ Illinois Energy Efficiency Stakeholder Advisory Group, *Illinois Statewide Technical Reference Manual for Energy Efficiency Version 6.0, Volume 3*, February 2017, p. 258.

¹¹⁵ Massachusetts Electric and Gas Energy Efficiency Program Administrators, *Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures, 2016-2018 Program Years – Plan Version*, October 2015, p. 151.

¹¹⁶ Lighting Research Center. Rensselaer Polytechnic Institute. *Lighting Patterns for Homes. Light Bulb Features*, www.lrc.rpi.edu/patternbook/resources/lamp_features.asp. (Last accessed January 24, 2018).

¹¹⁷ Natural Resources Canada. *Energy Efficiency Regulations. General Service Lamps and Modified Spectrum Incandescent Lamps*, www.nrcan.gc.ca/energy/regulations-codes-standards/products/6869 (Last accessed January 24, 2018).

- › The next anticipated regulation expected to be imposed in the USA by federal legislation will impose an efficiency level of 45 lumens per watt in 2020¹¹⁸, as shown in the following table. The U.S. Energy Independence and Security Act of 2007 (EISA) mandates that general-service light bulbs must achieve 45 lumens per watt as of January 1, 2020. Considering that Canada's residential lighting market is also evolving rapidly and is closely following the trends in the U.S. market, the Evaluator considers it advisable to pay close attention to the anticipated U.S. legislation in establishing the baseline wattage. NRCAN intends to update the general service lamps minimum energy performance requirement in Amendment 16 to the Energy Efficiency Regulations of Canada, which is scheduled for pre-consultation in 2019¹¹⁹ and is therefore expected to come into force within a few years after 2019. The intent is to align the Canadian regulations with the requirements in force or soon to be put in force in the United States, namely EISA 2020, as far as general-service lighting products are concerned. This Amendment 16 would effectively ban the import and fabrication of halogen incandescent lamps as a result of the minimum acceptable efficiency level being higher than halogen incandescent technology efficiency. Incandescent light bulbs are expected to be available in retail outlets for up to two years after the legislation is implemented before their stocks are depleted.

The displaced wattage values for replaced light bulbs of 40 W, 60 W and 100 W during the EUL of LEDs and their annual average displaced wattage values are shown in Table 74 below.

Table 74: Baseline Evolution during the Effective Useful Life of LED A19 Lamps

Replaced Lamp (W)	Typical Efficient Lamp (W)	Incandescent Baseline 1 year (2017)		Halogen Incandescent Baseline – Canadian Legislation ^{120,121} 6 years (2018-2023)		CFL Equivalent Baseline – American Legislation ¹²² 18 years (2024-2041)	
		Baseline (W)	Displaced Wattage (W)	Baseline (W)	Displaced Wattage (W)	Baseline (W) ¹²³	Displaced Wattage (W)
40	9	40	31	29	20	12	3
60	9	60	51	43	34	20	11
100	9	100	91	72	63	35	26

¹¹⁸ US EPA. Summary of the Energy Independence and Security Act. Public Law 110-140 (2007).

Online : www.epa.gov/laws-regulations/summary-energy-independence-and-security-act

¹¹⁹ Natural Resources Canada. *Forward Regulatory Plan 2017-19*, <http://www.nrcan.gc.ca/energy/regulations-codes-standards/18318> (Last accessed January 24, 2018).

¹²⁰ Natural Resources Canada. *Energy Efficiency Regulations. General Service Lamps and Modified Spectrum Incandescent Lamps*, www.nrcan.gc.ca/energy/regulations-codes-standards/products/6869, (Last accessed January 24, 2018).

¹²¹ Also equivalent to Incandescent Equivalent 1st Tier EISA 2007.

¹²² As imposed by U.S. federal legislation. Incandescent Equivalent 2nd Tier EISA 2007.

¹²³ Baseline wattage values were established based on the minimum efficiency level of 45 lumen/watts dictated by the EISA regulation and on the assumed lumen levels of 550 lumens for 40-watt lamps, 800 lumens for 60-watt lamps and 1,600 lumens for 100-watt lamps.

The following equation was used to establish the equivalent EUL to be applied to first-year savings to determine the lifetime energy savings.

$$EUL = \frac{\Delta W_{Incandescent} \times 1 \text{ year} + \Delta W_{Halogen} \times 6 \text{ years} + \Delta W_{CFL} \times 18 \text{ years}}{\Delta W_{Incandescent}}$$

The resulting equivalent EUL values for A19 LED lamps typically replacing 40 W, 60 W and 100 W incandescent lamps are respectively seven, nine and ten years. It should be noted that using the minimum efficiency levels of EISA 2020 starting in 2024 until the end of the EUL is optimistic. Because LED lamps are rapidly gaining popularity while CFLs' market shares are declining, it is possible that, by 2024, the baseline for covered lamps will be LEDs.¹²⁴ In that case, savings would occur over a maximum of seven years. However, since it is difficult to determine this with certainty, the Evaluator preferred using the efficiency levels set in the proposed American legislation until the end of the EUL of A19 LED lamps.

A similar analysis was conducted for reflector lamps (GU10 lamps), and the results are outlined in Table 75. While reflector lamps are not impacted by the current Canadian regulation, they will be affected by the requirements of EISA 2020. Starting in 2024, the baseline wattage is therefore increased to match the minimum efficiency level of 45 lumen/watt. Using an approximate lumen level of 350 lumens and 430 lumens for 35 W and 50 W lamps respectively, the baseline wattage values are found to be essentially at the level of LED lamps currently installed. Since currently there is no intermediate technology between halogen and LED reflector lamps, it is recommended to cap the equivalent EUL of reflector lamps at seven years.

Table 75: Baseline Evolution during the Effective Useful Life of LED Reflector Lamps

Replaced Lamp (W)	Typical Efficient Lamp (W)	Halogen Baseline 7 years (2017-2023)		CFL Equivalent Baseline – American Legislation ¹²⁵ 18 years (2024-2041)	
		Baseline (W)	Displaced wattage (W)	Baseline (W)	Displaced wattage (W)
35	7	35	28	8	1
50	7	50	43	10	3

As for decorative lamps (G25 and chandelier lamps), CFL replacements are not widely available in the market. Using an approximate lumen level of 300 lumens for G25 lamps and E12 chandelier lamps, the baseline wattage values are also found to be very close to the efficient LED lamp wattage. As presented

¹²⁴ Barclay, D., von Trapp, K. and Miziolek C.,

Party Like It's 2020: EISA Phase 2 – An Examination of DOE Rulemaking and Implications for Programs, Poster presented at the 2017 International Energy Program Evaluation Conference, Baltimore, MD.

¹²⁵ As imposed by US federal legislation. Incandescent Equivalent 2nd Tier EISA 2007.

in Table 76, the Evaluator has therefore applied the same approach as for reflector lamps and has capped the savings at seven years, since they will also be affected by the requirements of EISA 2020.

Table 76: Baseline Evolution during the Effective Useful Life of LED Decorative Lamps

Lamp Type	Replaced Lamp (W)	Typical Efficient Lamp (W)	Halogen Baseline 7 years (2017-2023)		CFL Equivalent Baseline – American Legislation ¹²⁶ 8 years (2024-2031)	
			Baseline (W)	Displaced wattage (W)	Baseline (W)	Displaced wattage (W)
G25	40	7	40	33	7	0
E12 Chandelier	40	5	40	35	7	2

Finally, LED nightlights and LED holiday lights are not affected by the Canadian or American legislation since they are not defined as general-service lamps (they generate less than 310 lumens). For LED nightlights, it is recommended to use their equipment life of 23 years as the equivalent EUL. For LED holiday lights, it is recommended to cap their equivalent EUL at 25 years because it is very unlikely that this product will produce savings throughout its entire equipment life of 129 years¹²⁷ considering factors such as early replacement.

13.1.14 Revised Gross Savings

The annual gross savings for each category of product installed in 2017 through EPI are listed in Table 77 for single-family homes and in Table 78 for apartments. Overall, the total gross energy and peak demand savings amounted to 19.439 GWh and 2.317 MW at the generator, which represents 170.989 GWh in lifetime energy savings, based on a weighted average EUL value of 8.80 years.

The tables below also show the estimated gross savings at the generator using a line loss factor of 1.099 between the meter and the generator. This value comes from a weighted average of the line loss factors of EPI participants according to their rate code (the residential rate code corresponds to a line loss factor of 10.0%, the municipal rate code 4.6%, and the small general rate code 9.5%).

¹²⁶ As imposed by US federal legislation. Incandescent Equivalent 2nd Tier EISA 2007.

¹²⁷ An equipment life of 129 years was established based on an average rated lifetime hours of 30,000 hours for holiday lights installed under EPI and annual hours of use of 232 hours.

Table 77: Revised Gross Energy and Peak Demand Savings by Product Category for EPI Single-family Homes

Category of Product	LED Lamps					
	9W Replacing 40W	9W Replacing 60W	9W Replacing 100W	9.5W Replacing 40W	9.5W Replacing 60W	9.5W Replacing 100W
Energy Savings						
Total Number of Units	5,752	206,973	2,794	1,513	24,718	849
Installation Rate (%)	98%	98%	98%	98%	98%	98%
Total Number of Units Installed	5,637	202,834	2,738	1,483	24,224	832
Unitary Savings Value (kWh)	30.6	50.3	89.7	30.1	49.8	89.2
Interactive Effects Factor	-16.9%	-16.9%	-16.9%	-16.9%	-16.9%	-16.9%
Total Gross Energy Savings – at the Meter (GWh)	0.143	8.478	0.204	0.037	1.002	0.062
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099
Total Gross Energy Savings – at the Generator (GWh)	0.158	9.318	0.224	0.041	1.102	0.068
Effective Useful Life (years)	7	9	10	7	9	10
Gross Lifetime Energy Savings – at the Generator (GWh)	1.103	83.859	2.243	0.285	9.915	0.678
Peak Demand Savings						
Demand-to-energy Ratio ¹²⁸	0.120	0.120	0.120	0.120	0.120	0.120
Total Gross Peak Demand Savings – at the Meter (MW)	0.017	1.017	0.024	0.004	0.120	0.007
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099
Total Gross Peak Demand Savings – at the Generator (MW)	0.019	1.118	0.027	0.005	0.132	0.008

¹²⁸ Peak demand-to-energy ratios are applied to the total gross energy savings at the meter. Ratios from Navigant are used as is, but ratios for lighting products were adjusted to account for the difference in interactive effects factors for energy and peak demand savings.

Revised Gross Energy and Peak Demand Savings by Product Category for EPI Single-family Homes (Continued)

Category of Product	LED Lamps						
	11W Replacing 60W	18W Replacing 75W	18W Replacing 100W	7W GU10 Replacing 35W	7W GU10 Replacing 50W	7W G25	5W Chandelier E12
Energy Savings							
Total Number of Units	12	191	1,596	1,806	11,410	4,041	28,298
Installation Rate (%)	98%	98%	98%	98%	98%	98%	98%
Total Number of Units Installed	12	187	1,564	1,770	11,182	3,960	27,732
Unitary Savings Value (kWh)	48.3	56.2	80.8	27.6	42.4	32.5	34.5
Interactive Effects Factor	-16.9%	-16.9%	-16.9%	-17.7%	-17.7%	-17.7%	-17.7%
Total Gross Energy Savings – at the Meter (GWh)	0.000	0.009	0.105	0.040	0.390	0.106	0.787
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099	1.099
Total Gross Energy Savings – at the Generator (GWh)	0.001	0.010	0.115	0.044	0.429	0.116	0.865
Effective Useful Life (years)	9	9	10	7	7	7	7
Gross Lifetime Energy Savings – at the Generator (GWh)	0.005	0.086	1.154	0.309	3.002	0.815	6.058
Peak Demand Savings							
Demand-to-energy Ratio	0.120	0.120	0.120	0.117	0.117	0.117	0.117
Total Gross Peak Demand Savings – at the Meter (MW)	0.000	0.001	0.013	0.005	0.046	0.012	0.092
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099	1.099
Total Gross Peak Demand Savings – at the Generator (MW)	0.000	0.001	0.014	0.005	0.050	0.014	0.101

Revised Gross Energy and Peak Demand Savings by Product Category for EPI Single-family Homes (Continued)

Category of Product	LED Holiday Lights ¹²⁹	LED Nightlights	Faucet Aerators	Low-flow Showerheads		
				0.5 gpm Reduction	0.75 gpm Reduction	1.0 gpm Reduction
Energy Savings						
Total Number of Units	661	8,533	7,317	883	1,225	2,438
Installation Rate (%)	100%	97%	93%	89%	89%	89%
Total Number of Units Installed	661	8,277	6,805	786	1,090	2,170
Unitary Savings Value (kWh)	43.6	28.5	98	236	354	472
Interactive Effects Factor	-8.4%	-17.7%	0%	0%	0%	0%
Total Gross Energy Savings –at the Meter (GWh)	0.026	0.194	0.667	0.185	0.386	1.024
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099
Total Gross Energy Savings – at the Generator (GWh)	0.029	0.213	0.733	0.204	0.424	1.126
Effective Useful Life (years)	25	23	10	10	10	10
Gross Lifetime Energy Savings – at the Generator (GWh)	0.725	4.907	7.329	2.038	4.242	11.255
Peak Demand Savings						
Demand-to-energy Ratio	1.333	0.117	0.162	0.162	0.162	0.162
Total Gross Peak Demand Savings – at the Meter (MW)	0.035	0.023	0.108	0.030	0.063	0.166
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099
Total Gross Peak Demand Savings at the Generator (MW)	0.039	0.025	0.119	0.033	0.069	0.182

¹²⁹ Since no information was provided on the building type in which LED holiday lights were installed, the Evaluator compiled all savings associated to this product under the “Single-family Homes” savings table.

Revised Gross Energy and Peak Demand Savings by Product Category for EPI Single-family Homes (Continued)

Category of Product	Pipe Insulation	Hot Water Tank Wrap	Smart Power Controllers	Total for Single-Family Homes
Energy Savings				
Total Number of Units	23,422	3,528	6,117	344,077
Installation Rate (%)	106%	97%	57%	-
Total Number of Units Installed	24,827	3,422	3,487	335,679
Unitary Savings Value (kWh)	12.7	159	411	-
Interactive Effects Factor	-12.9%	-12.9%	0.0%	-
Total Gross Energy Savings – at the Meter (GWh)	0.275	0.474	1.433	16.030
Line Loss Factor	1.099	1.099	1.099	-
Total Gross Energy Savings – at the Generator (GWh)	0.302	0.521	1.575	17.616
Effective Useful Life (years)	15	7	4	-
Gross Lifetime Energy Savings – at the Generator (GWh)	4.527	3.646	6.300	154.482
Peak Demand Savings				
Demand-to-energy Ratio	0.162	0.162	0.000	-
Total Gross Peak Demand Savings – at the Meter (MW)	0.044	0.077	0.000	1.906
Line Loss Factor	1.099	1.099	1.099	-
Total Gross Peak Demand Savings – at the Generator (MW)	0.049	0.084	0.000	2.094

Table 78: Revised Gross Energy and Peak Demand Savings by Product Category for EPI Apartments

Category of Product	LED Lamps					
	9W Replacing 40W	9W Replacing 60W	9W Replacing 100W	9.5W Replacing 40W	9.5W Replacing 60W	9.5W Replacing 100W
Energy Savings						
Total Number of Units	397	23,390	1,052	68	438	4
Installation Rate (%)	98%	98%	98%	98%	98%	98%
Total Number of Units Installed	389	22,922	1,031	67	429	4
Unitary Savings Value (kWh)	30.6	50.3	89.7	30.1	49.8	89.2
Interactive Effects Factor	-16.9%	-16.9%	-16.9%	-16.9%	-16.9%	-16.9%
Total Gross Energy Savings – at the Meter (GWh)	0.010	0.958	0.077	0.002	0.018	0.000
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099
Total Gross Energy Savings – at the Generator (GWh)	0.011	1.053	0.084	0.002	0.020	0.000
Effective Useful Life (years)	7	9	10	7	9	10
Gross Lifetime Energy Savings – at the Generator (GWh)	0.076	9.477	0.845	0.013	0.176	0.003
Peak Demand Savings						
Demand-to-energy Ratio	0.120	0.120	0.120	0.120	0.120	0.120
Total Gross Peak Demand Savings – at the Meter (MW)	0.001	0.115	0.009	0.000	0.002	0.001
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099
Total Gross Peak Demand Savings – at the Generator (MW)	0.001	0.126	0.010	0.000	0.002	0.001

Revised Gross Energy and Peak Demand Savings by Product Category for EPI Apartments (Continued)

Category of Product	LED Lamps						
	11W Replacing 60W	18W Replacing 75W	18W Replacing 100W	7W GU10 Replacing 35W	7W GU10 Replacing 50W	7W G25	5W Chandelier E12
Energy Savings							
Total Number of Units	0	6	52	90	1,060	340	1,503
Installation Rate (%)	98%	98%	98%	98%	98%	98%	98%
Total Number of Units Installed	0	6	51	88	1,039	333	1,473
Unitary Savings Value (kWh)	48.3	56.2	80.8	27.6	42.4	32.5	34.5
Interactive Effects Factor	-16.9%	-16.9%	-16.9%	-17.7%	-17.7%	-17.7%	-17.7%
Total Gross Energy Savings – at the Meter (GWh)	0.000	0.000	0.003	0.002	0.036	0.009	0.042
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099	1.099
Total Gross Energy Savings – at the Generator (GWh)	0.000	0.000	0.004	0.002	0.040	0.010	0.046
Effective Useful Life (years)	9	9	10	7	7	7	7
Gross Lifetime Energy Savings – at the Generator (GWh)	0.000	0.003	0.038	0.015	0.279	0.069	0.322
Peak Demand Savings							
Demand-to-energy Ratio	0.120	0.120	0.120	0.117	0.117	0.117	0.117
Total Gross Peak Demand Savings – at the Meter (MW)	0.000	0.000	0.000	0.000	0.004	0.001	0.005
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099	1.099
Total Gross Peak Demand Savings – at the Generator (MW)	0.000	0.000	0.000	0.000	0.005	0.001	0.005

Revised Gross Energy and Peak Demand Savings by Product Category for EPI Apartments (Continued)

Category of Product	LED Holiday Lights	LED Nightlights	Faucet Aerators	Low-flow Showerheads		
				0.5 gpm Reduction	0.75 gpm Reduction	1.0 gpm Reduction
Energy Savings						
Total Number of Units	0	1,142	1,208	70	176	410
Installation Rate (%)	100%	97%	93%	89%	89%	89%
Total Number of Units Installed	0	1,108	1,123	62	157	365
Unitary Savings Value (kWh)	43.6	28.5	95	207	310	413
Interactive Effects Factor	-8.4%	-17.7%	0.0%	0.0%	0.0%	0.0%
Total Gross Energy Savings –at the Meter (GWh)	0.000	0.026	0.107	0.013	0.049	0.151
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099
Total Gross Energy Savings – at the Generator (GWh)	0.000	0.029	0.117	0.014	0.053	0.166
Effective Useful Life (years)	25	23	10	10	10	10
Gross Lifetime Energy Savings – at the Generator (GWh)	0.000	0.657	1.173	0.142	0.534	1.656
Peak Demand Savings						
Demand-to-energy Ratio	1.333	0.117	0.162	0.162	0.162	0.162
Total Gross Peak Demand Savings – at the Meter (MW)	0.000	0.003	0.017	0.002	0.008	0.024
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099
Total Gross Peak Demand Savings at the Generator (MW)	0.000	0.003	0.019	0.002	0.009	0.027

Revised Gross Energy and Peak Demand Savings by Product Category for EPI Apartments (Continued)

Category of Product	Pipe Insulation	Hot Water Tank Wrap	Smart Power Controllers	Total for Apartments
Energy Savings				
Total Number of Units	1,543	380	429	33,758
Installation Rate (%)	106%	97%	57%	-
Total Number of Units Installed	1,636	369	245	32,896
Unitary Savings Value (kWh)	12.7	118	411	-
Interactive Effects Factor	-12.9%	-12.9%	0.0%	-
Total Gross Energy Savings – at the Meter (GWh)	0.018	0.038	0.101	1.659
Line Loss Factor	1.099	1.099	1.099	-
Total Gross Energy Savings – at the Generator (GWh)	0.020	0.042	0.110	1.823
Effective Useful Life (years)	15	7	4	-
Gross Lifetime Energy Savings – at the Generator (GWh)	0.298	0.291	0.442	16.507
Peak Demand Savings				
Demand-to-energy Ratio	0.162	0.162	0.000	-
Total Gross Peak Demand Savings – at the Meter (MW)	0.003	0.006	0.000	0.202
Line Loss Factor	1.099	1.099	1.099	-
Total Gross Peak Demand Savings – at the Generator (MW)	0.003	0.007	0.000	0.222

13.2 Net-to-gross Ratio

The NTGR allows for determining the net savings, i.e., the energy savings that can be reliably attributed to a program component. More precisely, the NTGR represents the positive or negative impact of the effects on the gross savings. In the case of EPI, two effects were considered, namely free-ridership and internal spillover.

13.2.1 Free-ridership

For EPI, free-ridership can occur when participants would still have installed the energy-efficient products in the absence of the program component. The free-ridership level was assessed using a self-report approach, which involved asking non-low-income participants a set of questions during a telephone survey.

The questions were designed to assess the likelihood for participants to have purchased and installed their energy-efficient products in the absence of the program component. The questions consider all the applicable variables related to the decision-making process, including planning, efficiency, quantity, timing and cost. Additional questions were used to determine the extent to which participants' decisions on whether to have products installed had been influenced by previous participation in one of ENS's program components or by ENS's efforts to raise awareness about energy efficiency.

In the past few years, the Evaluator used the participant survey to assess free-ridership for LED lamps and DHW measures. Since free-ridership for DHW products had been very low for several years (13% in 2016 for RDI and 0% in 2013 for RP&C), and these products do not contribute a large share of the overall savings, the Evaluator only focused on LED lamps in the 2017 evaluation. Separate free-ridership levels were established for owners and tenants, since the Evaluator expected free-ridership levels to be lower for tenants.

The feedback collected from the participants who had LED lamps installed was converted into an overall free-ridership level for each participant. Furthermore, different free-ridership levels were established for owners and tenants. The algorithm behind this calculation is presented in Appendix XXI.

Using this approach to analyze the survey results, free-ridership levels of 26 percent for owners and 14 percent for tenants were established for LED lamps. The overall free-ridership level for all non-low-income participants was established at 25 percent for LED lamps in 2017 (tenants accounted for only 2 percent of the overall lighting savings). This level is lower than the levels established in 2016 for RDI (30%) and RP&C (30%).

As for the other types of products installed through EPI, the Evaluator considers the free-ridership value for those products to be nil.

As a result, an overall free-ridership level of 18 percent was established for all non-low-income participants. Table 79 summarizes the free-ridership levels.

**Table 79: Average Free-ridership Level by Product Category for EPI
Non-low-income Participants**

Measure Category	Average Free-ridership Level	Sample Size	Population Size ¹³⁰	Margin of Error	Percentage of Gross Energy Savings in EPI
LED Lighting					
Owners	26%	49	7,006	5.0%	70%
Tenants	14%	31	180	3.9%	1%
All Participants	25%	NA	NA	NA	72%
Other Products					
All Participants	0%	NA	NA	NA	28%
All Products					
All Participants	18%	NA	NA	NA	100%

13.2.2 Internal Spillover

For EPI, internal spillover occurs when participants purchase and install additional energy-efficient products under the influence of their previous participation in the program component, yet without receiving any kind of additional support from the program component.

The participant survey results were used to assess internal spillover. The methodology used to calculate the level of internal spillover is presented in Appendix XXII. As with the free-ridership levels, spillover levels were separately established for owners and tenants, because the Evaluator expected the tenants' spillover level to be lower than that of the owners.

Based on the 2017 survey results, an internal spillover factor has been established at 6 percent for non-low-income owners and 1 percent for non-low-income tenants. For all non-low-income participants, an internal spillover factor has been established at 6 percent, which is higher than the 2016 spillover factor (5%) and the 2015 spillover factor (2%). Table 80 summarizes the spillover levels.

Table 80: Average Internal Spillover Level for EPI Non-low-income Participants

Product Category	Average Internal Spillover Level	Sample Size	Population Size ¹³¹	Margin of Error	Percentage of Gross Energy Savings in EPI
All Products					
Owners	6%	63	7,525	4.1%	98%
Tenants	1%	37	202	2.1%	2%
All Participants	6%	NA	NA	NA	100%

¹³⁰ Population size is based on the number of unique reference numbers.

¹³¹ Population size is based on the number of unique reference numbers.

13.2.3 NTGR Calculation

The NTGR has been calculated using the following equation:

$$NTGR = (1 - \% \text{ free-ridership} + \% \text{ internal spillover})$$

Using the free-ridership and internal spillover levels established for non-low-income participants, the NTGR value for this group of participants has been established at 0.87 for tenants and 0.80 for owners for LED lamps. The NTGR for low-income participants is assumed to be 1.00. Using the proportions of the savings respectively associated with low-income and non-low-income participants, the overall NTGR values has been established at 0.87 for LED lamps, as listed in Table 81. The same methodology was applied to other product categories, except that free-ridership was assumed to be nil for all types of participants. The NTGR was established at 1.01 for tenants and at 1.06 for owners. Based on the total gross evaluated savings of each product type (LED lamps and other products), the weighted average NTGR has been established at 0.92.

Table 81: Overall NTGR Calculation

	LED Lamps			Other Products		
	Non-low-income Participants		Low-income Participants	Non-low-income Participants		Low-income Participants
	Tenants	Owners		Tenants	Owners	
NTGR	0.87	0.80	1.00	1.01	1.06	1.00
Proportion of Gross Savings	1%	65%	34%	2%	59%	39%
NTGR for All Participants	0.87			1.04		
Overall NTGR	0.92					

13.3 Net Savings

Net savings are defined as the energy-use reductions that are specifically attributable to EPI. Net impacts were estimated by applying the overall NTGR shown above to the gross savings and using the following equation:

$$Net\ Savings = Gross\ Savings \times NTGR$$

This equation was used to calculate both peak demand savings and energy savings.

The net energy savings for EPI in 2017 have been estimated at 17.877 GWh at the generator, and the peak demand savings at 2.129 MW at the generator. By applying 0.6531 kg CO₂ eq/kWh, which is Nova Scotia's specific factor¹³² for GHG emissions generated by electricity production, it is estimated that the net energy savings have resulted in 11,675 tonnes of avoided CO₂ eq annually. Based on the average EUL of 8.80 years, the net lifetime energy savings were established at 157.288 GWh.

The detailed results are shown in Table 82, with all building types combined.

¹³² At the time of writing, 2017 data was not available. The Nova Scotia-specific factor was obtained from Nova Scotia Power's 2016 total system emissions data (7,079,268 CO₂ eq tonnes) and total electricity generation (10,839 GWh), from the following two sources:

Nova Scotia Power, *Total System Emissions*, <http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx> (Last accessed December 17, 2017).

Emera Inc., *Management's Discussion & Analysis As at February 10, 2017*, <http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693> (Last accessed December 17, 2017)

Table 82: Evaluated Net Energy and Peak Demand Savings by Product Category for EPI

Category of Product	LED Lamps					
	9W Replacing 40W	9W Replacing 60W	9W Replacing 100W	9.5W Replacing 40W	9.5W Replacing 60W	9.5W Replacing 100W
Energy Savings						
Total Gross Energy Savings – at the Meter (GWh)	0.153	9.436	0.281	0.039	1.020	0.062
NTGR	0.87	0.87	0.87	0.87	0.87	0.87
Total Net Energy Savings – at the Meter (GWh)	0.133	8.210	0.244	0.034	0.888	0.054
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099
Total Net Energy Savings – at the Generator (GWh)	0.147	9.022	0.269	0.037	0.975	0.059
Effective Useful Life (years)	7	9	10	7	9	10
Net Lifetime Energy Savings – at the Generator (GWh)	1.026	81.202	2.686	0.259	8.779	0.592
Peak Demand Savings						
Total Gross Peak Demand Savings – at the Meter (MW)	0.018	1.132	0.034	0.005	0.122	0.007
NTGR	0.87	0.87	0.87	0.87	0.87	0.87
Total Net Peak Demand Savings – at the Meter (MW)	0.016	0.985	0.029	0.004	0.107	0.006
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099
Total Net Peak Demand Savings – at the Generator (MW)	0.018	1.083	0.032	0.004	0.117	0.007

Evaluated Net Energy and Peak Demand Savings by Product Category for EPI (Continued)

Category of Product	LED Lamps						
	11W Replacing 60W	18W Replacing 75W	18W Replacing 100W	7W GU10 Replacing 35W	7W GU10 Replacing 50W	7W G25	5W Chandelier E12
Energy Savings							
Total Gross Energy Savings – at the Meter (GWh)	0.000	0.009	0.108	0.042	0.426	0.115	0.829
NTGR	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Total Net Energy Savings – at the Meter (GWh)	0.000	0.008	0.094	0.037	0.371	0.100	0.721
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099	1.099
Total Net Energy Savings – at the Generator (GWh)	0.000	0.009	0.104	0.040	0.408	0.110	0.793
Effective Useful Life (years)	9	9	10	7	7	7	7
Net Lifetime Energy Savings – at the Generator (GWh)	0.004	0.078	1.037	0.282	2.854	0.769	5.550
Peak Demand Savings							
Total Gross Peak Demand Savings – at the Meter (MW)	0.000	0.001	0.013	0.005	0.050	0.013	0.097
NTGR	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Total Net Peak Demand Savings – at the Meter (MW)	0.000	0.001	0.011	0.004	0.043	0.012	0.084
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099	1.099
Total Net Peak Demand Savings – at the Generator (MW)	0.000	0.001	0.012	0.005	0.048	0.013	0.093

Evaluated Net Energy and Peak Demand Savings by Product Category for EPI (Continued)

Category of Product	LED Holiday Lights	LED Nightlights	Faucet Aerators	Low-flow Showerheads		
				0.5 gpm Reduction	0.75 gpm Reduction	1.0 gpm Reduction
Energy Savings						
Total Gross Energy Savings – at the Meter (GWh)	0.026	0.220	0.774	0.198	0.435	1.175
NTGR	1.04	1.04	1.04	1.04	1.04	1.04
Total Net Energy Savings – at the Meter (GWh)	0.027	0.229	0.805	0.206	0.452	1.222
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099
Total Net Energy Savings – at the Generator (GWh)	0.030	0.252	0.884	0.227	0.497	1.343
Effective Useful Life (years)	25	23	10	10	10	10
Net Lifetime Energy Savings – at the Generator (GWh)	0.754	5.787	8.842	2.267	4.966	13.428
Peak Demand Savings						
Total Gross Peak Demand Savings – at the Meter (MW)	0.035	0.026	0.125	0.032	0.070	0.190
NTGR	1.04	1.04	1.04	1.04	1.04	1.04
Total Net Peak Demand Savings – at the Meter (MW)	0.037	0.027	0.130	0.033	0.073	0.198
Line Loss Factor	1.099	1.099	1.099	1.099	1.099	1.099
Total Net Peak Demand Savings – at the Generator (MW)	0.040	0.029	0.143	0.037	0.080	0.218

Evaluated Net Energy and Peak Demand Savings by Product Category for EPI (Continued)

Category of Product	Pipe Insulation	Hot Water Tank Wrap	Smart Power Controllers	Total for All Products
Energy Savings				
Total Gross Energy Savings – at the Meter (GWh)	0.293	0.512	1.534	17.688
NTGR	1.04	1.04	1.04	0.92
Total Net Energy Savings – at the Meter (GWh)	0.304	0.532	1.595	16.267
Line Loss Factor	1.099	1.099	1.099	-
Total Net Energy Savings – at the Generator (GWh)	0.335	0.585	1.753	17.877
Effective Useful Life (years)	15	7	4	-
Net Lifetime Energy Savings – at the Generator (GWh)	5.019	4.095	7.011	157.288
Peak Demand Savings				
Total Gross Peak Demand Savings – at the Meter (MW)	0.047	0.083	0.000	2.108
NTGR	1.04	1.04	1.04	0.92
Total Net Peak Demand Savings – at the Meter (MW)	0.049	0.086	0.000	1.937
Line Loss Factor	1.099	1.099	1.099	-
Total Net Peak Demand Savings – at the Generator (MW)	0.054	0.095	0.000	2.129

Table 83 compares the energy and peak demand savings established by this evaluation and those claimed in the 2017 tracking report.

Table 83: Comparison of Tracked and Evaluated Savings at the Generator

	Initial Gross Savings	Adjusted Gross Savings	NTGR*	Net Savings
Energy Savings				
ENS Tracked Savings	21.257 GWh	20.460 GWh	0.88	18.082 GWh
Evaluation Results	21.308 GWh	19.439 GWh	0.92	17.877 GWh
Peak Demand Savings				
ENS Tracked Savings	3.487 MW	3.461 MW	0.87	3.012 MW
Evaluation Results	2.401 MW	2.317 MW	0.92	2.129 MW
*The average NTGR values listed in this table correspond to the ratio of the net savings to the gross savings for all the product categories combined.				

The overall evaluated net energy savings are 1 percent lower than the tracked net energy savings. The decrease in the overall installation rate (from 96% to 91%) was balanced out by the increase in the NTGR value (from 0.88 to 0.92). The decrease in the overall installation rate was mainly attributable to the decrease in the smart power controller installation rate (from 78% to 57%). The adjustments made to the unitary savings and the interactive effects had only a small impact.

The evaluated net peak demand savings were 29 percent lower than the tracked net peak demand savings. This difference was mainly associated with the lower evaluated peak demand-to-energy ratios used for lighting products based on the findings of the Residential Lighting Metering Study.

14 OVERALL SAVINGS FOR THE EXISTING RESIDENTIAL PROGRAM

Table 84 below summarizes the participation level, as well as the gross and net savings for each Existing Residential program component and for the whole program.

Table 84: Overall Savings for Existing Residential

	Participation Level	Gross Savings	NTGR	Net Savings
HEA				
Energy Savings	931 participants	8.306 GWh	0.76	7.007 GWh
Lifetime Energy Savings		166.116 GWh	0.76	140.139 GWh
Peak Demand Savings		2.348 MW	0.76	1.981 MW
Green Heat				
Energy Savings	1,829 measures installed	5.026 GWh	0.59	2.980 GWh
Lifetime Energy Savings		91.027 GWh	0.59	53.925 GWh
Peak Demand Savings		5.114 MW	0.60	3.073 MW
EPI				
Energy Savings	13,672 participants	19.439 GWh	0.92	17.877 GWh
Lifetime Energy Savings		170.989 GWh	0.92	157.288 GWh
Peak Demand Savings		2.317 MW	0.92	2.129 MW
Total				
Energy Savings		32.771 GWh		27.864 GWh
Lifetime Energy Savings		428.132 GWh		351.352 GWh
Peak Demand Savings		9.779 MW		7.183 MW

CONCLUSION

The Existing Residential program is comprised of two well-established program components (HEA and Green Heat) and a new component (EPI, which has resulted from the merger of RDI and RP&C in early 2017). Existing Residential aimed to achieve 33.4 GWh in net energy and 6.5 MW in peak demand savings in 2017. It actually achieved 27.864 GWh in net energy savings and 7.183 MW in net peak demand savings at the generator in 2017, resulting in 18,197 tonnes of avoided CO₂ eq annually. The total net lifetime energy savings amount to 351.352 GWh. Therefore, the program succeeded in achieving its planned peak demand savings, but failed to achieve its planned energy savings. EPI was the biggest contributor to the program's total net energy savings, while Green Heat was the biggest contributor to total net peak demand savings in 2017. Although Green Heat did not achieve its planned energy savings (with a shortfall of 0.550 GWh), it was EPI's failure to achieve its planned energy savings (with a shortfall of 6.533 GWh) that accounted for the bulk of the 5.486 GWh difference between the planned energy savings and the evaluated results for 2017.

The following subsections summarize the main findings about each of the three Existing Residential program components.

Home Energy Assessment

HEA performed well in 2017, achieving 7.007 GWh in net energy savings and 1.981 MW in net peak demand savings at the generator and thus exceeding the planned energy and peak demand savings and 2016 results. A total of 931 participants completed projects through HEA in 2017, an increase compared to 2016 (893 participants).

Satisfaction with HEA was generally high among both participants and the EAs. Participants especially appreciated the EAs' customer service and expertise, as well as the information provided to them through the initial energy assessment and the subsequent recommendations report. Homeowners also viewed getting expert advice on the most suitable upgrade options for their homes as a main motivation for participating in HEA. The main reasons cited by the small number of participants who were less satisfied with HEA were the rebate being too low and unclear program component requirements. Echoing this dissatisfaction, the main areas for HEA improvement suggested by participants included higher rebates and more clarity about the HEA incentive levels and how to qualify for the HEA incentives.

EAs were particularly satisfied with ENS's clear instructions on how to deliver HEA, HEA's integration with NRCAN guidelines and its environmental benefits. EAs echoed participant feedback, agreeing that the rebate calculation method is perhaps too complex for homeowners to understand and poorly explained in the program component materials.

Green Heat

Green Heat achieved 2.980 GWh in net energy savings and 3.073 MW in net peak demand savings in 2017, meeting its planned peak demand savings (1.7 MW) but not its planned energy savings (3.5 GWh). Participation increased significantly in the past two years, with 1,829 measures installed in 2017 in comparison to 1,018 in 2016 and only 298 in 2015. The introduction of MSHPs in late 2015, in combination with the removal of the pre-approval process and the inclusion of non-electrically heated households as of August 2017, contributed to higher participation. Despite the increase in participation level, net energy savings were lower than expected mainly because the revised savings values for MSHPs and ASHPs established through a billing analysis were much lower than the tracked values.

Over the past two years, the methodology used to establish energy savings has involved performing billing analyses and has resulted in improved accuracy. For MSHPs installed in non-electrically heated homes, more participant feedback is needed to establish their savings with greater accuracy. Conducting the survey with a bigger sample of such participants would help not only determine how Green Heat influences homeowners' decisions to replace non-electrical heating systems by MSHPs, but also more accurately define the baseline case. As for peak demand savings, documenting the performance data at a minimum temperature for all ASHPs would allow for establishing a more accurate unitary savings value because the currently used value was established based on only a small sample of models.

As a result of the change from a program component approach that required pre-approval (the old path) and excluded non-electrically heated homes to a new mail-in approach (the new path) that includes non-electrically heated homes, contractors are now more satisfied with Green Heat. Participants continued to report a high level of satisfaction as with the old path; the new path is less burdensome for ENS. Despite its positive impact on ENS and the contractors' satisfaction, the free-ridership measured among the new path participants using electrical heating was significantly higher than the free-ridership measured among old path participants. This increase in free-ridership can be explained by two main reasons: (1) participants can now apply for the program 90 days after purchasing their heat pump, thereby increasing the probability of those participants not having been influenced by Green Heat for their equipment purchase; and (2) the smaller amount of paperwork now makes participation more attractive for people who would not have bothered filling out the pre-approval forms previously required.

Some important data about the overall MSHP market in Nova Scotia was not available. So, the Evaluator could not determine with certainty this product category's current market adoption status. However, the market evolution assessment has revealed that the MSHP market has undergone many changes over the last few years. Heat pumps are becoming a more popular option as a primary heating system, and the number of MSHPs incentivized by ENS keeps increasing.

Efficient Product Installation

EPI achieved 17.877 GWh in net energy savings and 2.129 MW in net peak demand savings in 2017, failing to achieve its planned savings, namely 24.4 GWh and 3.6 MW respectively, mainly because the participation level was not as high as expected. It should be noted that the planned 2017 savings for EPI were relatively high, since the combined energy savings of RDI and RP&C in 2016 were 22.346 GWh. A total of 13,672 participants took part in EPI in 2017. Savings and participation have gone down in recent years mainly due to the decreasing pool of potential participants. Nonetheless, the program component has contributed significantly to the growth of energy-efficient lighting product penetration in Nova Scotia's market by providing direct installation of such products for over 100,000 participants since 2012.

As with RDI and RP&C in previous years, participant satisfaction with EPI was very high in 2017, indicating that the merger has been smooth and successful. Interactions with installers (including their work quality and the information they provided to participants), the time required to complete the work, and the energy-efficient products installed were all cited as reasons for this high level of satisfaction with EPI.

Again this year, LED lamps accounted for the bulk of savings, representing about two-thirds of the total net energy and peak demand savings. To continue improving LED lamps' savings calculations, the Evaluator conducted a residential metering study in 2017, validating the HOU-related assumptions used in energy savings calculations and refining the methodology used for calculating peak demand savings.

An analysis of the tracking report has shown that the number of A-type lamp replacements per home decreased significantly in 2017. The Evaluator believes that this was largely due to a decrease in the number of lighting sockets occupied by incandescent lamps, since participants probably purchased other lighting technologies to replace their burned-out lamps. A lower number of incandescent lamps in homes would suggest that the next step in maximizing LED lamps' savings and increasing EPI's total savings is to assess and document the energy-saving potential of other types of replacements, such as CFL and halogen incandescent lamps.

LIST OF APPENDICES

The following are presented in the Existing Residential Program – Appendices.

Home Energy Assessment

- Appendix I - HEA: 2017 Recommendations
- Appendix II - HEA: Interview Guide with the Energy Advisors
- Appendix III - HEA: Participant Survey Questionnaire
- Appendix IV - HEA: Participant Survey Results
- Appendix V - HEA: Algorithm for Free-ridership Calculation
- Appendix VI - HEA: Internal Spillover Methodology

Green Heat

- Appendix VII - GH: 2017 Recommendations
- Appendix VIII - GH: Contractor Interview Guide
- Appendix IX - GH: Old Path Participant Survey Questionnaire
- Appendix X - GH: Old Participant Survey Results
- Appendix XI - GH: New Path Participant Survey Questionnaire
- Appendix XII - GH: New Participant Survey Results
- Appendix XIII - GH: On-site Visit Sampling Methodology and Protocol
- Appendix XIV - GH: Algorithm for Free-ridership Calculation

Efficient Product Installation

Appendix XV - EPI: 2017 Recommendations

Appendix XVI - EPI: Participant Survey Questionnaire

Appendix XVII - EPI: Participant Survey Results

Appendix XVIII - EPI: On-site Visit Sampling Methodology and Protocol

Appendix XIX - EPI: Detailed Calculations Unitary Savings Values

Appendix XX - EPI: Residential Lighting Metering Study Report

Appendix XXI - EPI: Algorithm for Free-ridership Calculation

Appendix XXII - EPI: Internal Spillover Methodology



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EXISTING RESIDENTIAL PROGRAM

2017 DSM EVALUATION

EFFICIENCY NOVA SCOTIA

Appendix Report

March 15, 2018



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Appendix I

HEA: 2017 RECOMMENDATIONS

This appendix summarizes all the recommendations made by the Evaluator as part of the 2017 evaluation. There were no incomplete 2016 recommendations at the time of writing.

Section	Recommendations
Executive Summary	1. Review the current incentive structure to look for possible ways to simplify it. EAs and participants alike consider rebate calculations complicated. Knowing that ENS has already begun reviewing the incentive structure to make necessary changes, the Evaluator recommends continuing this effort while trying to make this structure as simple and straightforward as possible for both EAs and participants.
	2. Conduct a billing analysis to review the overestimation ratio. The Evaluator has found that a new version of HOT2000 was used to calculate savings for 9 percent of HEA participants. The Evaluator predicts that this proportion will probably increase in 2018. The Evaluator recommends conducting a new billing analysis in the next evaluation to establish an overestimation ratio specific to the new version of HOT2000 for HEA.

Appendix II

HEA: INTERVIEW GUIDE WITH THE ENERGY ADVISORS

PROGRAM NAME: HOME ENERGY ASSESSMENT

Interview date and time	
Company name	
Interviewee name	
Area code and phone number	
Email	

Introduction

Thank you for taking the time to speak with me. Today, I am interested in your opinion regarding Efficiency Nova Scotia's Home Energy Assessment program, from your perspective as a program partner. As you may know, Econoler, in partnership with Corporate Research Associates, is conducting a program evaluation again this year for the Home Energy Assessment program. Our discussion should last approximately half an hour.

Do you have any questions before we begin?

Part A: Involvement and Satisfaction

The first questions will be about your involvement in and satisfaction with the Home Energy Assessment program.

- A1. How long have you been an energy advisor for the Home Energy Assessment program (specify months or years)?
- A2. On a scale from 1 to 10, where 1 is "not at all satisfied" and 10 is "completely satisfied", how would you rate your satisfaction with the Home Energy Assessment Program in terms of...?

Aspects of the program	Score 1=not at all satisfied 10=completely satisfied NA=Not applicable DK=Don't know	Reason Please share the reason(s) for your score (regardless of the score).
The overall program		
Eligible measures and equipment		
The incentive structure		
Program marketing and outreach activities initiated by ENS		
Your relationship with ENS staff		
Communication with ENS staff (including how program updates and changes are communicated)		

A3. What challenges, if any, have you experienced in delivering the program so far in 2017?

A4a. What do you like and dislike about the Home Energy Assessment program?

A4b. What do you think customers like and dislike about the Home Energy Assessment program?

A5. What type of training or information, if any, is missing to help you better understand or deliver the program?

A6. I will read a list of topics that could be the focus of training sessions. Using a scale from 1 to 10, where 1 means “not at all useful” and 10 means “extremely useful”, please tell me how useful training sessions on these topics would be to you.

- ☐ The program in general including its guidelines, incentives and eligible measures
- ☐ The information that needs to be collected on-site, including how to use and fill out the data collection forms or other program documents
- ☐ Building envelope retrofit construction best practices
- ☐ Newer technologies like heat pump water heaters, solar PV (photovoltaic), etc.
- ☐ HOT2000 software
- ☐ Indoor air quality, including moisture and ventilation issues
- ☐ Other non-energy benefits, such as GHG emissions and increased comfort
- ☐ The other programs offered by ENS or other Canadian organizations
- ☐ What else, if anything, should training focus on to help you with the Home Energy Assessment Program?

A7. Thinking about how training can be delivered, please rank the following in order, from the most to the least appealing to you personally.

- ☐ In-person
- ☐ Online or webinar
- ☐ Over the phone
- ☐ Paper documentation
- ☐ What other training delivery method, if any, would you prefer?

Part B: Barriers and Recommendations

Now thinking of the program’s outreach...

B1. What could be done by ENS to increase the number of homes that register for a pre-retrofit assessment (in terms of marketing, outreach activities, technical support, etc.)? Is there anything that service organizations could do?

B2. What prevents homeowners from going through the program following the pre-retrofit assessment?

B3a. Are there upgrades recommended in the Homeowner Upgrade Report that are rarely implemented by participants? If so, which ones?

- B3b. What prevents participants from performing those upgrades?
- B3c. What can be done to encourage participants to implement all of the upgrades/the upgrades that are rarely implemented?
- B4. Do you have other suggestions to improve the Home Energy Assessment program?

Part C: Market Trends

Now, I am interested in hearing your thoughts on how energy efficiency has changed over the last few years.

- C1a. What changes or trends in energy efficiency in general, if any, have you seen over the past several years in the Nova Scotia residential market?

[If needed, probe for changes or trends related to the efficiency, materials or prices of energy efficiency products or equipment installed in Nova Scotia homes.]

- C1b. In your opinion, what explains these changes or trends?

[Probe whether the Home Energy Assessment program has had an influence: rebates/financing, ENS advertising and communications, etc.]

- C2a. More specifically, what changes have you observed in the last 5 years in terms of customers' choice of building envelope measures and heating systems for their homes?

[If needed, probe for changes or trends related to the efficiency, materials or prices of building envelope and heating systems installed in Nova Scotia homes.]

- C2c. Within that time frame, what has been ENS' influence on customers' choice of building envelope measures and heating systems for their homes? Rate ENS' influence on a 1-10 scale where 1 means "not at all influential" and 10 means "extremely influential" and please explain your score.

Score:

Explanation:

C3. In the past few years, have you noticed any differences in the level of efficiency of the products and equipment implemented in new home constructions compared to those implemented in existing homes? If so, what explains this difference between both residential sectors?

C4. In your opinion, where is the greatest potential for installing energy-efficient products: in the existing houses or new construction sector? Why?

Explanation:

C5. What additional measures or equipment should ENS incent or support as part of the Home Energy Assessment Program or another program to increase market adoption? Why?

Explanation:

C6. Will it become easier or more difficult for ENS and service organizations to promote higher than standard efficiency products in the coming years? Why?

Explanation:

C7. Thinking broadly about the residential market, are there issues or trends you believe ENS needs to consider going forward with the Home Energy Assessment program? If so, what are they?

END: Those are all the questions I have for you today. Do you have anything to add regarding the program or this interview?

Thank you for your collaboration and the time you took to answer our questions.

Appendix III

HEA: PARTICIPANT SURVEY QUESTIONNAIRE

Hello may I please speak with [INSERT NAME]?

- 1 Yes [GO TO INTRODUCTION]
- 2 No [SAY “Perhaps you can help me anyway.” GO TO INTRODUCTION]

Introduction

Hello, my name is *** and I am with Corporate Research Associates, a Halifax-based survey research company. We are performing an evaluation of energy efficiency programs and services provided by Efficiency Nova Scotia. Our records indicate that you or your household recently participated in Efficiency Nova Scotia’s Home Energy Assessment program.

We would appreciate your collaboration in answering questions related to your participation in this program. The information you provide will be used to help Efficiency Nova Scotia evaluate and improve the program. Is this a good time for you?

(IF NEEDED: This program encourages homeowners to improve the energy efficiency of their home by having an energy advisor conduct an assessment of the home and provide them with a set of upgrade recommendations.)

(IF NEEDED: You may have recently been contacted by Corporate Research Associates or by an Efficiency Nova Scotia representative about your experience with the program. This survey is different as it focuses on other aspects of your participation in the program.

(IF NEEDED: The survey will take about fifteen minutes.)

Verification and Recall (Series V)

- V1. We understand you participated in the Home Energy Assessment program. Is that correct?
- 1 Yes [CONTINUE]
 - 2 No, does not recall participating [PROMPT: “Are you sure? Someone would have come to your house to evaluate the energy efficiency of your home and sent you an Energy Efficiency Evaluation Report telling you about upgrades you could make to your home to improve its energy efficiency. They might have talked about the possibility of you getting rebates or financing to cover some of the cost of these upgrades.”] [IF PERSIST AS NO, THANK, TERMINATE AND RECORD]
 - 3 Don’t know/Refused [PROBE: “Is there someone else in the household who would know about having participated in the Home Energy Assessment program?”] [IF YES, ASK TO SPEAK TO THE APROPRIATE PERSON AND RESTART AT INTRODUCTION. IF PERSISTS AS NO, THANK, TERMINATE AND RECORD.]

[IF REFUSED, ASK “Can we schedule a more convenient time for you to conduct this survey?”]

[SCHEDULED, IF NECESSARY, FOR: _____]

Participation [P Series]

- P1. Now I’m going to ask you to think back to when you decided to schedule an energy efficiency assessment and participate in the Home Energy Assessment program. What was the SINGLE most important reason you were interested in having your home evaluated by an energy advisor? [DO NOT READ – CODE ONE ONLY]
1. (To save on energy/to save on energy costs)
 2. (I was thinking about/planning to get energy efficient upgrades anyway)
 3. (To find out how energy efficient my home was/to get my home evaluated)
 4. (To get expert’s advice about what upgrades to get/how to make home more energy efficient)
 5. (To help the environment)
 6. (Rebates/Financing)
 - 96.(Other) [SPECIFY_____])
 98. (Don’t know) [GO TO SECTION S]
 99. (Refused) [GO TO SECTION S]
- P2. Were there any other reasons? [SAME LIST AS IN P1] [DO NOT READ. ACCEPT MULTIPLE RESPONSES]
- 97 None/no other reasons

Satisfaction with Program (S Series)

- S1. Using a scale from 1 to 10 where 1 is “not at all satisfied” and 10 is “completely satisfied” how would you rate your satisfaction with the program overall? [RECORD NUMBER, 98=Don’t know, 99 Refused] DO NOT ACCEPT A RANGE
- S2. [IF S1<8] What was the most important reason you were not more satisfied with the program overall? [PROBE FOR SPECIFIC REASON. ACCEPT MULTIPLE RESPONSE]
96. (RECORD VERBATIM: _____)
98. (Don’t know)
99. (Refused)
- S3. On a scale of 1 to 10, where 1=‘not at all satisfied’ and 10=‘completely satisfied’, how satisfied were you with each of the following aspects of the Home Energy Assessment Program? [DO NOT RANDOMIZE] [97 = Not Applicable, 98 = Don’t know/Don’t recall, 99 = Refused]
- a) The initial energy assessment overall
 - b) The Energy Efficiency Evaluation Report you received about your home’s energy use and recommendations for energy efficiency upgrades
 - c) The final energy assessment overall
 - d) The expertise of the energy advisor
 - e) The customer service provided by the energy advisor
 - f) [IF REBATE IN THE DATABASE] The rebate amount
 - g) [IF FINANCING IN THE DATABASE] The financing option
 - h) Length of time allowed to complete your upgrades
- S4. In addition to the Energy Efficiency Evaluation Report telling you about upgrades you could make to your home to improve its energy efficiency, did you receive another report called the “Energy Action Plan” to help you move forward with the upgrades? It would have been sent to you by Efficiency Nova Scotia either by email or mail, was around 3 pages long, and included summary information of the energy assessment, as well as estimated costs, savings and payback. It would have had a table in it that listed possible costs to perform your upgrades, and potential rebate amounts for each of those upgrades. [DO NOT READ. CODE ONLY ONE]
- 1. Yes, did receive report
 - 2. No, did not receive report [GO TO VR1]
 - 98.(Don’t know/Don’t recall) [GO TO VR1]
- S5. [ASK IF S4=1] Did you read the Energy Action Plan report?
- 1. Yes (partially or totally)
 - 2. No
 - 98 (Don’t know/Don’t recall)

- S6. [ASK IF S5=1] On a scale of 1 to 10, where 1 means the report “wasn’t at all useful” and 10 means the report “was extremely useful,” how useful did you find the report? [1 TO 10 SCALE, 98=DON’T KNOW, 99 = REFUSED] [PROBE TO AVOID ACCEPTING A RANGE]
- S7. [DO NOT ASK IF S6=98 OR 99] Why do you give the report a rating of [INSERT RATING IN S6]? [VERBATIM BOX]
98. (Don’t know)

Verification of Actions Taken (VR Series)

VR1. I am going to read you a list of upgrades that may have been recommended by the energy advisor for your home. For each one, can you please tell me if that upgrade was recommended for your home? [DO NOT ROTATE - CODE ONE ONLY PER STATEMENT]

[1 = YES, RECOMMENDED, 2 = NO, NOT RECOMMENDED, 98 = DON’T KNOW / DON’T REMEMBER, 99 = REFUSED] [READ]

- a. Mini-split heat pump
- b. Air source central heat pump
- c. Ground source geothermal heat pump
- d. Drain water heat recovery system
- e. Building insulation including attic, ceiling, exterior wall, exposed floor, basement, crawlspace, or foundation insulation
- f. Windows, doors or skylights
- g. Efficient ventilation system (heat recovery ventilation system)
- h. Air sealing or draft proofing
- i. Heat pump water heater or solar water heating system
- j. Wood or pellet stove or furnace

[ASK VR2A-B IF ANY ITEM IN VR1A THRU J=1 (“YES, RECOMMENDED”)]

VR2a. IF **MORE THAN ONE** ITEM IN VR1a-j=YES, READ: Through the Home Energy Assessment program, have you implemented at least one, all or none of the energy efficiency recommendations, meaning that you received a rebate or financing for installing the upgrades? Have you... [READ. ACCEPT ONE RESPONSE]

1. Implemented at least one upgrade
2. Implemented all the upgrades
3. Or Did not implement any upgrades
98. (Don’t know)
99. (Refused)

VR2b. IF **ONLY ONE** ITEM IN VR1a-j=YES, READ: Through the Home Energy Assessment program, have you implemented this energy efficiency recommendation, meaning that you received a rebate or financing for installing the upgrade? [DO NOT READ. ACCEPT ONE RESPONSE]

1. Yes, implemented the upgrade
2. No, did not implement the upgrade
98. (Don't know)
99. (Refused)

[ASK VR3 IF VR2A=1 ("YES, IMPLEMENTED AT LEAST ONE UPGRADE")]

VR3. Which of the following recommendations have you implemented under the Home Energy Assessment program? [ASK FOR EACH ITEM IN VR1a thru j = 1]

[1 = YES, IMPLEMENTED, 2 = NO, NOT IMPLEMENTED, 98 = DON'T KNOW / DON'T REMEMBER, 99 = REFUSED] [READ]

- a. Mini-split heat pump
- b. Air source central heat pump
- c. Ground source geothermal heat pump
- d. Drain water heat recovery system
- e. Building insulation including attic, ceiling, exterior wall, exposed floor, basement, crawlspace, or foundation insulation
- f. Windows, Doors, or Skylights
- g. Efficient ventilation system (heat recovery ventilation system)
- h. Air sealing or draft proofing
- i. Heat pump water heater or solar water heating system
- j. Wood or pellet stove or furnace
 1. Yes, implemented the upgrade
 2. No, did not implement the upgrade
 98. (Don't know)
 99. (Refused)

[ASK VR4a IF AT LEAST ONE “YES, IMPLEMENTED” IN VR3a-j), or yes, implemented all of the upgrades in VR2a, or VR2B = YES.

VR4a. On a scale of 1 to 10, where 1 is ‘not at all important’ and 10 is ‘extremely important’, how important, if at all, were the following when deciding what upgrade(s) to make to your household through the Home Energy Assessment Program? [READ AND ROTATE STATEMENTS - CODE ONLY ONE] [98 = Don’t know/Don’t recall, 99 = Refused] [PROBE TO AVOID ACCEPTING A RANGE]

- a. Reducing energy consumption, that is, increasing the energy efficiency of your household
- b. Reducing energy costs for your household
- c. Using the lowest cost options for replacing or upgrading your household features
- d. Increasing the value of your home
- e. Increasing the comfort of your home

VR4b. What other considerations, if any, were important in your decision to make upgrades to your household based on the Energy Efficiency Evaluation Report? [CODE VERBATIM]

96. (Specify _____)
97. None
98. Don’t know
99. Refused

[ASK VR5 FOR EACH ‘NO, DID NOT IMPLEMENT THE UPGRADE’ RESPONSE IN VR3a-j), OR VR2A=03 (None) or VR2B=02 (No).

VR5. What is the most important reason why you did not make the [INSERT ITEM FROM VR3a-j] to your home? Any other reasons? [DO NOT READ. ACCEPT MULTIPLE]

1. (Couldn’t afford this upgrade)
2. (Couldn’t find time to put in the upgrade)
3. (Inconvenient or difficult to make the upgrade in my home (such as access, or the need to move belongings))
4. (Lack of interest)
5. (Not having enough information to proceed with this upgrade)
6. (Not convinced that making that energy-efficient upgrade was worth the money)
7. (Rebate wasn’t high enough)
8. (Not knowing how to do the work yourself or challenges in hiring a contractor)
96. (Other :_____)
98. (Don’t know)
99. (Refused)

VR6. [ASK IF ANSWER=7 IN VR5] What would be a more reasonable rebate amount in your opinion?
[PROBE TO AVOID ACCEPTING A RANGE]

- 96. Enter amount in dollars: _____
- 98. Don't know
- 99. Refused

Free-Ridership [FR Series]

[ASK FR SERIES IF ANY "YES, IMPLEMENTED" RESPONSES IN VR3a-j, **OR** IF 'YES' IN VR2b, OR VR2A=02 (ALL

Now I'm going to ask you to think of all the energy-efficient upgrades that were implemented to your home under the Home Energy Assessment program.

FR1. BEFORE having your home evaluated by an energy advisor, did you have plans to implement the specific energy-efficient upgrades that were implemented through the program? Did you ...

- 1. Have plans to implement all of the upgrades
- 2. Have plans to implement some of the upgrades
- 3. Have no plan to implement any of the upgrades
- 98. (Don't know)
- 99. (Refused)

[IF FR1=1 or 2, THEN ASK:]

FR1a. I just want to make sure I understand - Before you had your home evaluated by an energy advisor, you had already made the decision to implement [all/some of] the energy efficiency upgrades that were implemented through the program?

- 1. Yes
- 2. No
- 98. (Don't know)
- 99. (Refused)

FR2. a. [IF REBATE IN DATABASE] Efficiency Nova Scotia paid you \$[INCENTIVE] for the energy efficiency upgrades you implemented in your home. If you had not received the rebate from Efficiency Nova Scotia, would you have paid for the full cost of the energy efficiency upgrades you implemented? Please answer using a scale of 0 to 10, with a 0 indicating that you "Definitely Would Not Have Paid" and a 10 indicating that you "Definitely Would Have Paid." [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

b. [IF FINANCING IN DATABASE] Efficiency Nova Scotia provided you with a \$[ACTUAL LOAN AMOUNT] loan for the energy efficiency upgrades you implemented in your home. If you had not received low interest financing from Efficiency Nova Scotia, would you have financed the cost of the energy efficiency upgrades through some other means? Please answer using a scale of 0 to 10, with a 0 indicating that you “Definitely Would Not Have Financed” and a 10 indicating that you “Definitely Would Have Financed.” [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response ___ 98 Don't Know ___ 99 Refused

[READ FIRST TIME THROUGH ONLY] Now I would like to ask you to consider what actions you would have taken if the Home Energy Assessment program had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely,” and a 10 indicating that it is “Very Likely.”

[DO NOT ACCEPT A RANGE – ASK FR3 SEQUENCE IN ORDER/DO NOT RANDOMIZE]

FR3a. If the program, rebate or financing had not been offered, what is the likelihood that you would have implemented exactly the same quantity of energy efficiency upgrades that were implemented through the Home Energy Assessment program?

___ Response ___ 98 Don't Know ___ 99 Refused

FR3b. If the program, rebate or financing had not been offered, what is the likelihood that you would have implemented standard equipment, material or product instead of energy-efficient equipment, material or product in your home?

___ Response ___ 98 Don't Know ___ 99 Refused

FR3c. [ASK IF FR2 a or b >=5] If the program, rebate or financing had not been offered, what is the likelihood that you would have postponed making energy efficient upgrades to your home by at least one year?

___ Response ___ 98 Don't Know ___ 99 Refused

FR4. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to implement the energy efficiency upgrades you implemented through the program. Using a scale from 0 to 10 where 0 means "No influence" and 10 means "Great influence," please rate the influence of each of the following in your decision to implement the energy efficiency upgrades. DO NOT ACCEPT A RANGE

Factor (READ AND RANDOMIZE)	Responses
a. The program rebate or financing	___ Response ___98 Don't Know ___99 Refused
b. Information or recommendations provided in the Energy Efficiency Evaluation <u>Report</u>	___ Response ___98 Don't Know ___99 Refused
c. Expert information or advice from the energy advisor who came to your home to conduct the energy assessment	___ Response ___98 Don't Know ___99 Refused

Cross-Influence (CI Series)

READ AND ROTATE (CI1 + CI2a-c) AND (CI3 + CI4a-c) SEQUENCES

CI1. Before participating in the Home Energy Assessment program in [DATE], had you at any time in the past already participated in another Efficiency Nova Scotia program?

1. Yes
2. No
98. (Don't know)
99. (Refused)

For the following statements, please indicate whether you agree or disagree.

CI2a. [IF CI1=1] Your previous participation in an Efficiency Nova Scotia program was a major factor in your decision to implement energy efficiency upgrades in your home under the Home Energy Assessment program.

1. Agree
2. Disagree
98. (Don't know)
99. (Refused)

- CI2b. [IF CI1=1] Because of your previous participation in an Efficiency Nova Scotia program and what you learned by participating in the program, you asked for an energy assessment of your home.
- 1. Agree
 - 2. Disagree
 - 98. (Don't know)
 - 99. (Refused)
- CI2c. [IF CI1=1] Because of your previous participation in an Efficiency Nova Scotia program and what you learned by participating in the program, you took into account the savings on your energy bill when evaluating different upgrades for your home in [DATE].
- 1. Agree
 - 2. Disagree
 - 98. (Don't know)
 - 99. (Refused)
- CI3. Before participating in the Home Energy Assessment program in [DATE], had you at any time in the past already seen Efficiency Nova Scotia promotional materials advertising the benefits of energy efficiency?
- 1. Yes
 - 2. No
 - 98. (Don't know)
 - 99. (Refused)

For the following statements, please indicate whether you agree or disagree.

- CI4a. [IF CI3=1] The energy efficiency promotional materials distributed by Efficiency Nova Scotia were a major factor in your decision to implement energy efficiency upgrades in your home under the Home Energy Assessment program.
- 1. Agree
 - 2. Disagree
 - 98. (Don't know)
 - 99. (Refused)
- CI4b. [IF CI3=1] The energy-efficiency promotional materials distributed by Efficiency Nova Scotia prompted you to ask for an energy assessment of your home under the Home Energy Assessment program.
- 1. Agree
 - 2. Disagree
 - 98. (Don't know)
 - 99. (Refused)

CI4c. [IF CI3=1] The energy-efficiency promotional materials distributed by Efficiency Nova Scotia prompted you to take into account the savings on your energy bill when evaluating different upgrades for your home in [DATE].

- 1. Agree
- 2. Disagree
- 98. (Don't know)
- 99. (Refused)

Spillover (SO Series)

[ASK SO SECTION IF VR2a = 1 OR 3, OR IF VR2b = 2, OR IF ANY OF VR3 = '2'.

You mentioned in a previous answer that there were some recommended upgrades that you decided not to implement through the Home Energy Assessment program.

SO1. **Since the time that you participated** in the Home Energy Assessment program, have you implemented one or more of the recommended upgrades on your own?

- 1. (Yes)
- 2. (No)
- 98. (Don't know)
- 99. (Refused)

[IF SO1=1]

SO2. Which upgrades have you implemented on your own after participating in the Home Energy Assessment program? [READ, ACCEPT MULTIPLE]

IF VR2a=1 (Yes, implemented at least one upgrade): LIST OF EACH ITEM IN VR1a thru j=1 ("Yes, recommended") AND VR3a thru l=2 ("No, not implemented")]

OR

IF VR2a=3 (No, have not implemented any upgrades): LIST OF EACH ITEM IN VR1a thru j=1 ("Yes, recommended")

OR

IF VR2b=2 (No, not implemented the upgrade): LIST OF ITEM IN VR1a thru j=1("Yes, recommended")

- 96. Other energy-efficient measures? [Please specify_____]
- 98. (Don't know)
- 99. (Refused)

[IF SO1=1]

SO3. Have you received financing or rebates from other Efficiency Nova Scotia programs for the energy efficiency upgrades you implemented on your own after participating in the Home Energy Assessment program?

1. Yes [Go to R Series]
2. No
98. (Don't know) [Go to R Series]
99. (Refused) [Go to R Series]

[IF SO3 = 2]

SO4. How influential was your experience with the Home Energy Assessment program on your decision to implement some or all of the measures that you installed after participating in the program? Please give your answer on a scale of 0 to 10, where 0 indicates that the Home Energy Assessment program "had no influence at all on your decision to implement additional energy efficiency upgrades" and 10 indicates that the program was "extremely influential in your decision to implement additional energy efficiency upgrades." [RECORD RESPONSE 0-10, 98 = Don't know, 99 = REFUSED] [DO NOT ACCEPT A RANGE]

Recommendations for Program Improvements [R Series]

R1. Do you have any recommendations for improving the Home Energy Assessment program?
PROBE: Anything else? [DO NOT READ. ACCEPT MULTIPLE]

1. (Offer more products/measures eligible to rebates or financing)
2. (Offer more information on the products/measures recommended)
3. (Improve the content of the Energy Efficiency Evaluation Report)
4. (Increase the time given to complete the upgrades)
5. (Advertise the program more or in a better way)
6. (Simplify the incentive structure/Make it easier to understand how to reach incentives)
7. (Increase Efficiency Nova Scotia rebates)
8. (No recommendation)
96. (Other [SPECIFY _____])
98. (Don't know)
99. (Refused)

Demographic Characteristics [D Series]

[ASK ALL RESPONDENTS]

These final questions are asked for statistical purposes only. The information collected is strictly confidential.

D1. What type of residence do you live in? [READ RESPONSES 1-7, SELECT ONE RESPONSE]

1. Detached single-family home
2. Semi-detached house
3. Mobile home or house trailer
4. Townhouse or duplex which share adjacent walls
5. Row house (Single story apartment building)
6. Apartment building that have fewer than five stories
7. Apartment building that have five or more stories
96. (Other [SPECIFY: _____])
98. (Don't know)
99. (Refused)

D2. How many bedrooms are in your home? [98=DK; Enter zero for a studio apartment with no bedrooms]

D5. Is your home occupied year round, or is it a seasonal home?

1. Year round residence
2. Seasonal / vacation home
96. (Other Specify _____)
98. (Don't Know)
99. (Refused)

D6. Including yourself, how many people live in this residence on a full-time basis?

Number of people: _____

D7. In what age category do you fall? Are you... [READ]

1. 18 to 24
2. 25 to 34
3. 35 to 44
4. 45 to 54
5. 55 to 64
6. 65 or over
99. (Refused)

D8. What is the highest level of education you have completed? [DO NOT READ]

1. (Less than high school graduation certificate)
2. (High school graduation certificate and/or some post-secondary)
3. (Trades certificate or diploma)
4. (College certificate or diploma)
5. (University certificate or diploma)
98. (Don't know)
99. (Refused)

D9. Which of the following income categories best describes your total annual household income before taxes in 2016? Stop me when I reach the right category. [READ LIST; SELECT ONE RESPONSE]

1. Less than \$15,000
2. \$15,000 - \$24,999
3. \$25,000 - \$34,999
4. \$35,000 - \$49,999
5. \$50,000 - \$69,999
6. \$70,000 - \$79,999
7. \$80,000 or more
98. (Don't know)
99. (Refused)

D10. [DO NOT READ] Gender:

1. Male
2. Female

END: Those are all the questions I have for you. Thank and terminate.

Appendix IV

HEA: PARTICIPANT SURVEY RESULTS

The participant survey results are presented in the following tables.

P1. Now I'm going to ask you to think back to when you decided to schedule an energy efficiency assessment and participate in the Home Energy Assessment program. What was the SINGLE most important reason you were interested in having your home evaluated by an energy advisor?

P2. Were there any other reasons?

Reasons for Participating	2015		2016		2017	
	Most Important Motivation	Second Most Important Motivation*	Most Important Motivation	Second Most Important Motivation*	Most Important Motivation	Second Most Important Motivation*
Sample Size	100	100	104	104	70	70
To save on energy/To save on energy costs	42%	19%	40%	15%	30%	10%
To get expert advice about what upgrades to get/How to make home more energy efficient	15%	12%	11%	13%	23%	9%
I was thinking about/planning to get energy efficient upgrades anyway	8%	9%	9%	8%	17%	11%
Rebates/Financing	10%	17%	21%	13%	16%	16%
To find out how energy efficient my home was/To get my home evaluated	20%	17%	14%	13%	10%	11%
To help make my home more comfortable	-	-	-	3%	1%	1%
To help the environment	1%	8%	-	4%	-	4%
Others	4%	2%	5%	6%	3%	-
None/No other reasons	-	32%	-	37%	-	41%
Don't know/Refused	-	1%	-	1%	-	6%
*Multiple responses						

S1. Using a scale from 1 to 10 where 1 is 'not at all satisfied' and 10 is 'completely satisfied', how would you rate your satisfaction with the program overall?

Satisfaction with HEA Overall	2016	2017
Sample Size	104	70
Mean*	8.1	8.6
*Don't know/Refused excluded from calculations		

S2. What was the most important reason you were not more satisfied with the program overall?

Key Reasons Not More Satisfied with HEA	2016	2017
Sample Size*	27	12 (#)
The rebate received was too small	30%	5
Program requirements/Eligibility criteria are unclear	15%	2
Scope of the program component is too narrow or limited	33%	1
Problem receiving rebate	4%	1
The first or final energy audit took too long	-	1
I did not agree with the recommendations that were made	7%	-
Did not receive help for upgrades	4%	-
The time period given to complete the upgrades is too short	4%	-
I did not get the final EnerGuide rating I was expecting	4%	-
It was difficult or long to schedule an appointment with the energy advisor	4%	-
Others	4%	2
None/No reasons	-	1
*Base: Respondents who were not satisfied with HEA (NOT SATISFIED: S1<8)		

S3. On a scale of 1 to 10, where 1='not at all satisfied' and 10='completely satisfied', how satisfied were you with each of the following aspects of the Home Energy Assessment program?

Satisfaction with Aspects of HEA	2015		2016		2017	
	Sample Size*	Mean*	Sample Size*	Mean*	Sample Size*	Mean*
The customer service provided by the energy advisor	-	-	104	9.0	70	9.3
The initial energy assessment overall	100	8.9	103	8.8	70	9.3
The expertise of the energy advisor	-	-	103	8.8	70	9.2
Length of time allowed to complete your upgrades	99	8.5	101	8.5	69	9.1
**The Energy Efficiency Evaluation Report you received about home's energy use and recommendations for energy efficiency upgrades	99	8.7	104	8.3	69	9.0
The final energy assessment overall	99	8.7	101	8.3	69	8.8
[IF FINANCING IN THE DATABASE] Financing option	1	10.0	4	9.0	8	8.0
[IF REBATE IN THE DATABASE] Rebate amount	85	7.6	97	7.1	61	7.6
*Not applicable, Don't know/Don't recall and Refused excluded from calculations						
**Slight wording change from 2015						

S4. In addition to the Energy Efficiency Evaluation Report telling you about upgrades you could make to your home to improve its energy efficiency, did you receive another report called the “Energy Action Plan” to help you move forward with the upgrades? It would have been sent to you by Efficiency Nova Scotia either by email or mail, was around 3 pages long, and included summary information of the energy assessment, as well as estimated costs, savings and payback. It would have had a table in it that listed possible costs to perform your upgrades, and potential rebate amounts for each of those upgrades.

S5. Did you read the Energy Action Plan report?

Energy Action Plan	2017	
	Recall Receiving	Read* Report
Sample Size	70	40
Yes	57%	90%
No	27%	3%
Don't know/Don't recall	16%	8%
*Base: Respondents who recalled receiving the report		

S6. On a scale of 1 to 10, where 1 means the report “wasn’t at all useful” and 10 means the report “was extremely useful,” how useful did you find the report?

Usefulness of Energy Action Plan	2017
Sample Size*	35
Mean**	8.0
*Base: Respondents who read report	
**Don't know/Refused excluded from calculations	

S7. Why do you give the report a rating of [INSERT RATING IN S6]?

Reasons for Rating of Energy Action Report	2017
Sample Size*	35
Didn't provide new information/Already knew information	20%
Informative/Covered a lot of information	17%
Information wasn't specific/detailed enough	14%
Recommended energy efficient upgrades	14%
Upgrades weren't useful/had already done upgrades	11%
Difficult to understand	6%
Didn't/couldn't do all of the upgrades	6%
It was clear/easy to understand	6%
Should have information on contractors	3%
Others	9%
Don't know	3%
*Base: Respondents who read report	

VR2a/VR2b. Through the Home Energy Assessment program, have you implemented at least one, all or none of the energy efficiency recommendations, meaning that you received a rebate or financing for installing the upgrades? Have you...

Recommended Energy Efficiency Measures Implemented	2015	2016	2017
Sample Size*	100	103	70
Implemented at least one upgrade	74%	78%	59%
Implemented all of the upgrades	24%	19%	34%
Did not implement any upgrades	1%	3%	6%
Don't know	1%	-	1%
*Base: Respondents who indicated they were given recommendations for at least one of the eligible measures			

VR1. I am going to read you a list of upgrades that may have been recommended by the energy advisor for your home. For each one, can you please tell me if that upgrade was recommended for your home?

VR3. Which of the following recommendations have you implemented under the Home Energy Assessment program?

Recommended Measures	2015		2016		2017	
	Recom- mended	Imple- mented	Recom- mended	Imple- mented	Recom- mended	Imple- mented
Sample Size	100	100	104	104	70	70
Building insulation including ceiling, exterior wall, exposed floor, basement, crawlspace, or foundation insulation	-	-	85%	71%	80%	54%
*Mini-split heat pump	45%	24%	35%	27%	73%	49%
*Air sealing or draft proofing	93%	85%	77%	63%	63%	41%
Windows/Doors/Skylights	81%	72%	67%	56%	61%	49%
Efficient ventilation system (heat recovery ventilation system)	-	-	16%	10%	23%	11%
Heat pump water heater or solar water heating system	-	-	12%	2%	20%	9%
Air source central heat pump	-	-	8%	3%	14%	6%
**Wood or pellet furnace or furnace	-	-	7%	2%	9%	4%
Drain water heat recovery	8%	3%	7%	1%	7%	-
*Ground source geothermal heat pump	7%	2%	4%	-	6%	-
*Slight wording change from 2015 **Slight wording change from 2016						

VR1/V3. Measure uptake calculated as the percentage of measures implemented by measures recommended.

Recommended Energy Efficiency Measure Uptake	2015	2016	2017
	Measure Uptake	Measure Uptake	Measure Uptake
Sample Size	100	104	70
Windows/Doors/Skylights	89%	84%	80%
Building insulation including ceiling, exterior wall, exposed floor, basement, crawlspace, or foundation insulation	-	84%	68%
*Mini-split heat pump	53%	77%	67%
*Air sealing or draft proofing	91%	82%	65%
Efficient ventilation system (heat recovery ventilation system)	-	63%	48%
Heat pump water heater or solar water heating system	-	17%	45%
**Wood or pellet furnace or furnace	-	29%	44%
Air source central heat pump	-	38%	43%
Drain water heat recovery	20%	14%	-
*Ground source geothermal heat pump	25%	-	-
*Slight wording change from 2015			
**Slight wording change from 2016			

VR4a. On a scale of 1 to 10, where 1 is ‘not at all important’ and 10 is ‘extremely important’, how important, if at all, were the following when deciding what upgrade(s) to make to your household through the Home Energy Assessment program?

Importance of Factors on Choice of Upgrades	2016		2017	
	Sample Size*	Mean**	Sample Size*	Mean**
Reducing energy costs for your household	99	9.5	62	9.6
Reducing energy consumption, that is, increasing the energy efficiency of your household	99	9.4	62	9.5
Increasing the comfort of your home	98	8.9	61	9.0
Increasing the value of your home	100	7.3	62	7.5
Using the lowest cost options for replacing or upgrading your household features	95	6.5	60	6.3
*Base: Respondents who implemented at least one of the eligible measures				
**Don't know/Don't recall and Refused excluded from calculations				

VR4b. What other considerations, if any, were important in your decision to make upgrades to your household based on the Energy Efficiency Evaluation Report?

Other Considerations	2016	2017
Sample Size*	100	62
Energy savings/Reducing energy cost	11%	6%
Make house more energy efficient	10%	6%
The cost/What we could afford	10%	5%
Make house more comfortable	9%	3%
HEA rebates/financing	4%	3%
Improve home's resale value	2%	2%
Be more environmentally friendly/Reduce carbon footprint	7%	-
Others	11%	6%
None	43%	71%
Don't know	4%	6%
*Base: Respondents who implemented at least one of the eligible measures		

VR5. What is the most important reason why you did not make the [INSERT ITEM FROM VR3a-j] to your home? Any other reasons?

Reasons for Not Making the Upgrade	2017							
	Heat Pump		Air Source Central Heat Pump		Building Insulation		Heat Pump, Water Heater, Solar Water Heating	
	Most Important Reason	Other Reasons	Most Important Reason	Other Reasons	Most Important Reason	Other Reasons	Most Important Reason	Other Reasons
Sample Size*	17 (#)	1 (#)	6 (#)	2 (#)	17 (#)	1 (#)	8 (#)	3 (#)
Couldn't afford this upgrade	6	-	1	1	5	-	5	1
Not convinced that making that energy-efficient upgrade was worth the money	3	-	-	1	3	1	2	2
Inconvenient or difficult to make the upgrade in my home	3	1	2	-	-	-	-	-
Rebate wasn't high enough	-	-	-	-	1	-	-	-
Not needed/Didn't need to be upgraded	1	-	-	-	4	-	-	-
Lack of interest	-	-	2	-	1	-	-	-
Couldn't find time to put in the upgrade	1	-	-	-	1	-	-	-
Others	1	-	1	-	-	-	1	-
Don't know/Refused	2	-	-	-	2	-	-	-
*Base: Respondents who chose not to make an upgrade that was recommended								

Reasons for Not Making the Upgrade	2017					
	Ground Source Geothermal Heat Pump	Drain Water Heat Recovery System	Windows, Door, Skylights	Air Sealing, Draft Proofing	Wood or Pellet Stove or Furnace	Ventilation System
	Most important Reason	Most Important Reason	Most Important Reason	Most Important Reason	Most Important Reason	Most Important Reason
Sample Size*	4 (#)	5 (#)	9 (#)	13 (#)	3 (#)	7 (#)
Couldn't afford this upgrade	3	-	2	4	-	3
Not convinced that making that energy-efficient upgrade was worth the money	-	2	1	5	-	
Inconvenient or difficult to make the upgrade in my home	-	-	-	-	-	
Rebate wasn't high enough	-	-	-	-	-	
Not needed/Didn't need to be upgraded	-	-	5	-	2	
Lack of interest	1	2	-	-	-	2
Couldn't find time to put in the upgrade	-	-	-	1	1	1
Others	-	-	1	2	-	
Don't know/Refused	-	1	-	1	-	1
*Base: Respondents who chose not to make an upgrade that was recommended						

VR6. What would be a more reasonable rebate amount in your opinion?

Rebate Amount	2017
Sample Size*	1
Preferred rebate amount	\$400
*Base: Respondent who indicated rebate wasn't high enough, building insulation respondent	

FR1. BEFORE having your home evaluated by an energy advisor, did you have plans to implement the specific energy-efficient upgrades that were implemented through the program? Did you ...

Already Made Decision to Install Upgrades Prior to Assessment	2016	2017
Sample Size*	100	62
Have plans to implement all of the upgrades	25%	26%
Have plans to implement some of the upgrades	67%	56%
Have no plan to implement any of the upgrades	5%	18%
Don't know	3%	-
*Base: Respondents who implemented at least one of the eligible measures		

FR1/FR1a. BEFORE having your home evaluated by an energy advisor, did you have plans to implement the specific energy-efficient upgrades that were implemented through the program? Did you ...

I just want to make sure I understand - Before you had your home evaluated by an energy advisor, you had already made the decision to implement [all/some of] the energy efficiency upgrades that were implemented through the program?

Already Made Decision to Install Upgrades Prior to Evaluation (validation question)	2015	2016**	2017
Sample Size*	100	100	62
Yes	53%	82%	81%
No	40%	13%	19%
Don't know	7%	5%	-
*Base: Respondents who implemented at least one of the eligible measures			
**Slight wording change in 2016 for Q.FR1			

FR2a/FR2b. Efficiency Nova Scotia paid you \$[INCENTIVE] for the energy efficiency upgrades you implemented in your home. If you had not received the rebate from Efficiency Nova Scotia, would you have paid for the full cost of the energy efficiency upgrades you implemented?

Please answer using a scale of 0 to 10, with a 0 indicating that you “Definitely **Would Not Have Paid**” and a 10 indicating that you “Definitely **Would Have Paid**.”

Efficiency Nova Scotia provided you with a \$[ACTUAL LOAN AMOUNT] loan for the energy efficiency upgrades you implemented in your home. If you had not received low interest financing from Efficiency Nova Scotia, would you have financed the cost of the energy efficiency upgrades through some other means?

Please answer using a scale of 0 to 10, with a 0 indicating that you “Definitely **Would Not Have Financed**” and a 10 indicating that you “Definitely **Would Have Financed**.”

Would Have Paid/Financed Cost of Upgrades	2016		2017	
	Sample Size*	Mean**	Sample Size*	Mean**
Would have paid/financed full cost of upgrades	95	7.9	62	7.0
*Base: Respondents who implemented at least one of the eligible measures **Don't know/Refused excluded from calculations				

FR3. Now I would like to ask you to consider what actions you would have taken if the Home Energy Assessment program had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely”, and a 10 indicating that it is “Very Likely.”

If the program, rebate or financing had not been offered, what is the likelihood that you would have:

Actions Taken in Absence of Program Component	2016		2017	
	Sample Size*	Mean**	Sample Size*	Mean**
Implemented exactly the same quantity of energy efficiency upgrades that were implemented through Home Energy Assessment program	98	6.7	61	5.8
Implemented standard equipment, material or product instead of energy-efficient equipment, material or product in your home	96	5.1	58	4.4
Postponed making energy efficient upgrades to your home by at least one year***	83	5.1	48	4.3
*Base: Respondents who implemented at least one of the eligible measures **Don't know/Refused excluded from calculations ***Base: Respondents likely to pay or finance the full cost or FR2a or FR2b ≥5				

FR4. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to implement the energy efficiency upgrades you implemented through the program. Using a scale from 0 to 10 where 0 means "No influence" and 10 means "Great influence", please rate the influence of each of the following in your decision to implement the energy efficiency upgrades.

Influence of HEA in Decisions	2016		2017	
	Sample Size*	Mean**	Sample Size*	Mean**
Expert information or advice from the energy advisor who came to your home to conduct the energy assessment	98	7.0	62	7.8
Information or recommendations provided in the Energy Efficiency Evaluation Report	98	7.2	62	7.3
The program rebate or financing	98	6.8	62	7.3
*Base: Respondents who implemented at least one of the eligible measures				
**Don't know/Refused excluded from calculations				

CI1. Before participating in the Home Energy Assessment program in [DATE], had you at any time in the past already participated in another Efficiency Nova Scotia program?

Previous Participation in Another ENS Program Component	2016	2017
Sample Size*	104	62
Yes	33%	31%
No	64%	68%
Don't know	3%	2%
*Base: Respondents who implemented at least one of the eligible measures		

CI2. For the following statements, please indicate whether you agree or disagree.

Impact of Previous ENS Program Component Participation	2016				2017			
	Sample Size*	Agree	Disagree	Don't know	Sample Size*	Agree	Disagree	Don't know
Because of your previous participation in an Efficiency Nova Scotia program and what you learned by participating in the program, you took into account the savings on your energy bill when evaluating different upgrades for your home in [DATE]	34	85%	12%	3%	19 (#)	18	1	-
Because of your previous participation in an Efficiency Nova Scotia program and what you learned by participating in the program, you asked for an energy assessment of your home	34	91%	9%	-	19 (#)	17	1	1
Your previous participation in an Efficiency Nova Scotia program was a major factor in your decision to implement energy efficiency upgrades in your home	34	62%	38%	-	19 (#)	15	4	-
*Base: Respondents who previously participated in another ENS program								

CI3. Before participating in the Home Energy Assessment program in [DATE], had you at any time in the past already seen Efficiency Nova Scotia promotional materials advertising the benefits of energy efficiency?

Previously Seen Energy Efficiency Promotional Materials Distributed by ENS	2016	2017
Sample Size*	104	62
Yes	76%	63%
No	20%	35%
Don't know	4%	2%
*Base: Respondents who implemented at least one of the eligible measures		

CI4. For the following statements, please indicate whether you agree or disagree.

Impact of Previously Seen ENS Energy Efficiency Promotional Materials	2016				2017			
	Sample Size*	Agree	Disagree	Don't know	Sample Size*	Agree	Disagree	Don't know
The energy-efficiency promotional materials distributed by Efficiency Nova Scotia prompted you to take into account the savings on your energy bill when evaluating different upgrades for your home in [DATE]	79	82%	18%	-	39	74%	26%	-
The energy-efficiency promotional materials distributed by Efficiency Nova Scotia prompted you to ask for an energy assessment of your home under the Home Energy Assessment Program	79	78%	22%	-	39	77%	23%	-
The energy efficiency promotional materials distributed by Efficiency Nova Scotia were a major factor in your decision to implement energy efficiency upgrades in your home	79	63%	37%	-	39	67%	33%	-
*Base: Respondents who previously saw ENS energy-efficiency promotional materials								

SO1. You mentioned in a previous answer that there were some recommended upgrades that you decided not to implement through the Home Energy Assessment program. Since the time that you participated in the Home Energy Assessment program, have you implemented one or more of the recommended upgrades on your own?

Implemented Upgrades After Participation	2015	2016	2017
Sample Size*	75	82	45
Yes	28%	22%	22%
No	72%	78%	78%
*Base: Respondents who did not implement all upgrades recommended			

SO2. Which upgrades have you implemented on your own after participating in the Home Energy Assessment program?

Other Upgrades Implemented After Participating**	2015	2016	2017
Sample Size*	21	12	8
	(%)	(#)	(#)
***Air sealing or draft proofing	24%	2	3
Building insulation including ceiling, exterior wall, exposed floor, basement, crawlspace, or foundation	-	6	2
Efficient ventilation system (heat recovery ventilation system)	-	-	1
High efficiency ductless mini-split heat pump	5%	-	1
Windows/Doors/Skylights	24%	1	1
Other energy-efficient measures	19%	-	1
Electronic programmable thermostats	14%	2	-
Heat pump (general)	-	2	-
LED lights	-	1	-
Propane stove	-	1	-
Efficient water heating system including a heat pump or solar water heating system	-	1	-
Electric water heater tank or pipe insulation	-	1	-
Wood or pellet furnace or boiler	-	1	-
Basement insulation	14%	-	-
Crawlspace insulation	10%	-	-
Ceiling insulation	5%	-	-
High efficiency air to air (or air source) heat pump with electric backup	5%	-	-
Don't know	10%	-	-
*Base: Respondents who implemented upgrades after participating **Multiple responses ***Slight wording change from 2015			

SO3. Have you received financing or rebates from other Efficiency Nova Scotia programs for the energy efficiency upgrades you implemented on your own after participating in the Home Energy Assessment program?

Received Financing or Rebates for Upgrades Implemented	2015 (%)	2016 (#)	2017 (#)
Sample Size*	21	19	10
Yes	-	2	-
No	100%	17	10
Don't know	-	-	-

*Base: Respondents who implemented upgrades after participating

SO4. How influential was your experience with the program on your decision to implement some or all of the measures that you installed on your own after participating in the Home Energy Assessment program? Please give your answer on a scale of 0 to 10, where 0 indicates that the Home Energy Assessment program “had no influence at all on your decision to implement additional energy efficiency upgrades” and 10 indicates that the program was “extremely influential in your decision to implement additional energy efficiency upgrades.”

Importance of HEA in Influencing Decision to Implement Additional Upgrades	2015		2016		2017	
	Sample Size*	Mean**	Sample Size*	Mean**	Sample Size*	Mean**
Influence of HEA on decision to implement additional upgrades	21	7.0	16	5.6	10	7.6

*Base: Respondents who implemented upgrades after participating and did not receive financing or rebates from other ENS program components

**Don't know/Refused excluded from calculations

R1. Do you have any recommendations for improving the Home Energy Assessment program?
Anything else?

Participant Suggestions for HEA*	2015	2016	2017
Sample Size	100	104	70
Clarify the incentive structure or financing options/Make it easier to understand how to reach incentives	-	-	10%
Increase Efficiency Nova Scotia rebates	8%	6%	9%
Offer more products/measures eligible for rebates or financing	13%	17%	7%
Offer more information on the products/measures recommended	10%	8%	4%
Improve the content of the Energy Efficiency Evaluation Report	3%	1%	4%
Increase the time given to complete the upgrades	11%	11%	3%
Advertise the program component more or in a better way	6%	3%	3%
Have a list of contractors	-	1%	3%
Better or more standardized equipment/training across all energy advisors	-	4%	1%
Improve wait time to get assessment done/Speed up the process	2%	1%	1%
Improve communication	2%	1%	-
Shouldn't have to wait to reapply	3%	1%	-
Others	11%	7%	6%
No recommendations	51%	49%	49%
Refused/Don't know	1%	2%	4%
*Multiple responses			

D1. What type of residence do you live in?

Type of Residence	2015	2016	2017
Sample Size	100	104	70
Detached single-family home	90%	87%	87%
Semi-detached house	3%	7%	6%
Townhouse or duplex which share adjacent walls	6%	4%	4%
Apartment building that has fewer than five stories	-	-	1%
Mobile home or house trailer	-	2%	-
Row house (single story apartment building)	-	1%	-
Others	-	-	1%
Don't know/Refused	1%	-	-

D2. How many bedrooms are in your home?

Numbers of Bedrooms	2015	2016	2017
Sample Size	100	104	70
1	-	1%	6%
2	16%	18%	11%
3	60%	47%	60%
4 or more	24%	34%	23%

D5. Is your home occupied year round, or is it a seasonal home?

Type of Home	2015	2016	2017
Sample Size	100	104	70
Year Round residence	98%	96%	90%
Seasonal/vacation home	1%	4%	10%
Others	1%	-	-

D6. Including yourself, how many people live in this residence on a full-time basis?

Full-time Residents	2015	2016	2017
Sample Size	100	103	63
0	-	-	-
1	13%	19%	14%
2	51%	43%	56%
3	16%	17%	11%
4	15%	14%	13%
5 or more	5%	5%	6%
Average*	3.4	2.4	2.5
*Don't know/Refused excluded from the Average calculation			

D7. In what age category do you fall? Are you...

Respondent Age	2015	2016	2017
Sample Size	100	104	70
18 to 24	-	-	-
25 to 34	12%	13%	10%
35 to 44	21%	17%	19%
45 to 54	17%	22%	19%
55 to 64	24%	24%	26%
65 or older	25%	23%	26%
Refused	1%	-	1%

D8. What is the highest level of education you have completed?

Education	2015	2016	2017
Sample Size	100	104	70
Less than high school graduation certificate	3%	5%	9%
High school graduation certificate or some post-secondary	15%	12%	19%
Trade certificate or diploma	9%	5%	4%
College certificate or diploma	22%	20%	26%
University certificate or diploma	51%	56%	41%
Don't know/Refused	-	3%	1%

D9. Which of the following income categories best describes your total annual household income before taxes in 2016?

	2015	2016	2017
Sample Size	100	104	70
Less than \$15,000	1%	-	3%
\$15,000 to \$24,999	2%	4%	4%
\$25,000 to \$34,999	3%	3%	3%
\$35,000 to \$49,999	18%	15%	13%
\$50,000 to \$69,999	14%	13%	13%
\$70,000 to \$79,999	10%	13%	11%
\$80,000 or more	36%	37%	36%
Refused/Don't know	16%	15%	17%

D10. Gender:

Gender	2015	2016	2017
Sample Size	100	104	70
Male	62%	63%	56%
Female	38%	38%	44%

Appendix V

HEA: ALGORITHM FOR FREE-RIDERSHIP CALCULATION

The figure below presents the algorithm for calculating the free-ridership level. The participant survey questionnaire included questions designed to assess the planning, quantity, efficiency, period, cost and influence of the program component. Questions were also asked to quantify cross-influence. This corresponds to the level of influence that previous participation in one of ENS's energy efficiency program components or ENS's efforts to raise energy efficiency awareness had on the decision to implement the energy efficiency measure. Each group of questions was transposed into a level of program component attribution, which was used to calculate the free-ridership level associated with each participant.

FR2ab. If you had not received the rebate or low interest financing from ENS, would have paid or financed the cost of the energy efficiency upgrades you implemented? (Scale 0 to 10)	FR2ab = Answer x 10% IF DK/REF: EMPTY
FR3a. If the program, rebate or financing had not been offered, what is the likelihood that you would have implemented exactly the same quantity of energy efficiency upgrades that were implemented through HEA? (Scale 0 to 10)	FR3a = Answer x 10% IF DK/REF: EMPTY
PA1 Score:	MEAN VALUE OF: (FR2ab ; FR3a)
FR1. Before having your home evaluated by a EA, did you have plans to implement the specific energy-efficient upgrades that were implemented through HEA? 1. Have plans to implement all of the upgrades 2. Have plans to implement some of the upgrades 3. Have no plan to implement any of the upgrades	IF 1 OR 2 : GO TO FR1a IF 3 OR DK/REF: FR1a = 0%
FR1a. [ASK IF FR1=1 OR 2] I just want to make sure - Before you had your home evaluated by a EA, you had already made the decision to implement all or some of the energy efficiency upgrades that Were implemented through HEA? 1. Yes 2. No	IF 1 and FR1=1, FR1a = 100% IF 1 and FR1=2, FR1a = 25% IF 2 OR DK/REF: FR1a = 0%
PA2 Score:	FR1a
FR4. Level of influence of three program factors (Scale 0 to 10)	FR4 = MAX(a ; b ; c)
PA3 Score:	(10 – FR4) x 10%
FR3c. [ASK IF FR2 a or b >=5] If the program, rebate or financing had <u>not been</u> offered, what is the likelihood that you would have postponed making energy efficient upgrades to your home by at least one year ? (Scale 0 to 10)	FR3c = (10 – Answer) x 10% IF DK/REF. FR3c = EMPTY

PA4 Score:	FR3c
Inconsistency Test PA1	IF ABS (FR2ab - FR3a) ≥ 50%: PA1 = MIN (FR2 ; FR3a)
Inconsistency Test PA2	IF FR1a=100% AND FR2ab OR FR3a < 70%: PA2 = EMPTY
Free-Ridership	MEAN VALUE OF: (PA1 ; PA2 ; PA3 ; PA4)
CI2/4a. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] was a major factor in your decision to implement energy efficiency upgrades in your home. CI2/4b. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted you to ask for an energy assessment of your home. CI2/4c. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted you to take into account the savings on your energy bill when evaluating different upgrades for your home. (Agree or Disagree)	CI = IF(CI2a OR CI4a=Agree) + IF(CI2b OR CI4b=Agree) + IF(CI2c OR CI4c=Agree)
Revised Free-Ridership	IF CI=0 OR 1, Revised FR = FR IF CI=2, Revised FR = FR*.75 IF CI=3, Revised FR = FR*.50

Appendix VI

HEA: INTERNAL SPILLOVER METHODOLOGY

Internal spillover was measured using a participant survey. Participants were asked whether following their participation in HEA, they implemented any additional energy efficiency measures that were recommended in their assessment report, without benefitting from any rebates offered by ENS program components. If a participant did admit to having implemented additional recommended measures, they were asked a set of questions designed to identify the additional energy efficiency measures implemented and to quantify their associated savings (type of measure, quantity, efficiency level, etc.). Subsequently, another question was asked to quantify the level of influence the program component had on the participant's decision to implement these additional measures. The value established regarding this level of influence was used to determine the portion of the additional savings attributable to the program component.

Then, the level of internal spillover was established by dividing the total quantity of the additional savings attributable to the program component by the total quantity of savings achieved by the program component for all the survey respondents.

The figure below illustrates the methodology used to calculate the internal spillover level.

INTRO. SO Section asked to participants who have not implemented all the energy efficiency upgrades recommended in their assessment report through HEA.	IF Upgrades left: CONTINUE IF All upgrades were implemented through HEA : END
SO1. Since the time that you participated in HEA, have you implemented one or more of the recommended upgrades on your own ?	IF Yes: CONTINUE IF No OR DK OR REF : END
SO3. Have you received financing or rebates from other ENS programs for the energy efficiency upgrades you implemented on your own after participating in HEA?	IF No: CONTINUE IF Yes OR DK OR REF : END
SO2. Which upgrades have you implemented on your own after participating in HEA?	SO2 = SUM (kWh associated with each upgrade)
Additional Upgrade Savings:	SO2
SO4. How influential was your experience with HEA on your decision to implement some or all of the measures that you installed on your own after participating in HEA? (Scale 0 to 10)	SO4 = Answer x 10%
Attribution Level:	SO4
Spillover Savings:	SO2 x SO4
Final Spillover Level = $\frac{\text{SUM of (SO2 x SO4) for All Respondents}}{\text{SUM of Program Savings for All Respondents}}$	

Appendix VII

GH: 2017 RECOMMENDATIONS

This appendix summarizes all the recommendations made by the Evaluator as part of the 2017 evaluation, as well as all 2016 evaluation recommendations that were not fully implemented.

Section	Recommendations
Executive Summary	1. Perform the ASHP billing analysis again in 2018. Similar to MSHPs, the billing analysis resulted in a major change made to the average savings values for ASHPs. As part of this analysis, participants were categorized based on their existing heating system type. Because of the small sample sizes for each category, it was difficult to establish distinct savings for each category. The Evaluator believes that the ASHP billing analysis should be conducted again in 2018 to obtain a larger sample of participants and improve the accuracy of savings.
	2. Conduct a survey with a larger sample of participants who installed MSHPs in non-electrically heated households. As part of the 2017 evaluation, a participant survey was conducted to establish the baseline scenario for MSHPs installed in previously non-electrically heated households. Unfortunately, the sample size was small because a low number of participants had installed MSHPs in non-electrically heated households at the time of the survey. The Evaluator believes that a survey with participants living in non-electrically-heated households should be conducted again in 2018 to determine the most appropriate baseline scenario to be used for such participants. This survey should ask participants about Green Heat's influence on their decision to purchase an MSHP and how this impacted the timing of their decision. Since MSHPs installed in non-electrically heated households generated lower savings, this feedback could provide more insight on whether the inclusion of this measure in Green Heat should be reconsidered.

Section	Recommendations
	3. Improve the collection of technical information about ASHPs. Peak demand savings for ASHPs are based on technical information such as heating capacity and the coefficient of performance (COP) at a temperature of -15°C. In 2015, the Evaluator was able to locate technical information on 15 ASHP models and established an average unitary peak demand savings value of 3.04 kW. Although it was recommended in the 2015 evaluation report that ENS start collecting performance data about ASHPs at -15°C, such information is still not tracked by ENS. In the absence of more accurate performance data, the unitary savings value of 3.04 kW is still used. Considering the fact that the number of ASHPs installed through Green Heat has significantly increased in the past two years (from 52 in 2015 to 143 in 2017), the Evaluator reiterates the recommendation to start tracking ASHP performance data at -15°C to increase the accuracy of the peak demand savings calculations. 4. Gather additional information to further characterize the MSHP market. While the market indicators presented in the Market Evolution section of this report provide some indication of the evolution of the market for MSHPs, certain key data points were unavailable or rely on information from participating contractors. As a result, the Evaluator was unable to formulate a clear conclusion on the current state of the MSHP market in Nova Scotia. Additional data should be collected in 2018, such as: › Market share of efficient MSHPs in Nova Scotia from a broader data set, including market share of secondary systems › Minimum efficiency levels of units sold by contractors › Data on the incremental cost difference between standard versus high-efficiency MSHPs and Green Heat eligible MSHPs 5. Develop a way for potential participants to better understand which ASHP equipment is eligible. Non-MSHP participants do not have a simple list of rebated equipment to choose from and therefore must rely on contractors to determine if equipment is eligible. To drive interest in non-MSHP measures, such as ASHPs, and prevent dissatisfied participants who purchased equipment thinking it was eligible for a rebate, ENS should develop a list of eligible equipment, similar to the list established for MSHPs. Contractors could be asked to develop and update this list.

Section	Recommendations
2016 Recommendations (Not fully implemented at the time of evaluation)	6. Increase program component advertising to households and collaborate with contractors. Evaluation results showed fairly high free-ridership levels for products rebated through Green Heat, especially for heat pumps and MSHPs. The Evaluator recommends focusing marketing efforts on (1) better communicating with households, and (2) collaborating with retailers. Advertising the program component more effectively to households could contribute to lowering the free-ridership level by reaching out to homeowners who have not yet decided to replace or supplement their equipment with heat pump, solar or biomass units. Indeed, many surveyed participants conceded that they had already made the decision to install a high-efficiency system before learning about Green Heat. For homeowners who have already decided to change their heating system, retailers could encourage them to choose the most efficient product by offering the necessary information to customers. However, both lack of point-of-sale material and retailer training result in retailers poorly understanding Green Heat. The Evaluator suggests increasing program component knowledge among retailers by providing them with an impetus to more actively promote higher efficiency models, and offering point-of-sale promotional material. ENS could request retailer inputs about which equipment to promote to achieve energy savings that would not occur otherwise.
Savings review for Mini-split heat pumps	7. Significant uncertainty remains about the magnitude of any savings decrease associated with participants who have accelerated their decision to replace their non-electrical heating systems with a heat pump and those who would not have purchased a heat pump in the absence of Green Heat. The Evaluator recommends that the impact of negative savings be quantified with greater precision in future years.
Savings review for Central Air-source, Air-to-water and Ground-Source Heat pumps	8. Considering the low savings for participants with secondary heat pumps (category 3) and the large proportion of participants in the tracking sheet who are in this category, the Evaluator recommends further investigating this type of participant, possibly by making it the focus of on-site visits in 2018. It is possible that secondary heat pumps in fact provide a large portion of the home's heat and that the displaced heating load by the new heat pump does not originate from electrical resistance heating; these assumptions could be validated by careful on-site analysis of secondary heating systems.

Appendix VIII

GH: CONTRACTOR INTERVIEW GUIDE

Instrument Information

Table 1: Research Objectives and Associated Questions

Research Objective	Associated Questions
Assess program outreach	Q13, Q14, Q15, Q16
Assess program delivery	Q8, Q9, Q10, Q11, Q12
Identify barriers to customer participation and possible solutions	Q11, Q12, Q23
Identify barriers to contractor participation and possible solutions	Q17, Q18, Q20, Q21, Q22, Q23
Identify program successes and challenges	Q36, Q37, Q38
Assess contractor satisfaction with program	Q24, Q25, Q26, Q27
Inquire about possible ways to increase # of projects and savings	Q23, Q38
Impact questions related to the market for MSHPs	Q28, Q29, Q30, Q31, Q32, Q34, Q35

Programmer Information

Programming note style conventions in this document:

- › **[PROGRAMMING]** Programming instructions are in bracketed CAPS.
- › *[Interviewer notes]* Onscreen interviewer instructions are bracketed in *italics*.
- › **[Piped value]** Database inputs are in **bold**.

Instrument

Introduction

Name: Response

Company: Response

Date: Response

Interviewer: Response

Script for Initial Phone Call or Voicemail

Hi, this is _____ from Research Into Action.

As you may know, we are part of the evaluation team for Efficiency Nova Scotia's Green Heat program, I would like to speak with you about your perspectives on how things are going with the program and hear about activities for the current year. Our conversation should take about 30 minutes.

Here are some times that are available for a call; please let me know if one of these works for you.

[INSERT DATES/TIMES; NOTE PROGRAM STAFF ARE ON ATLANTIC TIME.]

Thank you very much. I look forward to speaking with you.

Roles and Responsibilities

- Q1. First, to verify, do you sell heat pumps, wood stoves, or solar equipment directly to homeowners? [IF NO, Thank the respondent for their time and terminate the call. We want to limit our calls to contractor who serve end-users]]
- Q2. Let's start with a bit about you. Can you please tell me your title and briefly describe your role with your company?
- Q3. What is the principal type of work your firm does? [PROBE: HVAC, motors, etc.]
- Q4. What type of equipment do you sell? [Air source heat pump, ductless heat pump, pellet stoves, wood stoves, solar equipment]
- Q5. How long have you worked with the Green Heat program?
- Q6. How did you first become aware of the Green Heat program?
- Q7. I understand you have completed [# of Green Heat PROJECTS HERE] in 2017, as of October. Does that sound right? If not, how many have you done?

Program Processes

As you may know the program recently changed the participation process. Prior to August 2017, participants had to seek pre-approval for their project before purchasing/installing their heat pump. Since August 2017, participants can mail-in their application with proof of installation of an eligible heat pump to get their rebate. I have a few questions about this recent change in process.

- Q8. First, are you familiar with both Green Heat participation processes, pre and post August 2017?
- Q9. Have you completed projects under both systems?
- Q10. *[If completed projects through both systems]* How has this change in process affected you, if at all?
- Q11. *[If completed projects under old system]* How do you anticipate this change in process will affect you, if at all?
- Q12. *[If completed projects through both systems]* How has this change in process affected your customers, if at all?

Program Outreach

- Q13. How do you typically identify customers that go through the Green Heat program? These could be heat pump (ASHP or MSHP), solar, or biomass (wood or pellet stoves) customers? [PROBES: Are your customers people who talk to you about a project and you tell them about Green Heat? Are your Green Heat customers people you cold -call? That is, you approach potential customers you think are likely to do a heat pump or other Green Heat project?]
- Q14. How, if at all, has your approach to reaching out to customers changed since the program change?
- Q15. What do you tell customers about the benefits of energy efficient equipment offered through the Green Heat program? Are there any approaches or strategies that seem to be effective at convincing a reluctant customer to purchase an energy efficient device such as a program qualified heat pump? [PROBES: Do you discuss savings, non-energy benefits of the measure? How do you sell the Green Heat program to customers?]
- Q16. Do you use any materials provided by ENS to conduct outreach to customers? What do you use and how do you use them?

Support from Efficiency Nova Scotia

- Q17. I want to understand more about your working relationship with Efficiency Nova Scotia. How often, if at all, do you interact with someone from Efficiency Nova Scotia about the Green Heat program?

- Q18. Is your firm a member of the Efficiency Trade Network? Do you receive communications and updates from the Trade Network? How have you benefited, if at all, from your association with the ETN?
- Q19. What service or support, if any, have you received from Efficiency Nova Scotia to help you attract Green Heat customers?
- Q20. What service or support, if any, would you like to see from Efficiency Nova Scotia to help you sell more Green Heat projects? Why?
- Q21. *[If interacted with ENS staff]* Have ENS staff answered questions you had in a timely manner?
- Q22. *[If interacted with ENS staff]* What do you typically interact with staff about? How do you interact with them (phone, email, in-person)?
- Q23. Are there certain measures or services ENS should provide for Green Heat projects? If so, what measures or services should be added and why?

Contractor Satisfaction

- Q24. Has the Green Heat program helped you sell more energy efficient equipment (specifically heat pumps, solar, or biomass systems) than you had prior to participating in the program? *[If there has been a change]* How has the program, other than the rebate, helped you sell more?
- Q25. On a scale of zero to ten where, zero is not at all satisfied and ten is extremely satisfied, how satisfied have you been with the program asked of you? Has your satisfaction changed since the program revised its processes in August 2017?
- Q26. On that same zero to ten scale, overall, how satisfied have you been with Efficiency Nova Scotia in terms of providing you with the service and support you need to deliver Green Heat rebated equipment Why?
- Q27. Is there anything ENS could have done to improve how they communicate with you about the program?

Mini-split Heat Pumps Market

Before we finish, I would like to specifically discuss the mini-split heat pumps residential market and the influence of the Green Heat program on your sales of mini-split heat pumps. I would like to remind you that the mini-split heat pumps that qualify for the Efficiency Nova Scotia Green Heat program are (1) ductless, (2) must have a COP ≥ 1.75 at maximum capacity operation for -15°C outdoor temperature, and (3) must have an HSPF for region 5 of more than 9.6 for single-zone systems or of more than 8.7 for multi-zone systems.

Q28. Approximately how many mini-split heat pumps have you sold to residential customers so far in 2017? We want to know about all mini-split heat pumps, counting those that qualify and don't qualify for a rebate.

Q29. In October 2015, Efficiency Nova Scotia started offering a rebate on mini-split heat pumps through its Green Heat program. How do your 2017 sales of mini-split heat pumps to residential customers compare to your sales from two years ago when there was no rebate on mini-split heat pumps? Are they roughly the same or higher? If higher, by what percentage?

Higher by what percentage: _____

Q30. [IF HIGHER IN Q32] How have Efficiency Nova Scotia's actions in promoting energy-efficient mini-split heat pumps through its Green Heat program affected this increase in your sales of mini-split heat pumps in the last two years?

Q31. Of the mini-split heat pumps you have sold to residential customers so far in 2017, what proportion are Green Heat-qualified mini-split heat pumps?

_____ %

Q32. Again, thinking about your sales of mini-split heat pumps from two years ago when there was no rebate—what proportion of your sales from then would have qualified for the Green Heat program under today's requirements?

- Q33. On a scale of 0 to 10, where 0 means ‘it did not increase at all’ and “10” means “it increased a great deal” how much do you think the Green Heat program has increased each of the following things:
- a. The availability of high-efficiency mini-split heat pumps in your store(s)
Score:
Please explain your response:
 - b. Your sales staff’s knowledge of high-efficiency mini-split heat pumps and their benefits
Score:
Please explain your response:
 - c. Your company’s heat pump offerings, marketing and promotion being oriented toward high-efficiency mini-split heat pumps rather than standard-efficiency models
Score:
Please explain your response:
- Q34. I would like to discuss two customer scenarios with you: one where the customer is already set on buying a mini-split heat pump, and the other one where the customer who comes to you is not sure of the type of system they will buy. In your opinion, is the Green Heat program more effective at encouraging people who don’t already want a mini-split heat pump to buy a mini-split heat pump, or is the program more effective at encouraging customers who already want a mini-split heat pump to go for the most efficient model of mini-split heat pump? What proportion of your customers go in each category?
- Q35. For customers who do still choose standard efficiency models, why do they opt not to go with the energy-efficient models?

Successes, Challenges, and Opportunities

- Q36. How, if at all, has the Green Heat program been a success for your firm?
- Q37. How, if at all, has the Green Heat program been a challenge for your firm?
- Q38. Other than increase incentives, what could Efficiency Nova Scotia do to make the Green Heat program more effective, if anything?
- Q39. Is there anything else about the program that we have not discussed that you feel should be mentioned?

Appendix IX

GH: OLD PATH PARTICIPANT SURVEY QUESTIONNAIRE

Could I speak with [INSERT NAME]?

- 1 Yes [GO TO INTRODUCTION]
- 2 No [SAY “Perhaps you can help me anyway.” GO TO INTRODUCTION]

INTRODUCTION

Hello, my name is _____ from Corporate Research Associates, a Halifax-based survey research company. We are performing an evaluation of energy efficiency services provided by Efficiency Nova Scotia. Our records indicate that you or your household recently participated in the Green Heat Program.

We would appreciate your help in answering questions about this program. The information you provide will be used to help Efficiency Nova Scotia improve the program. Is this a good time for you?

(IF NEEDED: The program provides a rebate or financing for the installation of solar systems or home heating equipment, such as heat pumps, furnaces and boilers.)

(IF NEEDED: You may have recently been contacted by Corporate Research Associates and Efficiency Nova Scotia about your experience with the program. This survey is different as it focuses on other aspects of your participation in the program.)

(IF NEEDED: The survey will take about fifteen minutes.)

V1. Our records indicate that your household installed a **[EQUIPMENT]** through the Green Heat Program. Is this correct?

1. Yes [CONTINUE]
2. No, does not recall participating [PROBE: “Are you sure? According to our records, you would have received **[A REBATE/FINANCING]** from Efficiency Nova Scotia for installing a **[EQUIPMENT]**. [IF PERSIST AS NO, THANK, TERMINATE, RECORD AND KEEP DATA]
9. Don’t know/Refused [PROBE: “Is there someone else in your household who would know about having participated in the Green Heat program?”] [IF NO, ASK TO SPEAK TO THE APPROPRIATE PERSON AND RESTART AT INTRODUCTION. IF PERSISTS AS NO, THANK, TERMINATE, RECORD AND KEEP DATA.]

[IF REFUSED, ASK “Can we schedule a more convenient time for you to conduct this survey?”]

[SCHEDULED, IF NECESSARY, FOR: _____]

Participation [P Series]

- P1. First I'm going to ask you to think back to when you decided to install a **[EQUIPMENT]**. What was the SINGLE most important reason you were interested in installing a **[EQUIPMENT]**? [DO NOT READ – CODE ONE ONLY]
1. (To save on energy/to save on energy costs)
 2. (For better comfort)
 3. (To make home more energy efficient)
 4. (To help the environment)
 5. (To have a backup heating source)
 6. (Wanted wood stove/Like wood heat)
 7. (Old system wasn't working properly)
 96. (Other) [SPECIFY_____])
 98. (Don't know) [GO TO U1]
 99. (Refused) [GO TO U1]
- P2. Were there any other reasons? [SAME LIST AS IN P1] [DO NOT READ. ACCEPT MULTIPLE RESPONSES]
- 97 None/no other reasons

Usage [IF EQUIPMENT TYPE = MSHP] [U Series]

- U1. In addition to your newly installed high-efficiency mini-split heat pump, is there another heating system used for heating in your home?
1. Yes
 2. No
 98. (Don't know)
 99. (Refused)
- U2. [IF U1=1] What type of heating system is it? Is it... [READ IN ORDER AND ACCEPT ONE RESPONSE ONLY]
1. Electric baseboards or electric furnace
 2. Another heat pump
 3. Geothermal system
 4. Heating stove (wood or pellet)
 5. Gas or oil-fired furnace
 6. Or something else (SPECIFY:_____)
 98. (Don't know)
 99. (Refused)
- U3. Which part of your house is heated by the mini-split heat pump installed through the Green Heat program? Is it... [READ IN ORDER AND ACCEPT ONE RESPONSE ONLY]
1. One room only
 2. One floor
 3. The whole house
 4. Or something else (SPECIFY:_____)
 98. (Don't know)
 99. (Refused)

Free-Ridership – Mini-split Heat Pumps [IF EQUIPMENT TYPE = MINI-SPLIT HEAT PUMPS (MSHP)] [FRM Series]

Moving along to another topic... I will first ask you a series of questions regarding your decision to install a heat pump instead of installing another type of heating system or simply keeping your existing system. I will then ask you a series of questions regarding your decision to install a high-efficiency heat pump rather than a regular heat pump.

Series A: Questions on the decision to install a heat pump

FRM1. Had you already decided to install a heat pump before you heard about the Green Heat Program?

- 1. Yes
- 2. No
- 98. (Don't know)
- 99. (Refused)

FRM1a. [IF FRM1=1] I just want to make sure I understand – before you learned about the Green Heat Program, you had already made the decision to install a heat pump?

- 1. Yes
- 2. No
- 98. (Don't know)
- 99. (Refused)

FRM2. [IF FRM1=2, 98, 99 or FRM1a=2, 98, 99] If the program rebate or financing had not been offered, which of the following actions would you have taken? [READ IN ORDER, CODE ONE ONLY]

- 1. Kept your existing heating system [GO TO S SERIES]
- 2. Purchased a new electric heating system [GO TO S SERIES]
- 3. Purchased a new non-electric heating system (e.g. oil or gas system) [GO TO S SERIES]
- 4. Purchased a heat pump
- 98. (Don't know)
- 99. (Refused)

FRM3. [IF FRM1a=1 OR FRM2=4] If the program rebate or financing had not been offered, what is the likelihood that you would have postponed the purchase of a heat pump by at least one year? Please answer on a scale of 0 to 10, with a 0 indicating that it is “Very unlikely” and 10, “Very likely”. [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response ___ 98 Don't Know ___ 99 Refused

Series B: Questions on the decision to install a high-efficiency heat pump [ASK ALL MSHP RESPONDENTS]

Only high-efficiency heat pump models are eligible for a rebate under the Green Heat program, so the heat pump you have installed is much more efficient than the standard heat pump models on the market, especially at low temperatures of -15°C or less. Now, we will discuss your decision to install a high-efficiency heat pump model rather than a less efficient and less expensive model.

FRM4. Were you aware of the availability of high efficiency heat pumps that operate at temperatures below -15°C before you heard about the Green Heat Program?

- 1. Yes
- 2. No
- 98. (Don't know)
- 99. (Refused)

FRM4a. [IF FRM4=1] Before you heard about the Green Heat Program, had you already made the decision to install a **high-efficiency** heat pump model?

- 1. Yes
- 2. No
- 98. (Don't know)
- 99. (Refused)

FRM5a. [IF REBATE] Efficiency Nova Scotia gave a rebate of \$[INCENTIVE] for your new high-efficiency heat pump. If you had not received the rebate from Efficiency Nova Scotia, would you have paid the total cost of your high efficiency heat pump? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely **Would Not** Have Paid” and a 10 indicating that you “Definitely **Would Have** Paid.” [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response ___98 Don't Know ___99 Refused

FRM5b. [IF FINANCING] Efficiency Nova Scotia provided you with a \$[LOAN AMOUNT] for your new high-efficiency heat pump. If you had not received low interest financing from Efficiency Nova Scotia, would you have financed the cost of the heat pump through some other means? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely **Would Not** Have Financed” and a 10 indicating that you “Definitely **Would Have** Financed.” [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response ___98 Don't Know ___99 Refused

FRM6. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to install high-efficiency heat pump. Using a scale from 0 to 10, where 0 means "No influence" and 10 means "Great influence", please rate the influence of each of the following in your decision to install a high-efficiency heat pump.

Factor (READ AND RANDOMIZE)	Responses – DO NOT ACCEPT A RANGE
a. The program rebate or financing	___ Response ___98 Don't Know ___99 Refused
b. Information on the benefits of high efficiency heat pumps provided by Efficiency Nova Scotia	___ Response ___98 Don't Know ___99 Refused
c. Information on the benefits of high efficiency heat pumps provided by the retailers	___ Response ___98 Don't Know ___99 Refused

Free-Ridership – Heat Pumps [IF EQUIPMENT TYPE = AIR-SOURCE HEAT PUMPS OR GROUND SOURCE HEAT PUMP] [FRH Series]

FRH1. Moving along to another topic... Had you **already** decided to install a high efficiency [EQUIPMENT] **before** you heard about the Green Heat Program?

1. Yes
2. No
98. (Don't know)
99. (Refused)

FRH1a. [IF FRH1=1] I just want to make sure I understand – **before** you decided to participate in the Green Heat Program, you had already made the decision to install a high efficiency [EQUIPMENT]?

1. Yes
2. No
98. (Don't know)
99. (Refused)

FRH2a. [IF REBATE] Efficiency Nova Scotia gave a rebate of \$[INCENTIVE] for your new [EQUIPMENT]. If you had not received the rebate from Efficiency Nova Scotia, would you have paid the entire cost of your [EQUIPMENT]? Please answer on a scale of 0 to 10, with a 0 indicating that you "Definitely **Would Not** Have Paid" and a 10 indicating that you "Definitely **Would Have** Paid." [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response ___98 Don't Know ___99 Refused

FRH2b. [IF FINANCING] Efficiency Nova Scotia provided you with a \$[LOAN AMOUNT] loan for your new [EQUIPMENT]. If you had not received the financing from Efficiency Nova Scotia, would you have financed the cost of your new [EQUIPMENT] through some other means? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely **Would Not Have Financed**” and a 10 indicating that you “Definitely **Would Have Financed**.” [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response ___98 Don't Know ___99 Refused

[READ FIRST TIME THROUGH ONLY] Now I would like to ask you to consider what actions you would have taken if the Green Heat Program had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely,” and a 10 indicating that it is “Very Likely.”

[DO NOT ACCEPT A RANGE – ASK FRH3 a-c SEQUENCE IN ORDER/DO NOT RANDOMIZE]

FRH3a. If the program rebate or financing had not been offered, what is the likelihood that you would have installed a less efficient and less expensive heat pump?

___ Response ___98 Don't Know ___99 Refused

FRH3b. If the program rebate or financing had not been offered, what is the likelihood that you would have kept your old heating system instead of installing a new one?

___ Response ___98 Don't Know ___99 Refused

FRH3c. If the program rebate or financing had not been offered, what is the likelihood that you would have postponed installing the [EQUIPMENT] by at least one year?

___ Response ___98 Don't Know ___99 Refused

FRH4. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to install [a/an] [EQUIPMENT]. Using a scale from 0 to 10, where 0 means “No influence” and 10 means “Great influence”, please rate the influence of each of the following in your decision to install a [EQUIPMENT].

Factor (READ AND RANDOMIZE)	Responses – DO NOT ACCEPT A RANGE
a. The program rebate or financing	___ Response ___98 Don't Know ___99 Refused
b. Information provided by Efficiency Nova Scotia	___ Response ___98 Don't Know ___99 Refused

Free-Ridership – Solar and Biomass [IF EQUIPMENT TYPE = Solar water heating, Wood Stove, Pellet Stove or Wood Boiler/ Furnace] [FRS Series]

FRS1. Moving along to another topic... Had you **already** decided to install a [EQUIPMENT] **before** you heard about the Green Heat Program?

- 1. Yes
- 2. No
- 98. (Don't know)
- 99. (Refused)

FRS1a. [IF FRS1=1] I just want to make sure I understand – **before** you decided to participate in the Green Heat Program, you had already made the decision to install a [EQUIPMENT]?

- 1. Yes
- 2. No
- 98. (Don't know)
- 99. (Refused)

FRS2a. [IF REBATE] Efficiency Nova Scotia gave a rebate of \$[INCENTIVE] for your new [EQUIPMENT]. If you had not received the rebate from Efficiency Nova Scotia, would you have paid the entire cost of your [EQUIPMENT]? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely **Would Not** Have Paid” and a 10 indicating that you “Definitely **Would Have** Paid.” [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response ___ 98 Don't Know ___ 99 Refused

FRS2b. [IF FINANCING] Efficiency Nova Scotia provided you with a \$[LOAN AMOUNT] loan for your new [EQUIPMENT]. If you had not received the financing from Efficiency Nova Scotia, would you have financed the cost of your new [EQUIPMENT] through some other means? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely **Would Not** Have Financed” and a 10 indicating that you “Definitely **Would Have** Financed.” [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response ___ 98 Don't Know ___ 99 Refused

[READ FIRST TIME THROUGH ONLY] Now I would like to ask you to consider what actions you would have taken if the Green Heat Program had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely,” and a 10 indicating that it is “Very Likely.”

[DO NOT ACCEPT A RANGE – ASK FRS3 a-c SEQUENCE IN ORDER/DO NOT RANDOMIZE]

FRS3a. If the program rebate or financing had not been offered, what is the likelihood that you would have installed an electrical heating system instead of the [EQUIPMENT] you installed through the program?

___ Response ___98 Don't Know ___99 Refused

FRS3b. If the program rebate or financing had not been offered, what is the likelihood that you would have kept your old heating system instead of installing a new one?

___ Response ___98 Don't Know ___99 Refused

FRS3c. If the program rebate or financing had not been offered, what is the likelihood that you would have postponed installing the [EQUIPMENT] by at least one year?

___ Response ___98 Don't Know ___99 Refused

FRS4. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to install a [EQUIPMENT]. Using a scale from 0 to 10, where 0 means "No influence" and 10 means "Great influence", please rate the influence of each of the following in your decision to install a [EQUIPMENT].

Factor (READ AND RANDOMIZE)	Responses – DO NOT ACCEPT A RANGE
a. The program rebate or financing	___ Response ___98 Don't Know ___99 Refused
b. Information provided by Efficiency Nova Scotia	___ Response ___98 Don't Know ___99 Refused

Cross-Influence [CI Series]

READ AND ROTATE (CI1 + CI2a-c) AND (CI3 + CI4a-c) SEQUENCES

CI1. Before participating in the Green Heat program in 2017, had you at any time in the past already participated in another Efficiency Nova Scotia program?

1. Yes
2. No
98. (Don't know)
99. (Refused)

For the following statements, please indicate whether you agree or disagree.

CI2a. [IF CI1=1] Your previous participation in an Efficiency Nova Scotia program was a major factor in your decision to install [a/an] [EQUIPMENT] in your home.

1. Agree

- 2. Disagree
- 98. (Don't know)
- 99. (Refused)

CI2b. [IF CI1=1] Because of your previous participation in an Efficiency Nova Scotia program and what you learned by participating in this program, you asked a contractor or a distributor about energy efficient heating systems for your home.

- 1. Agree
- 2. Disagree
- 98. (Don't know)
- 99. Refused)

CI2c. [IF CI1=1] Because of your previous participation in another Efficiency Nova Scotia program and what you learned by participating in this program, you took into account the savings on your energy bill when evaluating different heating systems for your home.

- 1. Agree
- 2. Disagree
- 98. (Don't know)
- 99. (Refused)

CI3. Before participating in the Green Heat program in 2017, had you at any time in the past already seen Efficiency Nova Scotia promotional materials advertising the benefits of energy efficiency?

- 1. Yes
- 2. No
- 98. (Don't know)
- 99. (Refused)

For the following statements, please indicate whether you agree or disagree.

CI4a. [IF CI3=1] The energy efficiency promotional materials distributed by Efficiency Nova Scotia were a major factor in your decision to install [a/an] [EQUIPMENT] in your home.

- 1. Agree
- 2. Disagree
- 98. (Don't know)
- 99. (Refused)

CI4b. [IF CI3=1] The energy efficiency promotional materials distributed by Efficiency Nova Scotia prompted you to ask a contractor or a distributor about energy efficient heating systems for your home.

- 1. Agree
- 2. Disagree
- 98. (Don't know)

99. (Refused)

CI4c. [IF CI3=1] The energy efficiency promotional materials distributed by Efficiency Nova Scotia prompted you to take into account the savings on your energy bill when evaluating different heating systems for your home.

1. Agree

2. Disagree

98. (Don't know)

99. (Refused)

Satisfaction and Concerns [S Series]

Now, I have some questions about your satisfaction with the **[EQUIPMENT TYPE]** you installed and the Green Heat program.

S1. On a scale of 0 to 10 where 0 equals “not at all satisfied” and 10 equals “extremely satisfied”, how satisfied were you with the following when installing your new **[EQUIPMENT TYPE]**? How satisfied were you with... **[CODE ONLY ONE 0-10, 98=DK, 99=REFUSED] READ IN ORDER**

a. The clarity of program requirements

b. The confirmation of eligibility

c. The time allowed by the program to install your equipment and send your paperwork

d. The range of program eligible equipment

e. The quality of the equipment installed in your home

f. **[IF REBATE]** The amount of the rebate

g. **[IF REBATE]** The time it took to receive the rebate

h. **[IF FINANCING]** The eligibility requirements for the loan

i. The Green Heat program overall

S2. **[IF S1i<8]** What was the most important reason you were not more satisfied with the Green Heat program overall? **[PROBE FOR SPECIFIC REASON. ACCEPT MULTIPLE RESPONSE]**

96. (RECORD VERBATIM: _____)

98. (Don't know)

99. (Refused)

S3. For the next few statements, I'd like you to think back to the point when you started to consider installing **[a/an] [EQUIPMENT TYPE]**. On a scale of 0 to 10 where 0 equals “not at all a concern” and 10 equals “a major concern”, how much of a concern was... **[CODE ONLY ONE 0-10, 98=DK, 99=REFUSED] ROTATE ORDER**

a. Selecting the right equipment

b. The appearance of the equipment

c. Finding a qualified contractor

d. The reliability of the equipment

- e. The disruption of equipment installation in your home
- f. The overall purchase and installation cost of the equipment compared to other heating options

S4. What other concerns, if any, did you have with installing [a/an] [EQUIPMENT TYPE]? RECORD VERBATIM

- 97 None/no concerns
- 98 (Don't know)
- 99 (Refused)

S5. Now I'd like you to think back to the point when you began considering participating in the Green Heat program for your [EQUIPMENT TYPE]. On a scale of 0 to 10 where 0 equals "not at all a concern" and 10 equals a "major concern", how much of a concern was... [CODE ONLY ONE 0-10, 98=DK, 99=REFUSED] [RANDOMIZE]

- a. Completing the application paperwork
- b. Getting approval for your project
- c. Working with Efficiency Nova Scotia
- d. Realizing the promised energy savings
- e. [IF FINANCING] The ability to pay the loan back per the loan terms

S6. What other concerns, if any, did you have with participating in the Green Heat program? RECORD VERBATIM

- 97 None/no concerns
- 98 (Don't know)
- 99 (Refused)

Appropriate Price (and Rebate) of Measures [A Series]

For the next few questions, I'd like you to think about the cost of the [EQUIPMENT TYPE] you installed as part of the Green Heat program. ROTATE A1-A4

A1. At what price would you have considered the cost of [EQUIPMENT TYPE] to be so expensive that you would not have considered buying it?

- a. Record response (Force numeric)
- b. DK

A2. At what price, would you have considered the cost of [EQUIPMENT TYPE] to be priced so low that you would have felt the product quality couldn't be very good?

- a. Record response (Force numeric)
- b. DK

- A3. At what price would you have considered the cost of **[EQUIPMENT TYPE]** to be starting to get expensive, so that it was not out of the question, but you would have had to give some thought to buying it?
- Record response (Force numeric)
 - DK
- A4. At what price would you have considered the cost of **[EQUIPMENT TYPE]** to be a bargain—a great buy for the money?
- Record response (Force numeric)
 - DK

Market Transformation [IF EQUIPMENT TYPE = MSHP] [M Series]

- M1. How did you first become aware of mini-split heat pumps? [DO NOT READ. SINGLE RESPONSE]
- (Saw an advertisement)
 - (Through a contractor, retailer or distributor)
 - (Via a friend, acquaintance, or family member)
 - (Online, SPECIFY_____)
 96. (Other) [SPECIFY_____]
 - 98 Don't know
 - 99 Refused
- M2. Thinking back before you installed your mini-split heat pump, when do you recall first becoming aware of mini-split heat pumps as an option for heating and cooling your home? Was it... [CODE ONLY ONE]
- 6 months or less prior to installing your mini-split heat pump
 - More than 6 months up to 1 year prior to installing your mini-split heat pump
 - More than 1 year up to 2 years prior to installing your mini-split heat pump
 - More than 2 years up to 3 years prior to installing your mini-split heat pump
 - More than 3 years prior to installing your mini-split heat pump
 - 98 (Don't know)
 - 99 (Refused)
- M3. Prior to installing your mini-split heat pump in 2017, had you ever considered installing a mini-split heat pump? [CODE ONLY ONE]
- Yes
 - No
 - 98 (Don't know)
 - 99 (Refused)

M4. [IF M3 = 1, Yes] So you considered installing a mini-split heat pump prior to 2017. What kept you from installing a mini-split heat pump in previous years? [DO NOT READ, PROBE TO CODE]
ACCEPT MULTIPLE RESPONSE

- 1 (The mini-split heat pump was too expensive)
- 2 (Existing heating/cooling system worked well enough)
- 3 (Concerned about the reliability of mini-split heat pumps)
- 4 (Concerned about the appearance of mini-split heat pumps)
- 5 (Concerned about the energy savings a mini-split heat pump would provide over existing system)
- 97 Other, please specify: _____
- 98 (Don't know)
- 99 (Refused)

Recommendations for Program Improvements [R Series]

R1. What was the most helpful aspect of the Green Heat program? [RANDOMIZE, SINGLE RESPONSE, DO NOT READ]

- 1 (Lowering the cost of the installation)
- 2 (Assistance in finding an installer)
- 3 (Providing an efficient heating device)
- 4 (Providing education about efficient equipment)
- 5 (Providing a better heating system than previous system)
- 6 (More environmentally friendly)
- 96 (Other [SPECIFY _____])
- 98 (Don't know)
- 99 (Refused)

R2. Other than increase the rebate or loan amount, how could Efficiency Nova Scotia improve the Green Heat program? PROBE: Anything else? [DO NOT READ. ACCEPT MULTIPLE]

- 1. (Offer additional equipment eligible for rebates/financing)
- 2. (Offer more information on the equipment recommended)
- 3. (Simplify program application, forms and associated paperwork)
- 4. (Speed up the process)
- 5. (Increase the time given to complete the upgrades)
- 6. (Improve communication)
- 7. (Advertise the program more or in a better way)
- 8. (No recommendation)
- 96 (Other [SPECIFY _____])
- 98 (Don't know)
- 99 (Refused)

Demographics [D Series]

These final questions are asked for statistical purposes only. The information collected is strictly confidential.

D1. What type of residence do you live in? [READ RESPONSES 1-5, then 96; SELECT ONE RESPONSE]

1. Detached single-family home
2. Semi-detached house
3. Mobile home or house trailer
4. Townhouse or duplex which share adjacent walls
5. Row house
96. Or Another type [SPECIFY: _____]
98. (Don't know)
99. (Refused)

D2. How many bedrooms are in your home? [98=DK; Enter zero for a studio apartment with no bedrooms]

D3. Including yourself, how many people live in this residence on a full-time basis?

Number of people: _____ [NOTE: DON'T ALLOW ZERO FOR A RESPONSE]

98. (Nobody lives in the house on a full-time basis)
99. (Refused)

D4. What is your age group? Are you... [READ]

1. 18 to 24
2. 25 to 34
3. 35 to 44
4. 45 to 54
5. 55 to 64
6. 65 or over
9. (Refused)

D5. What is the highest level of education you have completed? [DO NOT READ]

1. (Less than high school graduation certificate)
2. (High school graduation certificate and/or some post-secondary)
3. (Trades certificate or diploma)
4. (College certificate or diploma)
5. (University certificate or diploma)
99. (Refused)

D6. Which of the following income categories best describes your total annual household income before taxes in 2016? Stop me when I reach the right category. [READ LIST; SELECT ONE RESPONSE]

1. Less than \$15,000
2. \$15,000 - \$24,999
3. \$25,000 - \$34,999
4. \$35,000 - \$49,999
5. \$50,000 - \$69,999
6. \$70,000 - \$79,999
7. \$80,000 or more
99. (Refused)

D7. [DO NOT READ] Gender:

1. Male
2. Female

END: Those are all the questions I have for you. I thank you very much for your time and cooperation and have a nice day!

Appendix X

GH: OLD PATH PARTICIPANT SURVEY RESULTS

P1. What was the SINGLE most important reason you were interested in installing a [EQUIPMENT]?

P2. Were there any other reasons?

Reasons for Participating	Total 2016		Total 2017	
	Most Important Reason	Second Most Important Reason*	Most Important Reason	Second Most Important Reason*
Sample Size	90	90	91	91
Save on energy/energy costs	54%	11%	49%	16%
Old system wasn't working properly	7%	1%	18%	4%
Wanted air conditioning	4%	12%	12%	11%
To make home more energy efficient	13%	20%	5%	18%
To replace another heat source	-	-	3%	-
For better comfort	7%	26%	3%	14%
To have a backup heating source	2%	4%	3%	3%
Convenience/Easier to use/maintain than wood heat	3%	8%	1%	1%
To help the environment	3%	4%	1%	2%
Wanted wood stove/Like wood heat	1%	9%	1%	2%
Rebate/Financing	-	2%	-	1%
Others	4%	9%	2%	5%
Nothing/No other reasons	-	21%	-	32%
Don't know	-	1%	-	1%
*Multiple responses				

U1. In addition to your newly installed high-efficiency mini-split heat pump, is there another heating system used for heating in your home?

Other Heating Systems Installed	2017
Sample Size*	51
Yes	82%
No	18%
*Base: MSHP respondents	

U2. What type of heating system is it? Is it...

Other Heating Systems Installed	2017
Sample Size*	42
Electric baseboards or electric furnace	71%
Heating stove (wood or pellet)	14%
Electric thermal storage/ETS	7%
Others	7%
*Base: MSHP respondents who have another heating system in their home	

U3. Which part of your house is heated by the mini-split heat pump installed through the Green Heat program? Is it...

Area Heated by Mini-Split Heat Pump	2017
Sample Size*	51
One floor	37%
The whole house	37%
Two floors	14%
Others	12%
*Base: MSHP respondents	

FRM1. Had you already decided to install a heat pump before you heard about the Green Heat Program?

FRM1a. I just want to make sure I understand – before you learned about the Green Heat Program, you had already made the decision to install a heat pump?

Already Made Decision to Install Equipment Prior to Green Heat	2017
Sample Size*	51
Yes	53%
No	45%
Don't know/Refused	2%
*Base: MSHP respondents	

FRM2. If the program rebate or financing had not been offered, which of the following actions would you have taken?

Actions Taken in Absence of Green Heat	2017
Sample Size*	24
Kept your existing system	46%
Purchased a heat pump	38%
Purchased a new electric heating system	4%
Don't know	13%
*Base: MSHP respondents who had not previously decided to install a heat pump prior to the program component	

FRM3. If the program rebate or financing had not been offered, what is the likelihood that you would have postponed the purchase of a heat pump by at least one year? Please answer on a scale of 0 to 10, with a 0 indicating that it is "Very unlikely" and 10, "Very likely".

Actions Taken in Absence of Green Heat	2017	
	Sample Size*	Mean**
Postponed the purchase of a heat pump by at least one year	36	3.9
*Base: MSHP respondents who previously decided to install a heat pump prior to hearing about Green Heat, or were likely to purchase a heat pump without the program component		
**Don't know/refused excluded from calculation		

FRM4. Were you aware of the availability of high efficiency heat pumps that operate at temperatures below -15°C before you heard about the Green Heat Program?

Aware of High Efficiency Heat Pumps	2017
Sample Size*	39
Yes	69%
No	31%
*Base: MSHP respondents who previously decided to install a heat pump prior to hearing about Green Heat, or were likely to purchase a heat pump without the program component	

FRM4a. Before you heard about the Green Heat Program, had you already made the decision to install a high-efficiency heat pump model?

Previously Decided to Install High Efficiency Heat Pump	2017
Sample Size*	27
Yes	70%
No	30%
*Base: MSHP respondents who were aware of high efficiency heat pumps prior to participating in the program component	

FRM5a. [IF REBATE] Efficiency Nova Scotia gave a rebate of \$[INCENTIVE] for your new high-efficiency heat pump. If you had not received the rebate from Efficiency Nova Scotia, would you have paid the total cost of your high efficiency heat pump? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely Would Not Have Paid” and a 10 indicating that you “Definitely Would Have Paid.”

FRM5b. [IF FINANCING] Efficiency Nova Scotia provided you with a \$[LOAN AMOUNT] for your new high-efficiency heat pump. If you had not received low interest financing from Efficiency Nova Scotia, would you have financed the cost of the heat pump through some other means? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely Would Not Have Financed” and a 10 indicating that you “Definitely Would Have Financed.”

Would Have Paid Full Cost of High Efficiency Heat Pump	2017	
	Sample Size*	Mean**
IF REBATE: Would have paid full cost of heat pump	34	8.8
IF FINANCING: Would have financed the cost through some other means	4	5.0
*Base: MSHP respondents who previously decided to install a heat pump prior to hearing about Green Heat, or were likely to purchase a heat pump without the program component		
**Don't know/Refused excluded from calculations		

FRM6. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to install high-efficiency heat pump. Using a scale from 0 to 10, where 0 means "No influence" and 10 means "Great influence", please rate the influence of each of the following in your decision to install a high-efficiency heat pump.

Influence of Factors on Decision to Have High Efficiency Heat Pump Installed	2017	
	Sample Size*	Mean**
Information on the benefits of high efficiency heat pumps provided by the retailers	39	7.1
Information on the benefits of high efficiency heat pumps provided by ENS	37	6.9
The program component rebate or financing	39	4.4
*Base: MSHP respondents who previously decided to install a heat pump prior to hearing about Green Heat, or were likely to purchase a heat pump without the program component		
**Don't know/Refused excluded from calculations		

FRH1. Moving along to another topic... Had you **already** decided to install a high efficiency [EQUIPMENT] **before** you heard about the Green Heat Program?

FRH1a. I just want to make sure I understand – **before** you decided to participate in the Green Heat Program, you had already made the decision to install a high efficiency [EQUIPMENT]?

Already Made Decision to Install Equipment Prior to Green Heat	2017
Sample Size*	24
Yes	71%
No	25%
Don't know/Refused	4%
*Base: ASHP/GSHP Respondents	

FRH2a. [IF REBATE] Efficiency Nova Scotia gave a rebate of \$[INCENTIVE] for your new [EQUIPMENT]. If you had not received the rebate from Efficiency Nova Scotia, would you have paid the entire cost of your [EQUIPMENT]? Please answer on a scale of 0 to 10, with a 0 indicating that you "Definitely **Would Not** Have Paid" and a 10 indicating that you "Definitely **Would Have** Paid." [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

FRH2b. [IF FINANCING] Efficiency Nova Scotia provided you with a \$[LOAN AMOUNT] loan for your new [EQUIPMENT]. If you had not received the financing from Efficiency Nova Scotia, would you have financed the cost of your new [EQUIPMENT] through some other means? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely **Would Not Have Financed**” and a 10 indicating that you “Definitely **Would Have Financed**.” [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

Would Have Paid Full Cost of High Efficiency Heat Pump	2017	
	Sample Size*	Mean**
IF REBATE: Would have paid full cost of equipment	21	7.7
IF FINANCING: Would have financed the cost through some other means	3	3.7
*Base: ASHP/GSHP Respondents **Don't know/Refused excluded from calculations		

FRH3. Now I would like to ask you to consider what actions you would have taken if the Green Heat Program had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely,” and a 10 indicating that it is “Very Likely.”

Actions Taken in Absence of Green Heat	2017	
	Sample Size*	Mean**
Postponed installing the equipment by at least one year	24	4.1
Installed a less efficient and less expensive heat pump	24	3.9
Kept old heating system instead of installing new one	24	2.7
*Base: ASHP/GSHP Respondents **Don't know/refused excluded from calculation		

FRH4. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to install [a/an] [EQUIPMENT]. Using a scale from 0 to 10, where 0 means "No influence" and 10 means "Great influence", please rate the influence of each of the following in your decision to install a [EQUIPMENT].

Influence of Factors on Decision to Have Equipment Installed	2017	
	Sample Size*	Mean**
Information provided by ENS	24	6.0
The program component rebate or financing	24	5.6
*Base: ASHP/GSHP respondents who previously decided to install a heat pump prior to hearing about Green Heat, or were likely to purchase a heat pump without the program component **Don't know/Refused excluded from calculations		

FRS1. Moving along to another topic... Had you **already** decided to install a [EQUIPMENT] **before** you heard about the Green Heat Program?

FRS1a. I just want to make sure I understand – **before** you decided to participate in the Green Heat Program, you had already made the decision to install a [EQUIPMENT]?

Already Made Decision to Install Equipment Prior to Green Heat	2017 (#)
Sample Size*	16
Yes	11
No	5
*Base: Wood/Pellet/Solar respondents	

FRS2a. [IF REBATE] Efficiency Nova Scotia gave a rebate of \$[INCENTIVE] for your new [EQUIPMENT]. If you had not received the rebate from Efficiency Nova Scotia, would you have paid the entire cost of your [EQUIPMENT]? Please answer on a scale of 0 to 10, with a 0 indicating that you "Definitely **Would Not Have Paid**" and a 10 indicating that you "Definitely **Would Have Paid**."

Would Have Paid Full Cost of Equipment	2017	
	Sample Size*	Mean**
IF REBATE: Would have paid full cost of equipment	16	7.7
*Base: Wood/Pellet/Solar respondents **Don't know/Refused excluded from calculations		

FRS3. Now I would like to ask you to consider what actions you would have taken if the Green Heat Program had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely,” and a 10 indicating that it is “Very Likely.”

Actions Taken in Absence of Green Heat	2017	
	Sample Size*	Mean**
Postponed installing the equipment by at least one year	16	5.4
Kept old heating system instead of installing new one	15	4.9
Installed an electrical heating system instead of the equipment installed through the program component	16	2.7
*Base: Wood/Pellet/Solar respondents		
**Don't know/refused excluded from calculation		

FRS4. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to install a [EQUIPMENT]. Using a scale from 0 to 10, where 0 means “No influence” and 10 means “Great influence”, please rate the influence of each of the following in your decision to install a [EQUIPMENT].

Influence of Factors on Decision to Have Equipment Installed	2017	
	Sample Size*	Mean**
The program component rebate or financing	16	5.4
Information provided by ENS	16	5.3
*Base: Wood/Pellet/Solar respondents		
*Don't know/Refused excluded from calculations		

CI1. Before participating in the Green Heat program in [DATE], had you at any time in the past already participated in another Efficiency Nova Scotia program?

Previous Participation in Another ENS Program Component	2016 Total (%)	2017			
		Total (%)	MSHP (%)*	ASHP/GSHP (%)	Wood/Pellet/Solar (#)
Sample Size	90	79	39	24	16
Yes	37%	30%	21%	38%	7
No	60%	68%	77%	63%	9
Don't know/Refused	3%	1%	3%	-	-
*Base: Respondents who would have kept their existing system, or purchase a non-heat pump option in the absence of the program component					

Cl2a. Your previous participation in an ENS program was a major factor in your decision to install a [EQUIPMENT] in your home?

Previous Participation in Another ENS Program Component	2016 Total (%)	2017			
		Total (%)	MSHP (#)	ASHP/ GSHP (#)	Wood/Pellet/ Solar (#)
Sample Size*	33	24	8	9	7
Agree	70%	38%	3	3	3
Disagree	30%	63%	5	6	4
Don't know/Refused	-	-	-	-	-
*Base: Respondents who previously participated in another ENS program component					

Cl2b. Because of your previous participation in an ENS program and what you learned by participating in this program, you asked a contractor or a distributor about energy efficient heating systems for your home.

Previous Participation in Another ENS Program Component	2016 Total (%)	2017			
		Total (%)	MSHP (#)	ASHP/ GSHP (#)	Wood/Pellet/ Solar (#)
Sample Size*	33	24	8	9	7
Agree	76%	63%	5	7	3
Disagree	24%	38%	3	2	4
Don't know/Refused	-	-	-	-	-
*Base: Respondents who previously participated in another ENS program component					

Cl2c. Because of your previous participation in an ENS program and what you learned by participating in this program, you took into account the savings on your energy bill when evaluating different heating systems for your home.

Previous Participation in Another ENS Program Component	2016 Total (%)	2017			
		Total (%)	MSHP (#)	ASHP/ GSHP (#)	Wood/Pellet/ Solar (#)
Sample Size*	33	24	8	9	7
Agree	76%	83%	7	7	6
Disagree	18%	13%	1	2	-
Don't know/Refused	6%	4%	-	-	1
*Base: Respondents who previously participated in another ENS program component					

C13. Before participating in the Green Heat program in [YEAR], had you at any time in the past already seen Efficiency Nova Scotia promotional materials advertising the benefits of energy efficiency?

Previously Saw Energy Efficiency Promotional Materials Distributed by ENS*	2016 Total (%)	2017*			
		Total (%)	MSHP (%)	ASHP/ GSHP (%)	Wood/Pellet/ Solar (#)
Sample Size**	90	79	39	24	16
Agree	73%	75%	64%	96%	11
Disagree	26%	24%	33%	4%	5
Don't know/Refused	1%	1%	3%	-	-
*Wording change in 2017					
***Base: Respondents who would have kept their existing system, or purchase a non-heat pump option in the absence of the program component					

C14a. The energy efficiency promotional materials distributed by ENS were a major factor in your decision to install a [EQUIPMENT] in your home.

Previously Saw Energy Efficiency Promotional Materials Distributed by ENS	2016 Total (%)	2017			
		Total (%)	MSHP (%)	ASHP/ GSHP (%)	Wood/Pellet/ Solar (#)
Sample Size*	66	59	25	23	11
Agree	48%	58%	64%	61%	4
Disagree	50%	41%	32%	39%	7
Don't know/Refused	2%	2%	4%	-	-
*Base: Respondents who previously saw ENS energy efficiency promotional materials					

C14b. The energy efficiency promotional materials distributed by ENS prompted you to ask a contractor or a distributor about energy efficient heating systems for your home.

Previously Saw Energy Efficiency Promotional Materials Distributed by ENS	2016 Total (%)	2017			
		Total (%)	MSHP (%)	ASHP/ GSHP (%)	Wood/Pellet/ Solar (#)
Sample Size*	66	59	25	23	11
Agree	70%	80%	92%	70%	8
Disagree	30%	20%	8%	30%	3
Don't know/Refused	-	-	-	-	-
*Base: Respondents who previously saw ENS energy efficiency promotional materials					

CI4c. The energy - efficiency promotional materials distributed by ENS prompted you to take into account the savings on your energy bill when evaluating different heating systems for your home?

Previously Saw Energy Efficiency Promotional Materials Distributed by ENS	2016 Total (%)	2017			
		Total (%)	MSHP (%)	ASHP/GSHP (%)	Wood/Pellet/Solar (#)
Sample Size*	66	59	25	23	11
Agree	86%	83%	84%	78%	10
Disagree	14%	17%	16%	22%	1
Don't know/Refused	-	-	-	-	-
*Base: Respondents who previously saw ENS energy efficiency promotional materials					

S1. On a scale of 0 to 10 where 0 equals “not at all satisfied” and 10 equals “extremely satisfied”, how satisfied were you with the following when installing your new [EQUIPMENT TYPE]? How satisfied were you with...

Satisfaction with Aspect of Green Heat	2017							
	Total		MSHP		ASHP/GSHP		Wood/Pellet/Solar	
	Sample Size*	Mean*	Sample Size*	Mean*	Sample Size*	Mean*	Sample Size*	Mean*
***The eligibility requirements for the loan	9	9.8	6	9.8	3	9.7	-	-
The confirmation of eligibility	88	9.3	50	9.5	23	9.0	15	8.9
The clarity of program component requirements	90	9.2	51	9.4	24	8.9	15	8.7
The time allowed by the program component to install your equipment and send your paperwork	90	9.2	51	9.2	24	9.1	15	9.2

The quality of the equipment installed in your home	90	9.2	50	9.6	24	8.6	16	8.9
Green Heat program component overall	90	9.0	51	9.0	24	9.2	15	8.7
**The time it took to receive the rebate	81	8.9	45	8.8	21	9.2	15	8.7
The range of program component eligible equipment	86	8.8	49	9.1	23	8.4	14	8.3
**The amount of the rebate	81	7.7	44	7.5	21	8.4	16	7.5
*Don't know/Refused excluded from calculations **Base: Respondents who received a rebate ***Base: Respondents who received financing								

S2. What was the most important reason you were not more satisfied with the Green Heat program overall?

Reasons Not More Satisfied*	2016 Total (#)	2017			
		Total (#)	MSHP (#)	ASHP/ GSHP (#)	Wood/Pellet/ Solar (#)
Sample Size**	5	9	5	3	1
The rebate amount is too small	3	4	2	1	1
Energy efficient equipment didn't qualify	2	2	1	1	-
Program component too hard to understand – too many conditions	-	1	-	1	-
Too long to get the pre-approval	-	1	1	-	-
Lack of financial support	1	-	-	-	-
Others	1	1	1	-	-
Don't know	1	-	-	-	-
*Multiple responses					
**Base: Respondents who were less than satisfied with the program component (S1<8)					

S3. For the next few statements, I'd like you to think back to the point when you started to consider installing [a/an] **[EQUIPMENT TYPE]**. On a scale of 0 to 10 where 0 equals "not at all a concern" and 10 equals "a major concern", how much of a concern was...

Concern with Aspects of Green Heat	2017							
	Total		MSHP		ASHP/GSHP		Wood/Pellet/Solar	
	Sample Size	Mean*	Sample Size	Mean*	Sample Size	Mean*	Sample Size	Mean*
Selecting the right equipment	89	6.8	49	6.4	24	8.5	16	5.6
Reliability of the equipment	90	6.6	50	6.3	24	8.2	16	5.1
Finding a qualified contractor	91	6.3	51	6.2	24	7.2	16	5.5
The overall purchase an installation cost of the equipment compared to other heating options	89	6.3	50	6.2	23	6.7	16	6.1
The appearance of the equipment	91	5.0	51	5.6	24	4.0	16	4.5
The disruption of equipment installation in your home	91	4.4	51	4.1	24	5.4	16	3.9
*Don't know/Refused excluded from calculations								

S4. What other concerns, if any, did you have with installing [a/an] [EQUIPMENT TYPE]?

Concerns with Installing Equipment	2017			
	Total (%)	MSHP (%)	ASHP/GSHP (%)	Wood/Pellet/Solar (#)
Sample Size	91	51	24	16
It wouldn't provide enough heat	8%	12%	4%	-
The reliability of the equipment and how to properly use it	3%	2%	8%	-
Quality of contractor/having equipment installed properly	5%	8%	4%	-
It wouldn't work the way it was supposed to	4%	4%	4%	1
The location of the installed unit or space limitation	4%	6%	-	1
The appearance of the unit	3%	6%	-	-
Others	10%	8%	13%	2
None/no other concerns	62%	55%	67%	12

S5. Now I'd like you to think back to the point when you began considering participating in the Green Heat program for your **[EQUIPMENT TYPE]**. On a scale of 0 to 10 where 0 equals "not at all a concern" and 10 equals a "major concern", how much of a concern was...

Concerns with Participating in Green Heat	2017							
	Total		MSHP		ASHP/ GSHP		Wood/Pellet/ Solar	
	Sample Size*	Mean*	Sample Size*	Mean*	Sample Size*	Mean*	Sample Size*	Mean*
**The ability to pay the loan back per the loan terms	9	6.1	6	6.0	3	6.3	-	-
Realizing the promised energy savings	87	5.6	48	5.5	23	5.9	16	5.7
Getting approval for your project	91	4.9	51	4.4	24	5.7	16	5.4
Working with Efficiency Nova Scotia	90	3.8	51	3.9	24	3.3	15	4.3
Completing the application paperwork	90	3.9	51	3.9	24	3.9	15	4.1
*Don't know/Refused excluded from calculations								
**Base: Financing participants								

S6. What other concerns, if any, did you have with participating in the Green Heat program?

Concerns with Participating in Green Heat	2017			
	Total (%)	MSHP (%)	ASHP/ GSHP (%)	Wood/Pellet/ Solar (#)
Sample Size	91	51	24	16
Meet the requirements to be eligible for rebate	4%	8%	-	-
Selection of equipment to choose from	3%	2%	-	2
The cost of the equipment/installation	2%	2%	4%	-
The length of time to receive the rebate	1%	-	4%	-
Others	7%	12%	-	-
None/No concerns	82%	76%	92%	14

M1. How did you first become aware of mini-split heat pumps?

Awareness of Mini-Split Heat Pumps	2017
Sample Size*	51
Via a friend, acquaintance or family member	59%
Saw an advertisement	10%
Through a contractor, retailer, distributor	10%
At a home show	4%
Through work	4%
Online	2%
Others	8%
Don't know	4%
*Base: MSHP Respondents	

M2. Thinking back before you installed your mini-split heat pump, when do you recall first becoming aware of mini-split heat pumps as an option for heating and cooling your home? Was it...

First Awareness of Mini-Split Heat Pumps	2017
Sample Size*	51
6 months or less prior to installing your mini-split heat pump	14%
More than 6 months up to 1 year prior to installing your mini-split heat pump	12%
More than 1 year up to 2 years prior to installing your mini-split heat pump	29%
More than 2 years up to 3 years prior to installing your mini-split heat pump	16%
More than 3 years prior to installing your mini-split heat pump	29%
*Base: MSHP Respondents	

M3. Prior to installing your mini-split heat pump in 2017, had you ever considered installing a mini-split heat pump?

Previously Considered Installing a Heat Pump	2017
Sample Size*	51
Yes	45%
No	55%
*Base: MSHP Respondents	

M4. So you considered installing a mini-split heat pump prior to 2017. What kept you from installing a mini-split heat pump in previous years?

Barriers to Installing a Heat Pump in Previous Years**	2017
Sample Size*	23
The mini-split heat pump was too expensive	39%
Lack of information	13%
Existing heating/cooling system worked well enough	13%
Concerned about the reliability of mini-split heat pumps	13%
Wasn't ready to install a heat pump	9%
Concerned about the energy savings a mini-split heat pump would provide over existing system	4%
Others	13%
Don't know	4%
*Base: MSHP Respondents who considered installing mini-split heat pump prior to 2017	
**Multiple Responses	

R1. What was the most helpful aspect of the Green Heat program?

Helpful Aspects of Green Heat	2017			
	Total (%)	MSHP (%)	ASHP/GSHP (%)	Wood/Pellet/Solar (#)
Sample Size	91	51	24	16
The rebate	20%	14%	33%	3
Lowering the cost of the installation	16%	18%	17%	2
Information provided	11%	16%	8%	-
Providing education about efficient equipment	10%	16%	-	1
Financing option	8%	2%	13%	3
Providing an efficient heating device	7%	10%	4%	-
Good knowledgeable representatives	3%	-	13%	-
Easy application process	3%	2%	4%	1
Assistance in finding an installer	3%	2%	4%	1
Energy savings	2%	-	-	2
Don't know	4%	6%	-	1
Nothing	2%	4%	-	-
Others	10%	12%	4%	2

R2. Other than increase the rebate or loan amount, how could Efficiency Nova Scotia improve the Green Heat program?

Recommendations to Improve Green Heat*	2017			
	Total (%)	MSHP (%)	ASHP/ GSHP (%)	Wood/Pellet/ Solar (#)
Sample Size	91	51	24	16
Advertise the program component more or in a better way	13%	16%	8%	2
Offer more information and flexibility on the eligibility requirements	12%	12%	8	3
Offer additional equipment eligible for rebates/financing	10%	10%	4%	3
Simplify program component application, forms and associated paperwork	7%	4%	17%	-
Increase rebate	5%	10%	-	-
Improve communication	4%	4%	4%	1
Information on qualified contractors	3%	-	8%	1
Increase the time given to complete the upgrades	3%	2%	8%	-
Speed up process	3%	-	8%	1
No recommendations	16%	12%	25%	3
No recommendations	16%	12%	25%	3
Don't know	30%	33%	21%	5
*Multiple Responses				

D1. What type of residence do you live in?

Type of Residence	2016 Total (%)	2017			
		Total (%)	MSHP (%)	ASHP/ GSHP (%)	Wood/Pellet/ Solar (#)
Sample Size	90	91	51	24	16
Detached single-family home	87%	89%	82%	100%	15
Mobile home or house trailer	3%	4%	6%	-	1
Townhouse or duplex which share adjacent walls	4%	1%	2%	-	-
Semi-detached house	3%	2%	4%	-	-
Row house	1%	1%	2%	-	-
Others	1%	2%	4%	-	-
Don't know/Refused	-	-	-	-	-

D2. How many bedrooms are in your home?

Number of Bedrooms	2016 Total (%)	2017			
		Total (%)	MSHP (%)	ASHP/ GSHP (%)	Wood/Pellet/ Solar (#)
Sample Size	90	91	51	24	16
1	-	1%	2%	-	-
2	6%	13%	12%	4%	5
3	59%	45%	55%	33%	5
4+	36%	41%	31%	62%	6
Don't know	-	-	-	-	-

D3. Including yourself, how many people live in this residence on a full-time basis?

Number of People in Household	2016 Total (%)	2017			
		Total (%)	MSHP (%)	ASHP/ GSHP (%)	Wood/Pellet/ Solar (#)
Sample Size	90	91	51	24	16
1	8%	9%	6%	8%	3
2	52%	54%	59%	50%	7
3	20%	10%	14%	8%	-
4+	20%	27%	22%	33%	6
Refused	-	-	-	-	-

D4. What is your age group?

Age	2016 Total (%)	2017			
		Total (%)	MSHP (%)	ASHP/ GSHP (%)	Wood/Pellet/ Solar (#)
Sample Size	90	91	51	24	16
18-24	1%	3%	-	4%	2
25-34	8%	7%	4%	13%	1
35-44	17%	15%	14%	13%	4
45-54	17%	30%	29%	33%	4
55-64	32%	21%	29%	8%	2
65+	26%	23%	22%	29%	3
Refused	-	1%	2%	-	-

D5. What is the highest level of education you have completed?

Education	2016 Total (%)	2017			
		Total (%)	MSHP (%)	ASHP/ GSHP (%)	Wood/Pellet/ Solar (#)
Sample Size	90	91	51	24	16
Less than high school graduation certificate	9%	2%	2%	-	1
High school graduation certificate and/or some post-secondary	23%	21%	25%	4%	5
Trades certificate or diploma	4%	7%	4%	13%	1
College certificate or diploma	18%	22%	24%	21%	3
University certificate or diploma	44%	47%	43%	63%	6
Refused	1%	1%	2%	-	-

D6. Which of the following income categories best describes your total annual household income before taxes in 2016?

Income	2016 Total (%)	2017			
		Total (%)	MSHP (%)	ASHP/ GSHP (%)	Wood/Pellet/ Solar (#)
Sample Size	90	91	51	24	16
Less than \$15,000	2%	1%	-	-	1
\$15,000-\$24,999	2%	5%	6%	-	2
\$25,000-\$34,999	6%	7%	6%	4%	2
\$35,000-\$49,999	19%	9%	8%	13%	1
\$50,000-\$69,999	12%	11%	14%	8%	1
\$70,000-\$79,999	8%	13%	10%	17%	3
\$80,000 or more	38%	40%	37%	54%	4
Refused	13%	14%	20%	4%	2

D7. Gender?

Gender	2016 Total (%)	2017			
		Total (%)	MSHP (%)	ASHP/ GSHP (%)	Wood/Pellet/ Solar (#)
Sample Size	90	91	51	24	16
Male	62%	67%	65%	71%	11
Female	38%	33%	35%	29%	5

Appendix XI

GH: NEW PATH PARTICIPANT SURVEY QUESTIONNAIRE

Could I speak with [INSERT NAME]?

- 1 Yes [GO TO INTRODUCTION]
- 2 No [SAY “Perhaps you can help me anyway.” GO TO INTRODUCTION]

INTRODUCTION

Hello, my name is _____ from Corporate Research Associates, a Halifax-based survey research company. We are performing an evaluation of energy efficiency services provided by Efficiency Nova Scotia. Our records indicate that you or your household recently participated in the Green Heat Program.

We would appreciate your help in answering questions about this program. The information you provide will be used to help Efficiency Nova Scotia improve the program. Is this a good time for you?

(IF NEEDED: The program provides a rebate for the installation of home heating equipment, such as heat pumps, furnaces and boilers.)

(IF NEEDED: You may have recently been contacted by Corporate Research Associates and Efficiency Nova Scotia about your experience with the program. This survey is different as it focuses on other aspects of your participation in the program.)

(IF NEEDED: The survey will take about fifteen minutes.)

V1. Our records indicate that your household installed a mini-split heat pump through the Green Heat Program. Is this correct?

1. Yes [CONTINUE]
2. No, does not recall participating [PROBE: “Are you sure? According to our records, you would have received a rebate from Efficiency Nova Scotia for installing a mini-split heat pump. [IF PERSIST AS NO, THANK, TERMINATE, RECORD AND KEEP DATA]
9. Don’t know/Refused [PROBE: “Is there someone else in your household who would know about having participated in the Green Heat program?”] [IF NO, ASK TO SPEAK TO THE APPROPRIATE PERSON AND RESTART AT INTRODUCTION. IF PERSISTS AS NO, THANK, TERMINATE, RECORD AND KEEP DATA.]

[IF REFUSED, ASK “Can we schedule a more convenient time for you to conduct this survey?”]

[SCHEDULED, IF NECESSARY, FOR: _____]

Participation [P Series]

- P1. Now I'm going to ask you to think back to when you decided to install a mini-split heat pump. What was the SINGLE most important reason you were interested in installing a mini-split heat pump? [DO NOT READ – CODE ONE ONLY]
1. (To save on energy/to save on energy costs)
 2. (For better comfort)
 3. (To make home more energy efficient)
 4. (To help the environment)
 5. (To have a backup heating source)
 6. (Old system wasn't working properly)
 96. (Other) [SPECIFY _____]
 98. (Don't know) [GO TO U1]
 99. (Refused) [GO TO U1]
- P2. Were there any other reasons? [SAME LIST AS IN P1] [DO NOT READ. ACCEPT MULTIPLE RESPONSES]
- 97 None/no other reasons

Usage [U Series]

- U1. Before participating in the Green Heat Program, what did you use as your main heating system? Was it...? [READ AND ACCEPT ONE RESPONSE ONLY]
1. Electric baseboards or electric furnace
 2. Heat pump
 3. Geothermal system
 4. Heating stove (wood or pellet)
 5. Gas or oil-fired furnace
 96. Or something else (**SPECIFY:** _____)
 98. (Don't know)
 99. (Refused)
- U2. In addition to your newly installed high-efficiency mini-split heat pump, is there another heating system used for heating in your home?
1. Yes
 2. No
 98. (Don't know)
 99. (Refused)

- U3. [IF U2=1] What type of heating system is it? Is it... [READ IN ORDER AND ACCEPT ONE RESPONSE ONLY]
1. Electric baseboards or electric furnace
 2. Another heat pump
 3. Geothermal system
 4. Heating stove (wood or pellet)
 5. Gas or oil-fired furnace
 6. Or something else (SPECIFY:_____)
 98. (Don't know)
 99. (Refused)
- U4. Which part of your house is heated by the mini-split heat pump installed through the Green Heat program? Is it... [READ IN ORDER AND ACCEPT ONE RESPONSE ONLY]
1. One room only
 2. One floor
 3. The whole house
 4. Or something else (SPECIFY:_____)
 98. (Don't know)
 99. (Refused)

Free-Ridership – Mini-split Heat Pumps [FRM Series]

Moving along to another topic... I will first ask you a series of questions regarding your decision to install a heat pump instead of installing another type of heating system or simply keeping your existing system. I will then ask you a series of questions regarding your decision to install a high-efficiency heat pump rather than a regular heat pump.

Series A: Questions on the decision to install a heat pump

- FRM1. Had you already decided to install a heat pump before you heard about the Green Heat Program?
1. Yes
 2. No
 98. (Don't know)
 99. (Refused)
- FRM1a. [IF FRM1=1] I just want to make sure I understand – before you learned about the Green Heat Program, you had already made the decision to install a heat pump?
1. Yes
 2. No
 98. (Don't know)
 99. (Refused)

FRM2. [IF FRM1=2, 98, 99 or FRM1a=2, 98, 99] If the program rebate had not been offered, which of the following actions would you have taken? READ IN ORDER, CODE ONE ONLY

1. Kept your existing heating system [GO TO S SERIES]
2. Purchased a new electric heating system [GO TO S SERIES]
3. Purchased a new non-electric heating system (e.g. oil or gas system) [GO TO S SERIES]
4. Purchased a heat pump
98. (Don't know)
99. (Refused)

FRM3. [IF FRM1a=1 OR FRM2=4] If the program rebate had not been offered, what is the likelihood that you would have postponed the purchase of a heat pump by at least one year? Please answer on a scale of 0 to 10, with a 0 indicating that it is "Very unlikely" and 10, "Very likely".
[[PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response

___98 Don't Know

___99 Refused

Series B: Questions on the decision to install a high-efficiency heat pump [ASK ALL RESPONDENTS]

Only high-efficiency heat pump models are eligible for a rebate under the Green Heat program, so the heat pump you have installed is much more efficient than the standard heat pump models on the market, especially at low temperatures of -15°C or less. Now, we will discuss your decision to install a high-efficiency heat pump model rather than a less efficient and less expensive model.

FRM4. Were you aware of the availability of high efficiency heat pumps that operate at temperatures below -15°C before you heard about the Green Heat Program?

1. Yes
2. No
98. (Don't know)
99. (Refused)

FRM4a. [IF FRM4=1] Before you heard about the Green Heat Program, had you already made the decision to install a high-efficiency heat pump model?

1. Yes
2. No
98. (Don't know)
99. (Refused)

FRM5. Efficiency Nova Scotia gave you a rebate of \$[INCENTIVE] for your new high-efficiency heat pump. If you had not received the rebate from Efficiency Nova Scotia, would you have paid the total cost of your high-efficiency heat pump? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely **Would Not Have Paid**” and a 10 indicating that you “Definitely **Would Have Paid**.” [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response ___98 Don't Know ___99 Refused

FRM6. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to install a high-efficiency heat pump. Using a scale from 0 to 10, where 0 means “No influence” and 10 means “Great influence”, please rate the influence of each of the following in your decision to install a high-efficiency heat pump.

Factor (READ AND RANDOMIZE)	Responses – DO NOT ACCEPT A RANGE
a. The program rebate	___ Response ___98 Don't Know ___99 Refused
b. Information on the benefits of high efficiency heat pumps provided by Efficiency Nova Scotia	___ Response ___98 Don't Know ___99 Refused
c. Information on the benefits of high efficiency heat pumps provided by the retailers	___ Response ___98 Don't Know ___99 Refused

Cross-Influence [CI Series]

READ AND ROTATE (CI1 + CI2a-c) AND (CI3 + CI4a-c) SEQUENCES

CI1. Before participating in the Green Heat program in 2017, had you at any time in the past already participated in another Efficiency Nova Scotia program?

1. Yes
2. No
98. (Don't know)
99. (Refused)

For the following statements, please indicate whether you agree or disagree.

CI2a. [IF CI1=1] Your previous participation in an Efficiency Nova Scotia program was a major factor in your decision to install a high-efficiency heat pump in your home.

- 1. Agree
- 2. Disagree
- 98. (Don't know)
- 99. (Refused)

CI2b. [IF CI1=1] Because of your previous participation in an Efficiency Nova Scotia program and what you learned by participating in this program, you asked a contractor or a distributor about energy efficient heating systems for your home.

- 1. Agree
- 2. Disagree
- 98. (Don't know)
- 99. Refused)

CI2c. [IF CI1=1] Because of your previous participation in another Efficiency Nova Scotia program and what you learned by participating in this program, you took into account the savings on your energy bill when evaluating different heating systems for your home.

- 1. Agree
- 2. Disagree
- 98. (Don't know)
- 99. (Refused)

CI3. Before participating in the Green Heat program in 2017, had you at any time in the past already seen Efficiency Nova Scotia promotional materials advertising the benefits of energy efficiency?

- 1. Yes
- 2. No
- 98. (Don't know)
- 99. (Refused)

For the following statements, please indicate whether you agree or disagree.

CI4a. [IF CI3=1] The energy efficiency promotional materials distributed by Efficiency Nova Scotia were a major factor in your decision to install a high-efficiency heat pump in your home.

- 1. Agree
- 2. Disagree
- 98. (Don't know)
- 99. (Refused)

CI4b. [IF CI3=1] The energy efficiency promotional materials distributed by Efficiency Nova Scotia

prompted you to ask a contractor or a distributor about energy efficient heating systems for your home.

- 1. Agree
- 2. Disagree
- 98. (Don't know)
- 99. (Refused)

CI4c. [IF CI3=1] The energy efficiency promotional materials distributed by Efficiency Nova Scotia prompted you to take into account the savings on your energy bill when evaluating different heating systems for your home.

- 1. Agree
- 2. Disagree
- 98. (Don't know)
- 99. (Refused)

Satisfaction and concerns [S Series]

Now, I have some questions about your satisfaction with the mini-split heat pump you installed and the Green Heat program.

S1. On a scale of 0 to 10 where 0 equals "not at all satisfied" and 10 equals "extremely satisfied", how satisfied were you with the following when installing your new mini-split heat pump? How satisfied were you with... [CODE ONLY ONE 0-10, 98=DK, 99=REFUSED]

- a. The clarity of program requirements
- b. The initial confirmation of eligibility
- c. The requirement to send your application form within 90 days after installation
- d. The range of program eligible equipment
- e. The quality of the mini-split heat pump installed in your home
- f. The amount of the rebate
- g. The time it took to receive the rebate
- h. The Green Heat program overall

S2. [IF S1h<8] What was the most important reason you were not more satisfied with the Green Heat program overall? [PROBE FOR SPECIFIC REASON. ACCEPT MULTIPLE RESPONSE]

- 96. (RECORD VERBATIM: _____)
- 98. (Don't know)
- 99. (Refused)

- S3. For the next few statements, I'd like you to think back to the point when you started to consider installing a mini-split heat pump. On a scale of 0 to 10 where 0 equals "not at all a concern" and 10 equals "a major concern", how much of a concern was... [CODE ONLY ONE 0-10, 98=DK, 99=REFUSED] ROTATE ORDER
- a. Selecting the right equipment
 - b. The appearance of the mini-split heat pump
 - c. The reliability of the mini-split heat pump
 - d. Finding a qualified contractor
 - e. The disruption of equipment installation in your home
 - f. The overall purchase and installation cost of the mini-split heat pump compared to other heating options
- S4. What other concerns, if any, did you have with installing a mini-split heat pump?
RECORD VERBATIM
- 97. (None/no concerns)
 - 98. (Don't know)
 - 99. (Refused)
- S5. Now I'd like you to think back to the point when you began considering applying for a Green Heat rebate for your mini-split heat pump. On a scale of 0 to 10 where 0 equals "not at all a concern" and 10 equals "a major concern", how much of a concern was... [CODE ONLY ONE 0-10, 98=DK, 99=REFUSED] [RANDOMIZE]
- a. Completing the application paperwork
 - b. Receiving the rebate in the anticipated time
 - c. Working with Efficiency Nova Scotia
 - d. Realizing the promised energy savings
- S6. What other concerns, if any, did you have with participating in the Green Heat program?
RECORD VERBATIM
- 97. (None/no concerns)
 - 98. (Don't know)
 - 99. (Refused)

Appropriate Price (and Rebate) of Mini-split Heat Pumps [A Series]

For the next few questions, I'd like you to think about the cost of the mini-split heat pump you installed as part of the Green Heat program. ROTATE A1-A4

- A1. At what price would you have considered the cost of the mini-split heat pump to be so expensive that you would not have considered buying it?
- c. Record response (Force numeric)
 - d. DK

- A2. At what price, would you have considered the cost of the mini-split heat pump to be priced so low that you would have felt the product quality couldn't be very good?
- c. Record response (Force numeric)
 - d. DK
- A3. At what price would you have considered the cost of the mini-split heat pump to be starting to get expensive, so that it was not out of the question, but you would have had to give some thought to buying it?
- c. Record response (Force numeric)
 - d. DK
- A4. At what price would you have considered the cost of the mini-split heat pump to be a bargain—a great buy for the money?
- c. Record response (Force numeric)
 - d. DK

Market Transformation [M Series]

- M1. How did you first become aware of mini-split heat pumps? [SINGLE RESPONSE. DO NOT READ]
- 1 (Saw an advertisement)
 - 2 (Through a contractor, retailer, distributor)
 - 3 (Via a friend, acquaintance, or family member)
 - 4 (Online, SPECIFY: _____)
 - 96. (Other) [SPECIFY _____]
 - 98 (Don't know)
 - 99 (Refused)
- M2. Thinking back before you installed your mini-split heat pump, when do you recall first becoming aware of mini-split heat pumps as an option for heating and cooling your home? Was it.... [CODE ONLY ONE]
- 1 6 months or less prior to installing your mini-split heat pump
 - 2 More than 6 months up to 1 year prior to installing your mini-split heat pump
 - 3 More than 1 year up to 2 years prior to installing your mini-split heat pump
 - 4 More than 2 years up to 3 years prior to installing your mini-split heat pump
 - 5 More than 3 years prior to installing your mini-split heat pump
 - 98 (Don't know)
 - 99 (Refused)

- M3. Prior to installing your mini-split heat pump in 2017, had you ever considered installing a mini-split heat pump?
- 1 Yes
 - 2 No
 - 98 (Don't know)
 - 99 (Refused)
- M4. [IF M3=1] So you considered installing a mini-split heat pump prior to 2017. What kept you from installing a mini-split heat pump in previous years? [DO NOT READ, PROBE TO CODE]
ACCEPT MULTIPLE RESPONSE
- 1 (The mini-split heat pump was too expensive)
 - 2 (Existing heating/cooling system worked well enough)
 - 3 (Concerned about the reliability of mini-split heat pumps)
 - 4 (Concerned about the appearance of mini-split heat pumps)
 - 5 (Concerned about the energy savings a mini-split heat pump would provide over existing system)
 - 97 Other, please specify: _____
 - 98 (Don't know)
 - 99 (Refused)

Recommendations for Program Improvements [R Series]

- R1. What was the most helpful aspect of the Green Heat program? [RANDOMIZE, SINGLE RESPONSE, DO NOT READ]
- 1 (Lowering the cost of the installation)
 - 2 (Assistance in finding an installer)
 - 3 (Providing an efficient heating device)
 - 4 (Providing education about efficient equipment)
 - 5 (Providing a better heating system than previous system)
 - 6 (More environmentally friendly)
 - 97 (Other [SPECIFY _____])
 - 98 (Don't know)
 - 99 (Refused)

R2. Other than increase incentives, how could Efficiency Nova Scotia improve the Green Heat program? PROBE: Anything else? [DO NOT READ. ACCEPT MULTIPLE]

1. (Offer additional equipment eligible for rebates)
2. (Offer more information on the equipment recommended)
3. (Simplify program application, forms and associated paperwork)
4. (Speed up the process)
5. (Increase the time given to complete the upgrades)
6. (Improve communication)
7. (Advertise the program more or in a better way)
8. (No recommendation)
97. (Other [SPECIFY _____])
98. (Don't know)
99. (Refused)

Demographics [D Series]

These final questions are asked for statistical purposes only. The information collected is strictly confidential.

D1. What type of residence do you live in? [READ RESPONSES 1-5, then 96; SELECT ONE RESPONSE]

3. Detached single-family home
4. Semi-detached house
5. Mobile home or house trailer
6. Townhouse or duplex which share adjacent walls
7. Row house
97. Or another type [SPECIFY: _____]
98. (Don't know)
99. (Refused)

D2. How many bedrooms are in your home? [98=DK; Enter zero for a studio apartment with no bedrooms]

D3. Including yourself, how many people live in this residence on a full-time basis?

Number of people: _____ [NOTE: DON'T ALLOW ZERO FOR A RESPONSE]

98. (Nobody lives in the house on a full-time basis)
99. (Refused)

- D4. What is your age group? Are you... [READ]
- 7. 18 to 24
 - 8. 25 to 34
 - 9. 35 to 44
 - 10. 45 to 54
 - 11. 55 to 64
 - 12. 65 or over
 - 99. (Refused)
- D5. What is the highest level of education you have completed? [DO NOT READ]
- 6. (Less than high school graduation certificate)
 - 7. (High school graduation certificate and/or some post-secondary)
 - 8. (Trades certificate or diploma)
 - 9. (College certificate or diploma)
 - 10. (University certificate or diploma)
 - 99. (Refused)
- D6. Which of the following income categories best describes your total annual household income before taxes in 2016? Stop me when I reach the right category. [READ LIST; SELECT ONE RESPONSE]
- 1. Less than \$15,000
 - 2. \$15,000 - \$24,999
 - 3. \$25,000 - \$34,999
 - 4. \$35,000 - \$49,999
 - 5. \$50,000 - \$69,999
 - 6. \$70,000 - \$79,999
 - 7. \$80,000 or more
 - 99. (Refused)
- D7. [DO NOT READ] Gender:
- 1. Male
 - 2. Female

END: Those are all the questions I have for you. I thank you very much for your time and cooperation and have a nice day!

Appendix XII

GH: NEW PATH PARTICIPANT SURVEY RESULTS

P1. What was the SINGLE most important reason you were interested in installing a mini-split heat pump?

P2. Were there any other reasons?

Reasons for Participating	2017	
	Most Important Reason	Second Most Important Reason*
Sample Size	50	50
Save on energy/energy costs	70%	16%
Wanted air conditioning	10%	6%
To make home more energy efficient	6%	30%
For better comfort	6%	26%
Old system wasn't working properly	-	4%
To help the environment	-	4%
To have a backup heating source	2%	4%
Others	6%	2%
None/No other reasons	-	24%
Don't know	-	4%
*Multiple Responses		

U1. Before participating in the Green Heat Program, what did you use as your main heating system?

Main Heating System before Participating in Green Heat	2017
Sample Size	50
Electric baseboards or electric furnace	56%
Gas or oil-fired furnace	34%
Heating stove (wood or pellet)	4%
Heat pump	2%
Others	4%

U2. In addition to your newly installed high-efficiency mini-split heat pump, is there another heating system used for heating in your home?

Other Heating Systems Installed	2017
Sample Size	50
Yes	72%
No	28%

U3. What type of heating system is it?

Type of Heat System Used in Household	2017
Sample Size*	36
Heaving Stove (wood or pellet)	33%
Electric baseboards or electric furnace	33%
Gas or oil fired furnace	25%
Others	8%
*Base: Respondents who have another heating system in their home	

U4. Which part of your house is heated by the mini-split heat pump installed through the Green Heat program? Is it...

Area Heated by Heat Pump	2017
Sample Size	50
One floor	42%
The whole house	42%
Two floors	8%
One room only	2%
Others	6%

FRM1. Had you already decided to install a heat pump before you heard about the Green Heat Program?

FRM1a. I just want to make sure I understand – before you learned about the Green Heat Program, you had already made the decision to install a heat pump?

Already Made Decision to Install Equipment Prior to Green Heat	2017
Sample Size	50
Yes	72%
No	24%
Don't know/Refused	4%

FRM2. If the program rebate had not been offered, which of the following actions would you have taken?

Actions Taken in Absence of Green Heat	2017 (#)
Sample Size*	14
Purchased a heat pump	12
Kept your existing heating system	2
*Base: Respondents who had not previously decided to install a heat pump prior to the program component	

FRM3. If the program rebate had not been offered, what is the likelihood that you would have postponed the purchase of a heat pump by at least one year? Please answer on a scale of 0 to 10, with a 0 indicating that it is “Very unlikely” and 10, “Very likely”.

Actions Taken in Absence of Green Heat	2017	
	Sample Size**	Mean*
Postponed the purchase of a heat pump by at least one year	47	4.3
*Don't know/refused excluded from calculation		
**Base: Respondents who previously decided to install a heat pump prior to hearing about Green Heat, or were likely to purchase a heat pump without the program component		

FRM4. Were you aware of the availability of high efficiency heat pumps that operate at temperatures below -15°C before you heard about the Green Heat Program?

Aware of High Efficiency Heat Pumps	2017
Sample Size*	48
Yes	75%
No	25%
*Base: Respondents who previously decided to install a heat pump prior to hearing about Green Heat, or were likely to purchase a heat pump without the program component	

FRM4a. Before you heard about the Green Heat Program, had you already made the decision to install a high-efficiency heat pump model?

Previously Decided to Install High Efficiency Heat Pump	2017
Sample Size*	36
Yes	72%
No	25%
Don't know	3%
*Base: Respondents who were aware of high efficiency heat pumps prior to participating in the program component	

FRM5. Efficiency Nova Scotia gave you a rebate of \$[INCENTIVE] for your new high-efficiency heat pump. If you had not received the rebate from Efficiency Nova Scotia, would you have paid the total cost of your high-efficiency heat pump? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely Would Not Have Paid” and a 10 indicating that you “Definitely Would Have Paid.”

Would Have Paid Full Cost of High Efficiency Heat Pump	2017	
	Sample Size**	Mean*
Would have paid/financed full cost of heat pump	47	8.6
*Don't know/Refused excluded from calculations **Base: Respondents who previously decided to install a heat pump prior to hearing about Green Heat, or were likely to purchase a heat pump without the program component		

FRM6. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to install a high-efficiency heat pump. Using a scale from 0 to 10, where 0 means “No influence” and 10 means “Great influence”, please rate the influence of each of the following in your decision to install a high-efficiency heat pump.

Influence of Factors on Decision to Have High Efficiency Heat Pump Installed	2017	
	Sample Size**	Mean*
Information on the benefits of high efficiency heat pumps provided by the retailers	47	8.1
Information on the benefits of high efficiency heat pumps provided by ENS	48	6.5
The program component rebate	47	5.6
*Don't know/Refused excluded from calculations **Base: Respondents who previously decided to install a heat pump prior to hearing about Green Heat, or were likely to purchase a heat pump without the program component		

CI1. Before participating in the Green Heat program in 2017, had you at any time in the past already participated in another Efficiency Nova Scotia program?

Previous Participation in Another ENS Program Component	2017
Sample Size*	48
Yes	35%
No	65%
*Base: Respondents who previously decided to install a heat pump prior to hearing about Green Heat, or were likely to purchase a heat pump without the program component	

CI2a. Your previous participation in an Efficiency Nova Scotia program was a major factor in your decision to install a high-efficiency heat pump in your home.

Previous Participation in Another ENS Program Component was Factor in Decision to Install a High Efficiency Heat Pump	2017 (#)
Sample Size*	17
Agree	6
Disagree	11
Don't know/Refused	-
*Base: Respondents who previously participated in another ENS program component	

CI2b. Because of your previous participation in an Efficiency Nova Scotia program and what you learned by participating in this program, you asked a contractor or a distributor about energy efficient heating systems for your home.

Previous Participation in Another ENS Program Component	2017 (#)
Sample Size*	17
Agree	9
Disagree	8
Don't know/Refused	-
*Base: Respondents who previously participated in another ENS program component	

CI2c. Because of your previous participation in another Efficiency Nova Scotia program and what you learned by participating in this program, you took into account the savings on your energy bill when evaluating different heating systems for your home.

Previous Participation in Another ENS Program Component	2017 (#)
Sample Size*	17
Agree	15
Disagree	2
Don't know/Refused	-
*Base: Respondents who previously participated in another ENS program component	

CI3. Before participating in the Green Heat program in [YEAR], had you at any time in the past already seen Efficiency Nova Scotia promotional materials advertising the benefits of energy efficiency?

Previously Saw Energy Efficiency Promotional Materials Distributed by ENS	2017
Sample Size*	48
Yes	75%
No	25%
*Base: Respondents who previously decided to install a heat pump prior to hearing about Green Heat, or were likely to purchase a heat pump without the program component	

CI4a. The energy efficiency promotional materials distributed by Efficiency Nova Scotia were a major factor in your decision to install a high-efficiency heat pump in your home.

Previously Saw Energy Efficiency Promotional Materials Distributed by ENS	2017
Sample Size*	36
Agree	50%
Disagree	50%
Don't know/Refused	-
*Base: Respondents who had previously seen ENS promotional materials	

CI4b. The energy efficiency promotional materials distributed by Efficiency Nova Scotia prompted you to ask a contractor or a distributor about energy efficient heating systems for your home.

Previously Saw Energy Efficiency Promotional Materials Distributed by ENS	2017
Sample Size*	36
Agree	56%
Disagree	42%
Don't know/Refused	3%
*Base: Respondents who had previously seen ENS promotional materials	

CI4c. The energy efficiency promotional materials distributed by Efficiency Nova Scotia prompted you to take into account the savings on your energy bill when evaluating different heating systems for your home.

Previously Saw Energy Efficiency Promotional Materials Distributed by ENS	2017
Sample Size*	36
Agree	72%
Disagree	28%
Don't know/Refused	-
*Base: Respondents who had previously seen ENS promotional materials	

S1. On a scale of 0 to 10 where 0 equals "not at all satisfied" and 10 equals "extremely satisfied", how satisfied were you with the following when installing your new mini-split heat pump? How satisfied were you with...

Satisfaction with Aspects of Green Heat	2017	
	Sample Size	Mean*
The quality of the mini-split heat pump installed in your home	50	9.5
The requirement to send your application form within 90 days of installation	47	9.2
The range of program component eligible equipment	48	9.1
The initial confirmation of eligibility	48	9.0
The time it took to receive the rebate	45	9.0
The clarity of program component requirements	48	8.8
The Green Heat Program component overall	50	8.8
The amount of the rebate	47	7.4
*Don't know/Don't recall and Refused excluded from calculations		

S2. What was the most important reason you were not more satisfied with the Green Heat program overall?

Reasons Not More Satisfied*	2017 (#)
Sample Size**	7
The rebate amount is too small	3
Too many documents	1
The rebate application form is too complicated to complete	1
Program component hard to understand	1
Others	2
*Multiple responses	
**Base: Respondents who were less than satisfied with the program component (S1<8)	

S3. For the next few statements, I'd like you to think back to the point when you started to consider installing a mini-split heat pump. On a scale of 0 to 10 where 0 equals "not at all a concern" and 10 equals "a major concern", how much of a concern was...

Concern with Aspects of Green Heat	2017	
	Sample Size	Mean*
Selecting the right equipment	49	7.4
The reliability of the mini-split heat pump	50	7.2
Finding a qualified contractor	49	7.1
The overall purchase and installation cost of the mini-split heat pump compared to other heating options	49	6.2
The appearance of the mini-split heat pump	48	5.5
The disruption of equipment installation in your home	50	3.2
*Don't know and Refused excluded from calculations		

S4. What other concerns, if any, did you have with installing a mini-split heat pump?

Concerns with Installing Heat Pump	2017
Sample Size	50
It wouldn't provide enough heat	8%
Whether it would save money	4%
Quality and flexibility of contractor	4%
It wouldn't work the way it was supposed to	2%
The location of the installed unit	2%
Others	8%
None/no other concerns	72%

S5. Now I'd like you to think back to the point when you began considering applying for a Green Heat rebate for your mini-split heat pump. On a scale of 0 to 10 where 0 equals "not at all a concern" and 10 equals "a major concern", how much of a concern was...

Concerns with Applying for Green Heat Rebate	2017	
	Sample Size	Mean*
Realizing the promised energy savings	50	6.6
Completing the application paperwork	48	4.1
Receiving the rebate in the anticipated time	48	4.0
Working with Efficiency Nova Scotia	49	3.6
*Don't know and Refused excluded from calculations		

S6. What other concerns, if any, did you have with participating in the Green Heat program?

Concerns with Participating in Green Heat	2017
Sample Size	50
Confused by the rebate program components	2%
That I wouldn't qualify	2%
Others	2%
None/No concerns	94%

M1. How did you first become aware of mini-split heat pumps?

Awareness of Mini-Split Heat Pumps	2017
Sample Size	50
Via a friend, acquaintance or family member	50%
Saw an advertisement	28%
Online	8%
Through work	4%
Through a contractor, retailer, distributor	2%
Others	6%
Don't know	2%

M2. Thinking back before you installed your mini-split heat pump, when do you recall first becoming aware of mini-split heat pumps as an option for heating and cooling your home?

First Awareness of Mini-Split Heat Pumps	2017
Sample Size	50
6 months or less prior to installing your mini-split heat pump	12%
More than 6 months up to 1 year prior to installing your mini-split heat pump	10%
More than 1 year up to 2 years prior to installing your mini-split heat pump	28%
More than 2 years up to 3 years prior to installing your mini-split heat pump	26%
More than 3 years prior to installing your mini-split heat pump	24%

M3. Prior to installing your mini-split heat pump in 2017, had you ever considered installing a mini-split heat pump?

Previously Considered Installing a Heat Pump	2017
Sample Size	50
Yes	64%
No	36%

M4. So you considered installing a mini-split heat pump prior to 2017. What kept you from installing a mini-split heat pump in previous years?

Barriers to Installing a Heat Pump in Previous Years*	2017
Sample Size**	32
The mini-split heat pump was too expensive	53%
Planning on moving/spend a lot of time away from my home	9%
Wasn't ready to install a heat pump	6%
Lack of information	6%
Concerned about the energy savings a mini-split heat pump would provide over existing system	6%
Existing heating/cooling system worked well enough	6%
Concerned about the reliability of mini-split heat pumps	3%
Others	13%
Nothing	3%
*Multiple Responses	
**Base: Respondents who previously considered installing a heat pump	

R1. What was the most helpful aspect of the Green Heat program?

Helpful Aspects of Green Heat	2017
Sample Size	50
The rebate	32%
Information provided	14%
Lowering the cost of the installation	12%
Providing education about efficient equipment	8%
Easy application process	4%
Energy savings	4%
Providing an efficient heating device	4%
Providing a better heating system than a previous heating system	2%
Assistance in finding an installer	2%
Others	10%
Nothing	2%
Don't know	6%

R2. Other than increase incentives, how could Efficiency Nova Scotia improve the Green Heat program? PROBE: Anything else?

Recommendations to Improve Green Heat*	2017
Sample Size	50
Advertise the program component more or in a better way	24%
Offer more information on the equipment recommended or rebates	18%
Improve communication	12%
Offer additional equipment eligible for rebates	10%
Increase the rebates	6%
Simplify program component application, forms and associated paperwork	4%
Information on qualified contractors	2%
Speed up process	2%
Others	10%
No recommendations	30%
Don't know	16%
*Multiple Responses	

D1. What type of residence do you live in?

Type of Residence	2017
Sample Size	50
Detached single-family home	86%
Mobile home or house trailer	6%
Semi-detached house	4%
Townhouse or duplex which share adjacent walls	2%
Don't know/Refused	2%

D2. How many bedrooms are in your home?

Number of Bedrooms	2017
Sample Size	50
1	-
2	20%
3	58%
4+	20%
Don't know	2%

D3. Including yourself, how many people live in this residence on a full-time basis?

Number of People in Household	2017
Sample Size	50
1	14%
2	52%
3	18%
4+	14%
Nobody lives in the house on a full-time basis	2%

D4. What is your age group?

Age	2017
Sample Size	50
18-24	-
25-34	6%
35-44	14%
45-54	16%
55-64	24%
65+	34%
Refused	6%

D5. What is the highest level of education you have completed?

Education	2017
Sample Size	50
Less than high school graduation certificate	10%
High school graduation certificate and/or some post-secondary	12%
Trades certificate or diploma	10%
College certificate or diploma	18%
University certificate or diploma	44%
Refused	6%

D6. Which of the following income categories best describes your total annual household income before taxes in 2016?

Income	2017
Sample Size	50
Less than \$25,000	-
\$25,000-\$34,999	12%
\$35,000-\$49,999	16%
\$50,000-\$69,999	16%
\$70,000-\$79,999	6%
\$80,000 or more	28%
Refused	22%

D7. Gender?

Gender	2017
Sample Size	50
Male	64%
Female	36%

Appendix XIII

GH: ON-SITE VISIT SAMPLING METHODOLOGY AND PROTOCOL

This year, a total of 25 site visits were conducted to evaluate the Green Heat measures implemented.

Sampling Methodology

For solar projects, the Evaluator selected a sample of three sites to check for installation issues because the 2015 evaluation showed installation-related concerns with solar projects.

In preparation for the on-site visits of heat pump and biomass projects, the Evaluator prepared a sampling plan for the 367 projects listed in the tracking sheet provided in July 2017. The primary criterion considered in developing the sampling plan was the gross savings reported for each of the equipment categories. The square root of every equipment category's tracked gross savings was calculated and these square roots were added to arrive at a grand total. Then, the percentage represented by each equipment category in this grand total was calculated. The equipment categories were then ranked from the highest to the lowest according to the percentage they each represented in the grand total. Then, each of these percentages was multiplied by the sample population size (n=25). As shown in the following table, the actual sample size of each equipment category reflects the adjustments made to the statistical proportions to account for the extra focus placed on solar projects. The details for building the sample are summarized in the table below.

Table 2: Sample Distribution Results¹

Row Labels	Count of Measures	Sum of Net Savings (kWh)	√ of Savings	% of √ Savings	Calculated Sample (n=25)	Proposed Sample	Actual Sample
MSHP	304	968,823	984	44.2%	11.0	12	13
ASHP	30	151,655	389	17.5%	4.4	4	4
Wood Stove	18	128,500	358	16.1%	4.0	2	2
Pellet Stove	7	40,861	202	9.1%	2.3	2	1
GSHP	2	10,714	104	4.6%	1.2	1	1
Wood Furnace or Boiler	1	9,718	99	4.4%	1.1	1	1
Solar	5	8,342	91	4.1%	1.0	3	3
Grand Total	367	1,318,614	2,228	100.0%	25.0	25	25

The projects were randomly chosen from each of the equipment categories to prevent selection bias.

¹ As of July 14, 2017.

On-site Visit Protocols

The Evaluator prepared a standardized site-visit protocol for collecting relevant information. Under the old path, which was the only path available when on-site visits took place, savings could be claimed for a Green Heat project only if the new heating equipment displaced the majority of existing electrical heating. The site-visit protocol developed was focused on confirming the tracked information and identifying those patterns that could impact the tracked savings.

The biomass and heat pump protocols also involved verifying the primary and secondary heat sources prior to conversion, including their levels of contribution to the total heat load. Participants' declaration about the new system's usage patterns was also documented to allow for confirming whether the new measure was functioning as the primary heat source and displacing previous electric heating.

For heat pump and biomass projects, the types and characteristics of the space heating systems recorded in the tracking system were also reviewed prior to the visit. This information allowed the Evaluator to assess the accuracy of the tracked information stored in the demand side management data system and collect nameplate information from the installed equipment. Upon completion of the site visits, the collected information was used to validate the applications received by ENS and identify possible process improvement opportunities.

The solar projects' protocol required collecting information about the old heating systems (primary, secondary and water heating), validating the number of system components, their types, applications, manufacturers and model numbers, and documenting the panels' angles and any apparent obstructions. The Evaluator also documented how the new system was integrated into the old system, and confirmed the usage patterns reported in the tracking sheet, such as the number of occupants.

On-site Visit Data Collection Form

The data collection forms used by the Evaluator during the on-site visits are shown on the following pages.

1. General Information

Date of Visit:	_____
Project Name:	_____
Project Tracking Sheet #:	_____
Contact Name:	_____
Address:	_____
City:	_____
Telephone:	_____
Name of Contact Met with:	_____
Number of Full-time Occupants:	_____

2. Biomass

Primary Heating System

	In the Tracking Sheet	Validated On Site
Primary Heating Source:	_____	_____
Primary Heating System Type:	_____	_____
Primary Heating System Capacity:	_____	_____
% Total Heating from Primary Source (Participant Declaration):	_____	_____
Is the Equipment Still in Place? (Y/N):	_____	_____

Secondary Heating System

	In the Tracking Sheet	Validated On Site
Secondary Heating Source:	_____	_____
Secondary Heating System Type:	_____	_____
Secondary Heating System Capacity:	_____	_____
% Total Heating from Secondary Source (Participant Declaration):	_____	_____
Is the Equipment Still in Place? (Y/N):	_____	_____

New Heating System

	In the Tracking Sheet	Validated On Site
New Heating Source:	_____	_____
New Heating System	_____	_____
Model Name:	_____	_____
Model Number:	_____	_____
New Heating System Capacity:	_____	_____
% Total Heating from New Heating System (Participant Declaration):	_____	
Is the Equipment ENERGY STAR® Canada Certified? (Y/N):	_____	

New System Usage Patterns

Location of the New Equipment:	_____
Does the New System Serve All Living Space? (Y/N):	_____
If not, what % does the system serve?	_____
Method of Heat Distribution:	_____
Is the New System Used when the Home is NOT occupied?	_____
Is the New System Used as the Primary Heat Source?	_____
Describe the Supplementary System Used:	_____
Notes:	_____

3. Solar

Site Information

	In the Tracking Sheet	Validated On Site
Primary Heating Source:	_____	_____
Secondary Heating Source:	_____	_____
DHW Heating Source:	_____	_____

Solar System Information

	In the Tracking Sheet	Validated On Site
Number of Collectors:	_____	_____
Solar System Usage (DHW or Air):	_____	_____
Collector Manufacturer:	_____	_____
Collector Model Number:	_____	_____
Does the System Have a Heat Exchanger?	_____	_____
Is the Pump Run by PV?	_____	_____
Explain How the System Is Tied into the Space-heating System.	_____	_____
Collector Type - On-site	_____	_____
Collector Orientation	_____	_____
Collector Angle (approx.)	_____	_____
Roof or Ground-mounted?	_____	_____
Are the Collectors Obstructed by Trees or Adjacent Buildings, etc.?	_____	_____
NOTES on Installation Issues or Client Training	_____	_____

4. HVAC

Operating Information

What is the Normal Heating Set-point? (°C)

What is the Normal Cooling Set-point? (°C)

Are the Heating/Cooling Systems Set back
During Unoccupied Times?

How Many Degrees is the Set-back? (°C)

Primary Heating System

In the Tracking Sheet

Validated On Site

Primary Heating Source:

Primary Heating System Type:

Primary Heating System Capacity:

% Total Heating from Primary Source
(Participant Declaration):

Is the Equipment Still in Place? (Y/N):

Secondary Heating System

In the Tracking Sheet

Validated On Site

Secondary Heating Source:

Secondary Heating System Type:

Secondary Heating System Capacity:

% Total Heating from Secondary Source
(Participant Declaration):

Is the Equipment Still in Place? (Y/N):

New System Usage Patterns

Location of Indoor Unit(s):

Does Heat Pump Serve All Living Space? (Y/N):

If not, What % does the system serve?

Is the Heat Pump Used when the Home is NOT
Occupied?

Describe the Heat Pump Usage Patterns:

Notes:

Existing Cooling System

Existing A/C Prior to Heat Pump installation? (Y/N):

Cooling System Type (i.e., Window A/C, Stand-alone A/C, etc.):

Site Information

Heat Pump Type:

Was This a Replacement for a Malfunctioning Unit?

Heat Pump Manufacturer:

Outdoor Model Number:

Indoor Model Number:

**In the Tracking
Sheet**
**Validated On
Site**
**In the Tracking
Sheet**
**In the Spec.
Sheet**

SEER:

EER:

HSPF Region V:

Quantity:

Explanation if Quantity Different:

Rated Heating Capacity (BTU/h):

Rated Cooling Capacity (BTU/h):

Low Temp Heating Capacity (BTU/h):

COP at -15°C:

Heating Temperature Set-point (°C)

Cooling Temperature Set-point (°C)

Closed or Open Loop? (GSHP only):

Has a Correct Combination of Indoor and Outdoor Units Been Used?

Appendix XIV

GH: ALGORITHM FOR FREE-RIDERSHIP CALCULATION

The figures below show the algorithm for calculating the free-ridership level for each type of measure. The participant survey questionnaire included questions designed to assess the planning, quantity, efficiency, period, cost and influence of the program component. A set of questions was also asked to assess cross-influence, which refers to the level of influence that participants' previous participation in one of ENS's program components or energy efficiency awareness campaigns had on their decisions to implement energy efficiency measures. A participant's responses to each group of questions were converted into a value indicating the level of program component attribution and this value was used to calculate the free-ridership level associated with each participant.

For those participants who installed an MSHP, the algorithm consisted of two portions. The first portion assessed a participant's decision to install a heat pump. The second assessed a participant's decision to purchase a high-efficiency heat pump. The portion for assessing the decision to install a heat pump was given a weight of 75 percent, since the savings associated with the efficiency increase brought by an electric resistance system (with an HSPF of 3.412) to a standard heat pump (usually with an HSPF of 7.1, according to federal energy efficiency regulations) represent about 75 percent of the total savings attributable to a high-efficiency MSHP. Also, the portion of the free-ridership linked to the decision to purchase a high-efficiency heat pump (the remaining 25%) was considered only if the free-ridership level of the first portion was higher than 50 percent. It was assumed that if the probability of purchasing a heat pump was lower than or equal to 50 percent, the probability of purchasing a high-efficiency heat pump was close to nil.

Algorithm – Stoves and Solar

FR2. If you had not received the rebate or the financing from ENS, would you have paid the entire cost of your [EQUIPMENT]? (Scale 0 to 10)	FR2 = Answer x 10% IF DK OR REF. FR2 = EMPTY
FR3a. If the program rebate or financing had not been offered, what is the likelihood that you would have installed an electrical heating system instead of the [EQUIPMENT] you installed through the program? (Scale 0 to 10)	FR3a = (10 – Answer) x 10% IF 98 OR 99. FR3a = EMPTY
FR3b. [ASK IF EXISTING SYSTEM WAS WORKING] If the program rebate or financing had not been offered, what is the likelihood that you would have kept your old heating system instead of installing a new one? (Scale 0 to 10)	FR3b = (10 – Answer) x 10% IF 98 OR 99. FR3b = EMPTY
PA1 Score:	MEAN VALUE OF: (FR2 ; MIN(FR3a ; FR3b))
FR1. Had you <i>already</i> decided installing a [EQUIPMENT] <i>before</i> you heard about Green Heat?	IF 1. Yes: Use FR1a IF 2. No OR DK OR REF: FR1a = 0%
FR1a. [ASK IF FR1=YES] I just want to make sure - <i>before</i> you decided to participate in Green Heat, had you already made the decision to install a [EQUIPMENT]?	IF 1. Yes: FR1a = 100% IF 2. No OR DK OR REF : FR1a = 0%
PA2 Score:	FR1a
FR4. Level of influence (Scale 0 to 10)	FR4 = MAX(FR4a ; FR4d)
PA3 Score:	(10 – FR4) x 10%
FR3c. If Green Heat rebate or financing had not been offered, what is the likelihood that you would have postponed installing the [EQUIPMENT] by at least one year?	(10 – Answer) x 10% IF 2. No OR DK OR REF: FR3c = EMPTY

PA4 Score:	FR3c
Inconsistency Test PA1	IF ABS (FR2 – MIN (FR3a; FR3b)) ≥ 50% PA1 = MIN (FR2 ; FR3a; FR3b)
Inconsistency Test PA2	IF FR1a = 100% and FR2 < 70% PA2 = EMPTY
Free-Ridership	IF PA4 < MEAN (PA1; PA2; PA3): MEAN (PA1; PA2; PA3; PA4) OTHERWISE MEAN (PA1; PA2; PA3)
CI2/4a. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] was a major factor in your decision to install a [EQUIPMENT] in your home. CI2/4b. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted you to ask a contractor or a distributor about energy efficient heating systems for your home. CI2/4c. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted you to take into account the savings on your energy bill when evaluating different heating systems for your home. (Agree or Disagree)	CI = IF(CI2a OR CI4a=Agree) + IF(CI2b OR CI4b=Agree) + IF(CI2c OR CI4c=Agree)
Revised Free-Ridership	IF CI=0 OR 1, Revised FR = FR IF CI=2, Revised FR = FR*.75 IF CI=3, Revised FR = FR*.50

Algorithm – Air Source Heat Pump

FR2. If you had not received the rebate or the financing from ENS, would you have paid the entire cost of your [EQUIPMENT]? (Scale 0 to 10)	FR2 = Answer x 10% IF DK OR REF: FR2 = EMPTY
FR3a. If Green Heat rebate or financing had not been offered, what is the likelihood that you would have installed a less efficient and less expensive heat pump (Scale 0 to 10)	FR3a = (10 – Answer) x 10% IF DK OR REF: FR3a = EMPTY
FR3b. [ASK IF EXISTING SYSTEM WAS WORKING] IF Green Heat rebate or financing had not been offered, what is the likelihood that you would have kept your old heating system instead of installing a new one? (Scale 0 to 10)	FR3b = (10 – Answer) x 10% IF DK OR REF: FR3b = EMPTY
PA1 Score:	MEAN VALUE OF: (FR2 ; MIN(FR3a ; FR3b))
FR1. Had you <i>already</i> decided to install a high efficiency [EQUIPMENT] <i>before</i> you heard about Green Heat?	IF 1. Yes: Use FR1a IF 2. No OR DK OR REF: FR1a = 0%
FR1a. I just want to make sure - <i>before</i> you decided to participate in Green Heat, had you already made the decision to install a high efficiency [EQUIPMENT]?	IF 1. Yes: FR1a = 100% IF 2. No OR DK OR REF: FR1a = 0%
PA2 Score:	FR1a
FR4. Level of influence (Scale 0 to 10)	FR4 = MAX(a; b)
PA3 Score:	(10 - FR4) x 10%
FR3c. If Green Heat rebate or financing had not been offered, what is the likelihood that you would have postponed installing the [EQUIPMENT] by at least one year? (Scale 0 to 10)	FR3c = (10 – Answer) x 10% IF DK OR REF: FR3c = EMPTY

PA4 Score:	FR3c
Inconsistency Test PA1	IF ABS (FR2 – MIN (FR3a; FR3b)) ≥ 50% PA1 = MIN (FR2 ; FR3a; FR3b)
Inconsistency Test PA2	IF FR1a = 100% AND FR2 < 70% PA2 = EMPTY
Free-Ridership	IF PA4 < MEAN (PA1; PA2; PA3): MEAN (PA1; PA2; PA3; PA4) OTHERWISE MEAN (PA1; PA2; PA3)
CI2/4a. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] was a major factor in your decision to install a [EQUIPMENT] in your home. CI2/4b. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted you to ask a contractor or a distributor about energy efficient heating systems for your home. CI2/4c. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted you to take into account the savings on your energy bill when evaluating different heating systems for your home. (Agree or Disagree)	CI = IF(CI2a OR CI4a=Agree) + IF(CI2b OR CI4b=Agree) + IF(CI2c OR CI4c=Agree)
Revised Free-Ridership	IF CI=0 OR 1, Revised FR = FR IF CI=2, Revised FR = FR*.75 IF CI=3, Revised FR = FR*.50

Algorithm – Mini-split Heat Pump in Electrically Heated Households

Series A: Decision to install a HP	
FRM1. Had you already decided to install a heat pump before you heard about the Green Heat Program?	IF 1. Yes: Use FRM1a IF 2. No OR DK OR REF: FRM1a = 0%
FRM1a. I just want to make sure - before you learned about the Green Heat Program, had you already made the decision to install a heat pump?	IF 1. Yes: FRM1a = 100% IF 2. No OR DK OR REF: FRM1a = 0%
FRM2. [ASK IF FRM1a<>1] If the program had not been offered, which of the following actions would you have taken? 1. Kept your existing heating system 2. Purchased a new electric heating system 3. Purchased a new non-electric heating system (e.g. oil or gas system) 4. Purchased a heat pump	IF 1, 2 or 3: END IF 4: ASK FRM3
FRM3. [ASK IF FRM2=4] If the program had not been offered, what is the likelihood that you would have postponed the purchase of a heat pump by at least one year? (Scale 0 to 10)	FRM3 = (10 – Answer) x 10% IF DK OR REF: FRM3 = EMPTY
PA1 Score (Series A)	MEAN VALUE OF: (FRM1a ; FRM3)

Series B: Decision to install a high-efficiency HP	
FRM4. Were you aware of the availability of higher efficiency heat pumps that operate at temperatures below -15°C before you heard about Green Heat?	IF 1. Yes: Use FRM4a IF 2. No, DK OR REF: FRM4a = 0% and END
FRM4a. [ASK IF FRM4=1] Before you heard about the Green Heat Program, had you already made the decision to install a high-efficiency heat pump model?	IF 1. Yes: FRM4a=100% IF 2. No, DK OR REF: FRM4a = 0%
FRM5. [ASK IF FRM4=1] If you had not received the rebate from Efficiency Nova Scotia, would you have paid the total cost of your high-efficiency heat pump? (Scale 0 to 10)	FRM5 = Answer x 10% IF DK OR REF: FRM5 = EMPTY
FRM6. Level of influence (Scale 0 to 10)	FRM6 = (10 - MAX(a;b;c))*10%
PA2 Score (Series B)	IF PA1<=50% OR FRM4<>1 PA2 = 0%, OTHERWISE MEAN VALUE OF: (FRM4a;FRM5;FRM6)
Inconsistency Test #1	IF FRM4a = 100% and FRM5 < 70% FRM4a = EMPTY
Free-Ridership	0.75xPA1+0.25xPA2
CI2/4a. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] was a major factor in your decision to install a [EQUIPMENT] in your home. CI2/4b. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted you to ask a contractor or a distributor about energy efficient heating systems for your home. CI2/4c. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted you to take into account the savings on your energy bill when evaluating different heating systems for your home. (Agree or Disagree)	CI = IF(CI2a OR CI4a=Agree) + IF(CI2b OR CI4b=Agree) + IF(CI2c OR CI4c=Agree)
Revised Free-Ridership	IF CI=0 OR 1, Revised FR = FR IF CI=2, Revised FR = FR*.75 IF CI=3, Revised FR = FR*.50

Algorithm – Mini-split Heat Pump in Non-Electrically Heated Households

Series B: Decision to install a high-efficiency HP	
FRM4. Were you aware of the availability of higher efficiency heat pumps that operate at temperatures below -15°C before you heard about Green Heat?	IF 1. Yes: Use FRM4a IF 2. No, DK OR REF: FRM4a = 0% and END
FRM4a. [ASK IF FRM4=1] Before you heard about the Green Heat Program, had you already made the decision to install a high-efficiency heat pump model?	IF 1. Yes: FRM4a=100% IF 2. No, DK OR REF: FRM4a = 0%
FRM5. [ASK IF FRM4=1] If you had not received the rebate from Efficiency Nova Scotia, would you have paid the total cost of your high-efficiency heat pump? (Scale 0 to 10)	FRM5 = Answer x 10% IF DK OR REF: FRM5 = EMPTY
FRM6. Level of influence (Scale 0 to 10)	FRM6 = (10 - MAX(a;b;c))*10%
PA2 Score (Series B)	IF FRM4<>1 PA2 = 0%, OTHERWISE MEAN VALUE OF: (FRM4a;FRM5;FRM6)
Inconsistency Test #1	IF FRM4a = 100% and FRM5 < 70% FRM4a = EMPTY
Free-Ridership	PA2
CI2/4a. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] was a major factor in your decision to install a [EQUIPMENT] in your home. CI2/4b. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted you to ask a contractor or a distributor about energy efficient heating systems for your home. CI2/4c. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted you to take into account the savings on your energy bill when evaluating different heating systems for your home. (Agree or Disagree)	CI = IF(CI2a OR CI4a=Agree) + IF(CI2b OR CI4b=Agree) + IF(CI2c OR CI4c=Agree)
Revised Free-Ridership	IF CI=0 OR 1, Revised FR = FR IF CI=2, Revised FR = FR*.75 IF CI=3, Revised FR = FR*.50

Appendix XV

EPI: 2017 RECOMMENDATIONS

This appendix summarizes all the recommendations made by the Evaluator as part of the 2017 evaluation. There were no incomplete 2016 recommendations at the time of writing.

Section	Recommendations
Executive Summary	1. Document the energy-saving potential related to halogen incandescents and CFL lamp replacements. The tracking report indicated that the average number of A-type LED lamps installed per household significantly decreased among participating single-family homes. Although EPI achieved high savings in 2017, this trend suggests that fewer incandescents are present in homes, and will consequently provide fewer opportunities for LED replacements in the future. The Evaluator recommends that ENS start gathering information about the types of lamps installed in EPI participants' homes to analyze the savings potential that can be tapped if general-service lamp types other than incandescents are made eligible for replacement.

Appendix XVI

EPI: PARTICIPANT SURVEY QUESTIONNAIRE

Hello may I please speak with [INSERT NAME]?

- 1 Yes [GO TO INTRODUCTION]
- 2 No [SAY “Perhaps you can help me anyway.” GO TO INTRODUCTION]

Introduction

Hello, my name is _____ and I am with Corporate Research Associates, and we are performing an evaluation of energy efficiency services provided by Efficiency Nova Scotia. Our records indicate that you or your household recently participated in the Efficient Product Installation Service. Are you the person who was most involved with this program?

(IF NEEDED: As part of this service, someone would have come to your house and installed new lighting or domestic water heating energy efficiency products, such as LED light bulbs and faucet aerators, at no charge, as well as offered advice on ways your house can save energy).

[IF NO, ASK TO SPEAK TO THE APPROPRIATE PERSON]: “May I please speak to the person who knows the most about this program?”]

We would appreciate your help in answering questions related to your participation in this service. The information you provide will be used to help Efficiency Nova Scotia evaluate and improve the service. Is this a good time for you?

(IF NEEDED: You may have recently been contacted by Corporate Research Associates or by an Efficiency Nova Scotia representative about your experience with the service. This survey is different as it focuses on other aspects of your participation in the service.)

(IF NEEDED: The survey will take about fifteen minutes.)

1. Yes [CONTINUE]
2. No, I don't remember the service / Don't know [PROMPT: “Are you sure? Someone would have come to your house and installed energy-efficient products, at no charge, for you to save energy and money?” RECODE AS “YES” IF THE PROMPT WORKS; IF RESPONDENT STILL SAYS NO: Is there someone else in the household who would know about having participated in this Efficiency Nova Scotia service?
3. Yes [ASK TO SPEAK TO THEM AND REPEAT INTRODUCTION]
4. No, but they came to my previous home [CONTINUE]
5. No [THANK, TERMINATE, RECORD, AND KEEP DATA]
99. Refused [THANK, TERMINATE, RECORD, AND KEEP DATA]

[IF REFUSED, ASK “Can we schedule a more convenient time for you to conduct this survey?”

[SCHEDULED, IF NECESSARY, FOR: _____]

Verification and Recall [V Series]

V1. I am going to read you a list of energy-efficient products that, according to our records, were installed in your home by the Efficient Product Installation Service. For each one, can you please confirm that this product was in fact installed through the service? [READ WHAT IS ON RECORD (MEASURE#0 IN THE DATABASE)]. [1=YES, INSTALLED, 2=NO, NOT INSTALLED, 98=DON'T KNOW, 99=REFUSED]

[NOTE FOR PROGRAMMER: DO NOT PUT THE NUMBER OF EACH MEASURE]

- a) LED bulbs
- b) LED nightlights
- c) Pipe insulation
- d) Hot water tank wrap
- e) Low-flow showerheads or showerwands
- f) Bathroom and/or kitchen faucet aerators
- g) Programmable thermostats
- h) Smart power strips

[THANK, TERMINATE, RECORD AND KEEP DATA IF RESPONDENT SAYS “NO”, “DK” OR “REF” TO ALL QUESTIONS FROM V1]

Installation of Smart Power Strip [E Series]

[ASK PARTICIPANTS WHO HAD SMART POWER STRIP INSTALLED: **IF V1h=YES**]

E1. You just mentioned that a smart power strip for audio-visual equipment was installed in your household as part of the program. Do you still have this device installed in your household?

- 1. Yes
- 2. No
- 98. (Don't Know) [GO TO P SERIES]
- 99. (Refused) [GO TO P SERIES]

E2. [ASK IF E1=2 (NO)] Why did you choose to remove this device from your household? [DO NOT READ, CODE ALL THAT APPLY]

- 1. (Did not work like I thought it would)
- 2. (Too complicated to use)
- 3. (Did not believe any changes would result in lower energy bills)
- 4. (Not enough room for it)
- 5. (Turned off AV equipment too quickly)
- 96. (Other [SPECIFY: _____])
- 98. (Don't know)
- 99. (Refused)

- E3. [ASK IF E1=1 (YES)] Using a scale from 1 to 10, where 1 means “not at all satisfied” and 10 means “completely satisfied,” please tell me how satisfied you are with the smart power strip that was installed under the program. [98 = Don’t know/Don’t recall, 99 = Refused] [DO NOT ACCEPT A RANGE]
- E4. [ASK IF E3 < 8] What was the SINGLE most important reason you were not fully satisfied with this device? [PROBE FOR SPECIFIC REASON. ACCEPT ONE RESPONSE. DO NOT READ]
1. (Did not work like I thought it would)
 2. (Too complicated to use)
 3. (Did not notice any changes in energy bills)
 4. (Turns off AV equipment too quickly)
 5. (Takes up too much room)
 96. (Other [SPECIFY: _____])
 98. (Don’t know)
 99. (Refused)

Participation [P Series]

- P1. What was the SINGLE most important reason you agreed to participate in the Efficient Product Installation Service? [ACCEPT ONE RESPONSE] [DO NOT READ]
1. (To save on energy/to save on energy costs)
 2. (For better comfort)
 3. (To receive LED bulbs)
 4. (To help protect the environment)
 5. (No cost for services/service was free of charge)
 6. (To reduce my water consumption)
 7. (Wanted energy-efficient upgrades)
 96. (Other) [SPECIFY _____]
 98. (Don’t know) [GO TO P3]
 99. (Refused) [GO TO P3]
- P2. Were there any other reasons? [DO NOT READ. ACCEPT MULTIPLE. SAME LIST AS P1]
97. None/no other reasons
- P3. Were you home when the installer came to your home to install energy-efficient products?
1. Yes
 2. No
 98. (Don’t know)
 99. (Refused)

- P4. [ASK IF YES IN P3] Did your household receive information about energy-efficient products during the visit from the installer? **DO NOT READ, CODE ONE ONLY**
1. Yes, I received some information
 2. No, I did not receive any information
 98. (Don't recall)

Behaviour Changes [C Series]

- C1. After participating in the program, did you start doing, or increase doing, any of the following energy-efficiency actions at home? **[READ AND ROTATE STATEMENTS, EXCEPT ALWAYS POSE STATEMENT 'k' LAST – CODE ONE ONLY PER STATEMENT]**
- a. Turn off your lights now
 - b. Set your heating thermostat lower
 - c. Set your water heater thermostat lower
 - d. Hang your clothes to dry
 - e. Use cold water to wash your clothes
 - f. Use fans instead of air conditioning
 - g. Turn off appliances
 - h. Become more aware of power usage and saving energy
 - i. Reduce water consumption by not wasting water
 - j. Unplug items not in use
 - k. Did you either start doing or increase doing any other energy-efficiency actions at home, after participating in the program? **[RECORD VERBATIM, 97=No, 98=Don't know]**
 1. Start doing
 2. Increase doing
 3. Do not do
 4. I was already doing this before the program/have not changed my habit as a result of the program
 - 98 Don't know

Satisfaction with the Service [S Series]

- S1. Using a scale from 1 to 10 where 1 is "not at all satisfied" and 10 is "completely satisfied," how would you rate your satisfaction with the Efficient Product Installation Service overall? **[RECORD NUMBER, 98=Don't know, 99 Refused] DO NOT ACCEPT A RANGE**

- S2. [IF S1 < 8] What was the most important reason you were not more satisfied with the service overall? [PROBE FOR SPECIFIC REASON. ACCEPT MULTIPLE RESPONSE]
1. (I expected more)
 2. (Did not like the upgrades/changes made)
 3. (I did not like the low flow showerhead installed)
 4. (I did not like the installer who came to my home)
 5. (I did not notice any savings on my energy bill)
 6. (The process was complicated)
 97. (Other: Please specify : _____)
 98. (Don't know)
 99. (Refused)
- S3. [IF S1 ≥ 8] What was the most important reason you were satisfied with the service overall? [PROBE FOR SPECIFIC REASON. DO NOT READ – ACCEPT MULTIPLE RESPONSE]
1. (Lowered energy bill)
 2. (Good service)
 3. (Saves energy)
 4. (Better lights/lighting)
 5. (Informative/Information received)
 6. (I like the installer who visited the home)
 7. (Program was free)
 8. (Everything went smooth)
 9. (Reasonable time frame)
 10. (Products/services offered through program)
 97. (Other: Please specify : _____)
 98. (Don't know)
 99. (Refused)
- S4. Using a scale from 1 to 10, where 1 means “not at all satisfied” and 10 means “completely satisfied,” please tell me how satisfied you are with your experience with each of the following aspects of the Efficient Product Installation Service. [DO NOT RANDOMIZE] [97 = Not Applicable, 98 = Don't know/Don't recall, 99 = Refused] [DO NOT ACCEPT A RANGE]
- a) [ASK IF YES IN P3] The time required to complete work
 - b) The energy-efficient products installed
 - c) The quality of the work completed
 - d) [ASK IF YES IN P4] The information you received about energy-efficient products

- S5. Have you had any problems with the products installed in your home through the Efficient Product Installation Service?
1. Yes
 2. No
 98. (Don't know)
 99. (Refused)
- S6. [ASK IF YES IN S5] Which products led to problems? [RECORD ANSWER]
- S7. [IF YES IN S5] What problems did you have with the products installed in your home?
96. (RECORD VERBATIM: _____)
 98. (Don't know)
 99. (Refused)

Barriers to Action [B Series]

- B1. [ASK IF YES IN P3] Were there any energy efficiency products recommended through the Efficient Product Installation Service that you chose not to have installed in your home?
1. Yes
 2. No
 98. (Don't recall)
- B2. [ASK IF YES IN B1] Which products did you choose not to have installed? [RECORD ANSWER]
- B3. [ASK IF YES IN B1] Why did you choose not to have these products installed in your home?
96. (RECORD VERBATIM: _____)
 98. (Don't know)
 99. (Refused)

[ASK TO ALL]

- B4. Now thinking generally about energy efficient upgrades. There may be many reasons for not making energy efficient upgrades to your home. How much of a barrier, if at all, are each of the following in preventing your household from making energy efficiency upgrades? Please answer on a scale of 1 to 10, where 1 means 'not at all a barrier' and 10 means 'a major barrier'. [ROTATE. RECORD RESPONSE BETWEEN 1 AND 10. 98=DON'T KNOW, 99=REFUSED]
- a. Lack of money
 - b. Lack of time
 - c. Lack of information about energy efficiency products
 - d. Lack of interest
 - e. Not convinced of the energy savings
 - f. Not knowing how to get started, plan the upgrades or do the work

Recommendations (R Series)

- R1. Do you have any recommendations that you think would help improve the Efficient Product Installation Service? **PROBE:** Anything else? [DO NOT READ, ACCEPT MULTIPLE]
1. (Offer more products to be installed)
 2. (Offer more information on the products installed)
 3. (Complete work faster)
 4. (Improve quality of work)
 5. (Improve communication)
 6. (No recommendation)
 96. (Other [SPECIFY _____])
 98. (Don't know)
 99. (Refused)
- R2. [IF R1= 1] Which other energy efficiency products would you like to have had installed through the Efficient Product Installation Service? [DO NOT READ. ACCEPT MULTIPLE]
1. (Dishwasher)
 2. (Washing machine)
 3. (Dryer)
 4. (Windows/Envelope/Insulation)
 5. (Refrigerator)
 6. (Freezer)
 7. (Ventilation)
 8. (Thermostats)
 9. (Air sealing/Weather stripping)
 10. (Toilets)
 96. Other [SPECIFY _____])
 98. (Don't know)
 99. (Refused)

Free-Ridership [FR Series]

INSTRUCTION: FR SERIES SHOULD BE ASKED ONLY TO RESPONDENTS WHO INDICATED **“YES” IN V1a** (LED Bulbs). OTHERWISE **SKIP TO SO SERIES**.

The next questions will be about the **LED bulbs**, excluding night lights, that you had installed through the service.

- FR1. Did you or anyone in your household have specific plans to purchase and install LED bulbs prior to learning about the Efficient Product Installation Service? **[CODE ONE ONLY]**
1. Yes
 2. No
 98. (Don't know)
 99. (Refused)

FR1a. **IF FR1=YES, THEN ASK:** I just want to make sure I understand - Before you learned about the Efficient Product Installation Service, you had already made the decision to purchase and install LED bulbs in your home?

- 1. Yes
- 2. No
- 98. (Don't know)
- 99. (Refused)

FR2. If Efficiency Nova Scotia had not installed these LED bulbs at no charge as part of the Efficient Product Installation Service, would you have paid the full cost of the LED bulbs, which is approximately \$6 per bulb?

Please use a scale of 0-10 where 0="DEFINITELY **WOULD NOT** HAVE PAID" and 10="DEFINITELY **WOULD HAVE** PAID".

0-10 SCALE– RECORD NUMBER - 98 DON'T KNOW 99 PREFER NOT TO SAY

[READ FIRST TIME THROUGH ONLY] Now I would like to ask you to consider what actions you would have taken if the Efficient Product Installation Service had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is "Very Unlikely," and a 10 indicating that it is "Very Likely."

[DO NOT ACCEPT A RANGE – ASK FR3 SEQUENCE IN ORDER/DO NOT RANDOMIZE]

FR3a. If the service had not been offered, what is the likelihood that you would have taken the initiative to purchase LED bulbs at a store and then install them yourself in your home?

FR3b. [IF FR3a>=5] If the service had not been offered, what is the likelihood that you would have postponed replacing your bulbs with LEDs by at least one year?

FR3c. [ASK IF LED bulbs QUANTITY>1] If the service had not been offered, what is the likelihood that you would have purchased and installed all [QUANTITY] LED bulbs that were installed through the Efficient Product Installation Service?

FR4. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to have LED bulbs installed in your home. Using a scale from 0 to 10 where 0 means "No influence" and 10 means "Great influence", please rate the influence of each of the following in your decision to have the LED products installed in your home. **[DO NOT ACCEPT A RANGE]**

Factor (READ AND RANDOMIZE)	Responses
a. The installation of energy-efficient products, at no charge, offered by the service	___ Response ___98 Don't Know ___99 Refused ___ 97 Not applicable
b. Information or advice provided by the service staff	___ Response ___98 Don't Know ___99 Refused ___ 97 Not applicable

Cross-Influence [CI Series]

INSTRUCTION: CI SERIES SHOULD BE ASKED ONLY TO RESPONDENTS WHO INDICATED “YES” IN V1a (LED Bulbs). OTHERWISE **SKIP TO SO SERIES**.

READ AND ROTATE (CI1 + CI2) AND (CI3 + CI4) SEQUENCES

CI1. Before participating in the Efficient Product Installation Service in [DATE], had you at any time in the past already participated in another Efficiency Nova Scotia program or service?

1. Yes
2. No
98. Don't know
99. Prefer not to say

CI2. [IF CI1=1] For the following statement, please indicate whether you agree or disagree. Your previous participation in an Efficiency Nova Scotia program or service and what you learned by participating in this program greatly influenced your decision to have energy-efficient products installed in your home. Please use a scale of 0-10 where 0=“COMPLETELY DISAGREE” and 10 =“COMPLETELY AGREE”.

[0-10 SCALE WHERE 0 =“COMPLETELY DISAGREE” AND 10 =“COMPLETELY AGREE” -
RECORD NUMBER - 98 DON'T KNOW 99 PREFER NOT TO SAY

CI3. Before participating in the Efficient Product Installation Service in [DATE], had you at any time in the past already seen Efficiency Nova Scotia promotional materials advertising the benefits of energy efficiency?

1. Yes
2. No
98. Don't know
99. Prefer not to say

- CI4. [IF CI3=1] For the following statement, please indicate whether you agree or disagree. The energy efficiency promotional materials distributed by Efficiency Nova Scotia greatly influenced your decision to have energy-efficient products installed in your home. Please use a scale of 0-10 where 0="COMPLETELY DISAGREE" and 10 ="COMPLETELY AGREE".

[0-10 SCALE WHERE 0 ="COMPLETELY DISAGREE" AND 10 ="COMPLETELY AGREE" -
RECORD NUMBER - 98 DON'T KNOW 99 PREFER NOT TO SAY

Spillover [SO Series]

- SO1. Now I'd like you to think of the time **since you participated** in the Efficient Product Installation Service. Have you installed any additional energy-efficient products or retired any old appliances on your own?
1. Yes
 2. No [GO TO D SERIES]
 98. (Don't know/Don't recall) [GO TO D SERIES]
 99. (Refused) [GO TO D SERIES]
- SO2. [IF SO1= YES, THEN ASK] I just want to make sure I understand - **After** you participated in the Efficient Product Installation Service, you installed additional energy-efficient products or retired old appliances on your own, that is, without a rebate or assistance from a program. Is that correct?
1. Yes
 2. No [GO TO D SERIES]
 98. (Don't know) [Go To D SERIES]
 99. (Refused) [GO TO D SERIES]
- SO3. [IF SO2 = 1 "YES"] Have you received financing or rebates from any other Efficiency Nova Scotia programs for these additional energy-efficient products or appliances retired? IF UNCLEAR, PROBE FOR APPROPRIATE 'YES' RESPONSE BY READING THE TWO 'YES' RESPONSES
1. Yes, for all products or appliances [GO TO D SERIES]
 2. Yes, for some of the products or appliances
 3. No
 98. (Don't know [GO TO D SERIES])
 99. (Refused) [GO TO D SERIES]

Now, I will specifically talk about the additional actions you took on your own after participating in the Efficient Product Installation Service.

SO4a. [IF SO3 = 2 or 3 Yes/some or 'NO'] What, if any, additional energy-efficient products have you installed on your own after participating in the Efficient Product Installation Service? [DO NOT READ, ALLOW MULTIPLE] Probe: Any others?

1. (LED bulbs)
2. (Low flow showerheads)
3. (Faucet aerators)
4. (Pipe insulation/tank wrap)
5. (Smart power strip/smart power bar)
6. (Energy Star refrigerator)
7. (Energy Star clothes washer)
8. (LED fixtures)
9. (NEST or smart thermostats)
10. (Programmable thermostats)
11. (LED nightlights)
12. (Dehumidifiers)
13. (Bathroom fans)
14. (Air purifiers)
15. (Kitchen range hood fans)
97. (Other [SPECIFY _____])
98. (None)
99. (Don't know)

SO4b. [ASK FOR EACH RESPONSE IN SO4a] How many [INSERT RESPONSE IN SO4a FOR ALL SO4a RESPONSES, EXCEPT SAY feet of pipe insulation IF CODE 4] have you purchased and installed on your own? [RECORD NUMBER IN QUANTITY OR NUMBER OF FEET OF PIPE INSULATION. 98=DK, 99=REFUSED]

SO4c. [IF SO4a = 1, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15] Did you receive an instant rebate at the cashier on the [INSERT ANSWER FROM SO4a] you purchased? [REPEAT FOR EACH ANSWER TO SO4a]

1. Yes
2. No
98. (Don't know)
99. (Refused)

SO4d. [IF SO3 = 2 or 3 Yes/some or 'NO'3] What appliances, if any, have you retired on your own, that is, outside of a rebate or other assistance from a program, after participating in the Efficient Product Installation Service? [DO NOT READ, ALLOW MULTIPLE] Probe: Any others?

1. (Refrigerators)
2. (Freezers)
3. (Room air conditioning units)
4. (Dehumidifiers)
96. (Other [SPECIFY _____])
97. None
98. (Don't know)

SO4e. [ASK FOR EACH RESPONSE IN S04d] How many [INSERT RESPONSE IN SO4d] have you retired on your own? [RECORD NUMBER. 98=DK, 99=REFUSED]

SO5. [IF SO3 = 2 or 3 Yes/some or 'NO'] How influential was your experience with the Efficient Product Installation Service on your decision to install these additional energy-efficient products or retire these appliances on your own? Please, give your answer on a scale of 0 to 10, where 0 indicates that the Efficient Product Installation Service "had no influence at all on your decision," and 10 indicates that the service was "extremely influential to your decision." [RECORD RESPONSE 0-10, 98 = Don't know, 99 = REFUSED] [DO NOT ACCEPT A RANGE]

Demographic Characteristics (D Series)

These final questions are asked for statistical purposes only. The information collected is strictly confidential.

D1. What type of residence do you live in? [READ RESPONSES 1-7, THEN 96; SELECT ONE RESPONSE]

1. Apartment building that has fewer than five stories
2. Apartment building that has five or more stories
3. Row house (Single story apartment building)
4. Detached single-family home
5. Semi-detached house
6. Mobile home or house trailer
7. Townhouse or duplex which shared adjacent walls
96. Or some other type [SPECIFY: _____]
98. (Don't know)
99. (Refused)

D2. How many bedrooms are in your home? [98=DK; Enter zero for a studio apartment with no bedrooms]

D3. How many showers are in your home? [98=DK; Record number of showers]

RECORD NUMBER: _____ 98=DK

D4. Do you own or rent this home?

1. Own/buying
2. Rent/lease
3. Other (Describe) _____
99. (Refused)

D5. Do you pay the electric bills for your home?

1. Yes
2. No
96. (Other) [Specify _____]
98. (Don't Know)
99. (Refused)

D6. Including yourself, how many people live in this residence on a full-time basis?

Number of people: _____ [NOTE: DON'T ALLOW ZERO FOR A RESPONSE]
99. (Refused)

D7. What is your age group? Are you: [READ]

1. 18 to 24
2. 25 to 34
3. 35 to 44
4. 45 to 54
5. 55 to 64
6. 65 or over
99. (Refused)

D8. What is the highest grade of schooling completed by the head of your household? [READ IF NECESSARY]

1. (Less than high school graduation diploma)
2. (High school graduation diploma and/or some post secondary)
3. (Trades certificate or diploma)
4. (College certificate or diploma)
5. (University degree, certificate or diploma)
97. Other (SPECIFY: _____)
98. (Don't know)
99. (Refused)

D9. Which of the following income categories best describes your total annual household income before taxes in 2016? Stop me when I reach the right category. [READ LIST; SELECT ONE RESPONSE]

1. Less than \$15,000
2. \$15,000 - \$24,999
3. \$25,000 - \$34,999
4. \$35,000 - \$49,999
5. \$50,000 - \$69,999
6. \$70,000 - \$79,999
8. \$80,000 or more
98. (Don't know)
99. (Refused)

D10. [DO NOT READ] Gender:

1. Male
2. Female

END: THAT IS ALL THE QUESTIONS I HAVE FOR YOU. THANK YOU FOR TAKING THE TIME TO RESPOND TO THIS SURVEY.

Appendix XVII

EPI: PARTICIPANT SURVEY RESULTS

The participant survey results are presented in the following tables. In total, 63 interviews were completed with homeowners, and 37 interviews with tenants. The proportion of tenants and homeowners interviewed was not representative of the proportion in the survey sample file at the time of the survey, therefore the total columns in the tables below have been weighted to match the proportion of tenants to homeowners in the sample file. Meanwhile, results for tenants and homeowners shown in the tables below are unweighted results. Unweighted results are shown for these two groups for the following reason: the tenants accounted for a very small proportion of the overall survey sample; if weighted results were displayed for this group, in some instances the tenants would have a sample size of zero.

E1. You just mentioned that a smart power strip for audio-visual equipment was installed in your household as part of the program. Do you still have this device installed in your household?

Smart Power Strip Installed	2017		
	Tenants (#)	Homeowners (%)	Total (%)
Sample Size*	3	25	38
Yes	2	84%	84%
No	1	12%	12%
Don't know/Refused	-	4%	4%
*Base: Respondents who had smart power strip installed through EPI			

E2. Why did you choose to remove this device from your household?

Reason Smart Power Strip No Longer Installed**	2017	
	Tenants (#)	Homeowners (#)
Sample Size*	1	3
Turned AV equipment off too quickly	-	3
Did not work like I thought it would	1	1
*Base: Respondents who removed smart power strip **Multiple responses		

- E3. Using a scale from 1 to 10, where 1 means “not at all satisfied” and 10 means “completely satisfied”, please tell me how satisfied you are with the smart power strip that was installed under the program.

Satisfaction with Smart Power Strip	2017		
	Tenants	Homeowners	Total
Sample Size*	2	21	32
Mean**	7.0	7.9	7.9
*Base: Respondents who still have smart power strip installed **Don't know/Refused excluded from calculations			

- E4. What was the single most important reason you were not fully satisfied with this device?

Reasons for Dissatisfaction with Smart Power Strip**	2017	
	Tenants (#)	Homeowners (#)
Sample Size*	2	7
Did not work like I thought it would	-	3
Turns off AV equipment too quickly	2	1
Too complicated to use	-	1
It interfered with the TV	-	1
Others	-	1
*Base: Respondents who were dissatisfied with smart power strip (as indicated by a rating of 'less than 8') **Multiple response		

P1. What was the single most important reason you agreed to participate in the Efficient Product Installation Service?

P2. Were there any other reasons?

Reasons for Participating	2017					
	Most Important Motivation			Other Important Motivations*		
	Tenants	Home-owners	Total	Tenants	Home-owners	Total
Sample Size	37	63	100	36	62	98
To save on energy/energy costs	49%	68%	67%	17%	6%	7%
Wanted energy-efficient upgrades	14%	14%	14%	8%	11%	11%
To receive LED bulbs	5%	6%	6%	-	8%	8%
No cost for services/service was free of charge	8%	3%	3%	3%	8%	8%
To help protect the environment	5%	2%	2%	6%	13%	13%
For better comfort	-	2%	2%	-	2%	2%
Service was recommended to me by someone	-	-	-	-	2%	2%
I was following my landlord's desire to participate	5%	-	-	6%	-	-
Others	11%	3%	4%	3%	-	-
None/no other reasons	-	-	-	67%	52%	52%
Don't know	3%	2%	2%	-	2%	2%
*Multiple Responses						

P3. Were you home when the installer came to your home to install energy-efficient products?

Was Home During Installation	2017		
	Tenants	Homeowners	Total
Sample Size	37	63	100
Yes	89%	90%	90%
No	11%	10%	10%

P4. Did your household receive information about energy-efficient products during the visit from the installer?

Received Information	2017		
	Tenants	Homeowners	Total
Sample Size*	33	57	90
Yes	70%	74%	74%
No	12%	16%	16%
Don't recall	18%	11%	11%
*Base: Respondents who were home during the installation			

C1. After participating in the program, did you start doing, or increase doing, any of the following energy-efficiency actions at home?

Behavioural Changes	2017				
	Homeowners				
	Sample Size*	Start Doing	Increase Doing	Already Doing	Do not do
Turn off my lights now	62	5%	15%	77%	3%
Set heating thermostat lower	61	11%	7%	74%	8%
Set water heater thermostat lower	59	12%	5%	49%	34%
Hang clothes to dry	63	-	10%	62%	29%
Use cold water to wash clothes	63	-	6%	79%	14%
Use fans instead of air conditioning	60	2%	7%	68%	23%
Turn off appliances	61	3%	15%	69%	13%
Become more aware of power usage and saving energy	61	20%	28%	52%	-
Reduce water consumption by not wasting water	62	8%	15%	74%	3%
Unplug items not in use	62	15%	11%	44%	31%
*Responses of don't know are removed					

Behavioural Changes	2017				
	Tenants				
	Sample Size*	Start Doing	Increase Doing	Already Doing	Do not do
Turn off my lights now	37	5%	19%	76%	-
Set heating thermostat lower	36	11%	8%	64%	17%
Set water heater thermostat lower	35	3%	6%	23%	69%
Hang clothes to dry	37	3%	11%	54%	32%
Use cold water to wash clothes	35	3%	9%	77%	11%
Use fans instead of air conditioning	36	6%	11%	50%	33%
Turn off appliances	37	5%	24%	59%	11%
Become more aware of power usage and saving energy	37	8%	24%	57%	11%
Reduce water consumption by not wasting water	36	8%	17%	64%	11%
Unplug items not in use	37	8%	14%	46%	32%
*Responses of don't know are removed					

Behavioural Changes*	2017				
	Total				
	Sample Size*	Start Doing	Increase Doing	Already Doing	Do not do
Turn off my lights now	98	5%	15%	77%	3%
Set heating thermostat lower	97	11%	7%	73%	9%
Set water heater thermostat lower	94	11%	5%	48%	35%
Hang clothes to dry	100	-	10%	62%	29%
Use cold water to wash clothes	100	-	6%	79%	14%
Use fans instead of air conditioning	95	2%	7%	68%	24%
Turn off appliances	97	3%	15%	68%	13%
Become more aware of power usage and saving energy	97	19%	28%	53%	-
Reduce water consumption by not wasting water	98	8%	15%	74%	4%
Unplug items not in use	98	14%	11%	44%	31%
*Responses of don't know are removed					

C1k. Did you either start doing or increase doing any other energy-efficiency actions at home, after participating in the program? Specify those actions.

Other Actions Started or Increased after EPI Participation	2017		
	Tenants (%)	Homeowners (%)	Total (%)
Sample Size	37	63	100
Yes, started or increased other energy efficiency actions at home	11%	35%	34%
No	89%	62%	63%
Don't know	-	3%	3%
Other Actions Undertaken	Tenants (#)	Homeowners (%)	Total (%)
	Sample Size*	22	34
Installed new heating system/heat pump	-	36%	36%
Installed weather stripping/Draft proofing	1	18%	18%
Improved insulation	-	18%	18%
Installed new windows/doors	-	14%	13%
Installed solar panels	1	5%	5%
Installed pipe insulation and water heater tank wrap	-	5%	4%
Bought energy efficient appliances	-	5%	4%
Use appliances more efficiently/run dishwasher at night	1	-	-
Others	1	18%	18%
*Base: Participants who started or increased other energy efficiency actions			

S1. Using a scale from 1 to 10 where 1 is “not at all satisfied” and 10 is “completely satisfied” how would you rate your satisfaction with the Efficient Product Installation Service overall?

Satisfaction with EPI Overall	2017		
	Tenants	Homeowners	Total
Sample Size	37	63	100
Mean*	9.2	9.0	9.0
*Don't know/Refused excluded from calculations			

S2. What was the most important reason you were not more satisfied with the service overall?

Key Reasons Not More Satisfied with EPI Overall**	2017	
	Tenants (#)	Homeowners (#)
Sample Size*	2	5
I expected more	1	5
I did not like the installer who visited the home	-	1
I did not notice any savings on my energy bill	1	-
Others	1	-
I don't like the light bulbs I received	-	-
Don't know/Refused	-	-
*Base: Respondents who were not satisfied with the service (as indicated by a rating of 'less than 8')		
**Multiple responses		

S3. What was the most important reason you were satisfied with the service overall?

Key Reasons Satisfied with EPI Overall**	2017		
	Tenants	Homeowners	Total
Sample Size*	35	58	92
I like the installer who visited the home	23%	28%	27%
Informative/Information received	17%	17%	17%
Good service	14%	16%	15%
Saves energy	6%	16%	15%
Lowered energy bill	23%	14%	14%
Better lights/lighting	11%	10%	10%
Products/services offered through service	3%	9%	8%
Reasonable time frame	3%	9%	8%
Everything went smooth	3%	3%	3%
Service met my expectations	6%	2%	2%
Service was free	6%	2%	2%
Others	-	5%	5%
Don't know	6%	2%	2%
*Base: Respondents who were satisfied with the service (as indicated by a rating of 'less than 8')			
**Multiple response			

S4. Using a scale from 1 to 10, where 1 means “not at all satisfied” and 10 means “completely satisfied”, please tell me how satisfied you are with your experience with each of the following aspects of the Efficient Product Installation Service.

Satisfaction with Aspects of EPI	2017					
	Tenants		Homeowners		Total	
	Sample Size	Mean*	Sample Size	Mean*	Sample Size	Mean*
The quality of the work completed	37	9.5	63	9.5	100	9.5
**The time required to complete work	33	9.6	57	9.5	90	9.5
Energy-efficient products installed	37	9.5	63	9.2	100	9.2
***The information you received about energy-efficient products	23	9.4	41	9.5	65	9.5
*Not applicable, Don't know/Don't recall and Refused excluded from calculations						
**Base: Respondents who were home during the installation						
***Base: Respondents who received information during the visit from the installer about energy-efficient products						

S5. Have you had any problems with the products installed in your home through the Efficient Product Installation Service?

Any Problems with Products Installed	2017		
	Tenants	Homeowners	Total
Sample Size	37	63	100
Yes	-	11%	11%
No	100%	89%	89%

S6. Which products led to problems?

Products That Led to Problems*	2017
	Homeowners
Sample Size**	11
Smart power strip	57%
LED bulbs	43%
Hot water tank wrap	14%
Showerhead	14%
*Multiple responses	
**Base: Respondents who had problems with products installed	

S7. What problems did you have with the products installed in your home?

Specific Problems With Products Installed	2017
	Homeowners
Sample Size*	11
Power strip kept turning TV off	29%
Lights flickered	29%
Bulb burnt out	14%
Issues with water flow	14%
Power strip doesn't turn everything on at once	14%
Others	29%
*Base: Respondents who had problems with products installed	

B1. Were there any energy efficiency products recommended through the Efficient Product Installation Service that you chose not to have installed in your home?

Products Recommended But Not Installed	2017		
	Tenants	Homeowners	Total
Sample Size*	33	57	90
Yes	15%	23%	22%
No	79%	72%	72%
Don't recall	6%	5%	5%
*Base: Respondents who were home during the installation			

B2. Which products did you choose not to have installed?

Products Chosen Not to be Installed	2017		
	Tenants (#)	Homeowners (#)	Total (%)
Sample Size*	5	13	20
Showerhead	1	5	38%
Light bulbs	-	4	30%
Hot water tank wrap	1	2	16%
Faucet aerator	2	1	9%
Others	-	1	7%
Don't know	1	-	1%
*Base: Respondents who had products recommended but chose not to install			

B3. Why did you choose not to have these products installed in your home?

Reasons for Not Installing Recommended Products*	2017		
	Tenants (#)	Homeowners (#)	Total (%)
Sample Size**	5	13	20
Don't like it/Like the one I have	-	4	30%
Already have one	-	4	30%
Difficult to install	2	2	16%
Product wasn't available	-	1	7%
Cost	-	1	7%
I rent/Don't own home	1	-	1%
Others	1	1	8%
Refused	1	-	1%
*Multiple responses			
**Base: Respondents who had products recommended but chose not to install			

B4. Now thinking generally about energy-efficient upgrades. There may be many reasons for not making energy-efficient upgrades to your home. How much of a barrier, if at all, are each of the following in preventing your household from making energy-efficiency upgrades? Please answer on a scale of 1 to 10, where 1 means 'not at all a barrier' and 10 means 'a major barrier'.

Barriers for Making Energy-efficiency Upgrades	2017					
	Tenants		Homeowners		Total	
	Sample Size	Mean*	Sample Size	Mean*	Sample Size	Mean*
Lack of money	35	4.1	63	5.5	100	5.5
Lack of time	36	2.6	62	2.2	98	2.2
Lack of information about energy efficiency products	36	2.4	62	2.6	98	2.6
Lack of interest	36	2.6	61	2.1	97	2.1
Not convinced of the energy savings	35	2.4	62	2.4	98	2.4
Not knowing how to get started, plan the upgrades, or do the work	34	2.9	63	3.2	100	3.2
*Don't know/Refused excluded from calculations						

R1. Do you have any recommendations that you think would help improve the Efficient Product Installation Service? Anything else?

Participant Suggestions to Improve EPI*	2017		
	Tenants	Homeowners	Total
Sample Size	37	63	100
Improve communication	3%	10%	9%
Offer more information on the products installed	-	8%	8%
Better advertising/more awareness of service	-	5%	5%
Offer more products to be installed	3%	3%	3%
Better/brighter light bulbs	-	2%	2%
Better train the installers/inform them of other services	-	2%	2%
Improve quality of work	3%	-	-
Others	5%	13%	12%
None/no recommendations	89%	60%	62%
Don't know/Refused	-	8%	8%
*Multiple responses			

R2. Which other energy-efficiency products would you like to have had installed through the Efficient Product Installation Service?

Energy-efficiency Products that Respondents Would Have Liked Installed*	2017		
	Tenants (#)	Homeowners (#)	Total (%)
Sample Size**	1	2	3
Power bars	-	1	48%
Solar panels	-	1	48%
Different light bulbs	1	-	4%
*Multiple responses			
**Base: Respondents who recommended more products to be installed			

- FR1. Did you or anyone in your household have specific plans to purchase and install LED bulbs prior to learning about the Efficient Product Installation Service?
- FR1a. I just want to make sure I understand - Before you learned about the Efficient Product Installation Service, you had already made the decision to purchase and install LED bulbs in your home?

Already Made Decision to Install LEDs Prior to EPI	2017		
	Tenants	Homeowners	Total
Sample Size*	31	49	78
Yes	35%	63%	62%
No	65%	37%	38%
Don't know/Refused	-	-	-
*Base: Respondents who had LED bulbs installed through EPI			

FR2. If Efficiency Nova Scotia had not installed these LED bulbs at no charge as part of the Efficient Product Installation Service, would you have paid the full cost of the LED bulbs, which is approximately \$6 per bulb?

Would Have Paid for Full LED Cost in Absence of EPI*	2017					
	Tenants		Homeowners		Total	
	Sample Size	Mean**	Sample Size	Mean**	Sample Size	Mean**
Would have paid full cost	31	5.2	49	5.6	78	5.6
*Base: Participants who had LED bulbs installed through EPI						
**Don't know/Prefer not to say excluded from calculations						

FR3 Now I would like to ask you to consider what actions you would have taken if the Efficient Product Installation Service had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely,” and a 10 indicating that it is “Very Likely.”

Actions Taken in Absence of EPI	2017					
	Tenants		Homeowners		Total	
	Sample Size**	Mean*	Sample Size**	Mean*	Sample Size**	Mean*
Taken the initiative to purchase LED bulbs at a store and then install them yourself in your home	31	4.4	49	6.3	78	6.2
Postponed replacing your bulbs with LEDs by at least one year***	14	5.6	37	5.4	58	5.4
Purchased and installed all [QUANTITY] LED bulbs that were installed through the Efficient Product Installation Service****	31	3.2	47	4.8	75	4.7
*Don't know/Prefer excluded from calculations **Base: Participants that had LED bulbs installed through EPI ***Base: Participants who gave rating of 5 or higher for FR3a ****Base: Participants that had a quantity of more than one LED bulb						

FR4. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to have LED bulbs installed in your home. Using a scale from 0 to 10 where 0 means “No influence” and 10 means “Great influence”, please rate the influence of each of the following in your decision to have the energy-efficient products installed in your home.

Influence of Factors on Decision to Have Products Installed	2017					
	Tenants		Homeowners		Total	
	Sample Size*	Mean**	Sample Size*	Mean**	Sample Size*	Mean*
The installation of energy-efficient products, at no charge, offered by the service	31	8.4	48	8.9	77	8.9
Information or advice provided by the service staff	28	6.1	48	6.1	76	6.1
*Base: Participants who had LED bulbs installed through EPI **Don't know/Refused/Not applicable excluded from calculations						

CI1. Before participating in the Efficient Product Installation Service in [DATE], had you at any time in the past already participated in another Efficiency Nova Scotia program or service?

Previous Participation in Another ENS Service	2017		
	Tenants	Homeowners	Total
Sample Size*	31	49	78
Yes	26%	24%	25%
No	68%	69%	69%
Don't know/Prefer not to say	6%	6%	6%

*Base: Respondents who had LED bulbs installed through EPI

CI2. For the following statement, please indicate whether you agree or disagree. Your previous participation in an Efficiency Nova Scotia program or service and what you learned by participating in this program greatly influenced your decision to have energy-efficient products installed in your home. Please use a scale of 0-10 where 0="COMPLETELY DISAGREE" and 10 ="COMPLETELY AGREE".

Previous Participation in an ENS Service Greatly Influenced Decision to Have Energy-efficient Products Installed	2017		
	Tenants	Homeowners	Total
Sample Size*	8	12	19
Mean**	8.5	7.9	7.9

*Base: Respondents who participated in another ENS service, and who had LED bulbs installed through EPI

**Don't know/Prefer not to say excluded from calculations

CI3. Before participating in the Efficient Product Installation Service in [DATE], had you at any time in the past already seen Efficiency Nova Scotia promotional materials advertising the benefits of energy efficiency?

Previously Seen Energy-efficiency Promotional Materials Distributed by ENS	2017		
	Tenants	Homeowners	Total
Sample Size*	31	49	78
Yes	65%	65%	65%
No	29%	31%	31%
Don't know	6%	4%	4%

*Base: Respondents who had LED bulbs installed through EPI

- CI4. For the following statement, please indicate whether you agree or disagree. The energy efficiency promotional materials distributed by Efficiency Nova Scotia greatly influenced your decision to have energy-efficient products installed in your home. Please use a scale of 0-10 where 0=“COMPLETELY DISAGREE” and 10 =“COMPLETELY AGREE”.

Previously Seen ENS Energy-efficiency Promotional Materials Greatly Influenced Decision to Have Energy-efficient Products Installed	2017		
	Tenants	Homeowners	Total
Sample Size*	19	32	51
Mean**	8.8	8.3	8.3
*Base: Respondents who previously saw ENS energy-efficiency promotional materials, and who had LED bulbs installed through EPI **Don't know/Prefer not to say excluded from calculations			

- SO1. Now I'd like you to think of the time since you participated in the Efficient Product Installation Service. Have you installed any additional energy-efficient products or retired any old appliances on your own?
- SO2. I just want to make sure I understand - After you participated in the Efficient Product Installation Service, you installed additional energy-efficient products or retired old appliances on your own. Is that correct?

Installed Additional Products or Retired Appliances After Participation	2017		
	Tenants	Homeowners	Total
Sample Size	37	63	100
Yes	24%	33%	33%
No	73%	67%	67%
Don't know/Don't recall	3%	-	-

- SO3. Have you received financing or rebates from any other Efficiency Nova Scotia programs for these additional energy-efficient products or appliances retired?

Received Other Financing/Rebates	2017		
	Tenants (#)	Homeowners (%)	Total (%)
Sample Size*	9	21	33
Yes, for all products or appliances	-	5%	5%
Yes, for some of the products or appliances	-	24%	23%
No	9	71%	72%
Don't know	-	-	-
*Base: Respondents who installed additional products or retired appliances after participating in EPI			

SO4a. Now, I will specifically talk about the additional actions you took on your own after participating in the Efficient Product Installation Service.

What, if any, additional energy-efficient products have you installed on your own after participating in the Efficient Product Installation Service? Any others?

Other Products Installed After Participating**	2017		
	Tenants (#)	Homeowners (%)	Total (%)
Sample Size*	9	20	31
ENERGY STAR refrigerator	1	25%	20%
Heat pump	-	15%	14%
ENERGY STAR clothes washer	2	10%	10%
Stove	-	10%	10%
Clothes dryer	2	10%	10%
Hot water heater	-	10%	10%
Kitchen range hood fan	-	10%	10%
LED bulbs	2	5%	6%
Dishwasher	1	5%	5%
Microwave	1	5%	5%
Energy-efficient heating system/heater	-	5%	5%
Programmable thermostats	-	5%	5%
Freezer	1	-	-
Smart power strip/smart power bars	1	-	-
Dehumidifier	1	-	-
Others	2	10%	10%
None	-	20%	19%
Don't know	-	-	-
*Base: Respondents who installed additional products or retired appliances after participating in EPI and did not receive financing or rebates from other ENS services **Multiple responses			

SO4b. How many [INSERT RESPONSE IN SO4a FOR ALL SO4a RESPONSES, EXCEPT SAY feet of pipe insulation IF CODE 4] have you purchased and installed on your own?

SO4c. Did you receive an instant rebate at the cashier on the [INSERT ANSWER FROM SO4a] you purchased?

Other Products Installed After Participating	2017			
	Total			
	Sample Size*	Mean Number Purchased and Installed	Sample Size	Received an Instant Rebate (% saying yes)
LED bulbs	2	9.1	2	-
ENERGY STAR refrigerator	5	1.0	6	2%
ENERGY STAR clothes washer	3	1.0	3	-
Programmable thermostats	2	1.0	2	-
Dehumidifier	0**	1.0	0	-
Kitchen range hood fan	3	1.0	3	-
*Base: Respondents who installed products after participating in EPI and did not receive financing or rebates from other ENS services				
**Weighted sample size is zero, however unweighted sample size is 1 respondent.				

SO4d. What appliances, if any, have you retired on your own, that is, outside of a rebate or other assistance from a program, after participating in the Efficient Product Installation Service?

Appliances Retired Outside of a Rebate or Assistance from Other Service, after Participating in EPI**	2017		
	Tenants (#)	Homeowners (%)	Total (%)
Sample Size*	9	20	31
Stove	-	25%	24%
Refrigerator	1	20%	20%
Laundry machine/washer/dryer	1	15%	15%
Microwave	-	15%	14%
Freezers	1	10%	10%
Dishwasher	1	-	-
Dehumidifier	1	-	-
Others	1	20%	20%
None	5	35%	36%
*Base: Respondents who installed additional products or retired appliances after participating in EPI and did not receive financing or rebates from other ENS services			
**Multiple Responses			

SO4e. How many [INSERT RESPONSE IN SO4d] have you retired on your own?

Number of Appliances Retired Outside of a Rebate or Assistance from Other Service, after Participating in EPI	2017	
	Total	
	Sample Size*	Mean**
Refrigerators	6	1.0
Freezers	3	1.0
Dehumidifiers	0***	2.0
*Base: Respondents who installed additional products or retired appliances after participating in EPI and did not receive financing or rebates from other ENS services **Don't know/Refused excluded from calculations ***Weighted sample size is zero, however unweighted sample size is 1 respondent.		

SO5. How influential was your experience with the Efficient Product Installation Service on your decision to install these additional energy-efficient products or retire these appliances on your own? Please, give your answer on a scale of 0 to 10, where 0 indicates that the Efficient Product Installation Service “had no influence at all on your decision” and 10 indicates that the service was “extremely influential to your decision.”

Influence of EPI on Decision to Install Other Products	2017					
	Tenants		Homeowners		Total	
	Sample Size*	Mean**	Sample Size*	Mean**	Sample Size**	Mean
Influence EPI had on decision to install energy-efficient products or retire products after participating in EPI	8	5.8	20	5.5	31	5.5
*Base: Respondents who installed additional products or retired appliances after participating in EPI and did not receive financing or rebates from other ENS services **Don't know/Refused excluded from calculations						

D1. What type of residence do you live in?

Type of Home	2017		
	Tenants	Homeowners	Total
Sample Size	37	63	100
Detached single-family home	14%	87%	84%
Semi-detached house	8%	5%	5%
Mobile home or house trailer	-	5%	5%
Row house/single story apartment building	5%	2%	2%
Apartment building that has fewer than five stories	43%	-	2%
Apartment building that has five or more stories	-	2%	2%
Townhouse or duplex which shares adjacent walls	27%	-	1%

D2. How many bedrooms are in your home?

Number of Bedrooms	2017		
	Tenants	Homeowners	Total
Sample Size	37	63	100
1	8%	2%	2%
2	62%	19%	21%
3	16%	46%	45%
4 or more	11%	33%	32%
Don't know	3%	-	-

D3. How many showers are in your home?

Number of Showers	2017		
	Tenants	Homeowners	Total
Sample Size	37	63	100
0	-	2%	2%
1	54%	60%	60%
2	41%	32%	32%
3	-	6%	6%
4 or more	-	-	-
Don't know	5%	-	-

D4. Do you own or rent this home?

Home Ownership	2017		
	Tenants	Homeowners	Total
Sample Size	37	63	100
Own/Buying	3%	90%	87%
Rent/lease	92%	10%	13%
Others	3%	-	-
Refused	3%	-	-

D5. Do you pay the electric bills for your home?

You Pay Electricity Bills	2017		
	Tenants	Homeowners	Total
Sample Size	37	63	100
Yes	76%	98%	97%
No	14%	2%	2%
Others	5%	-	-
Don't know/Refused	5%	-	-

D6. Including yourself, how many people live in this residence on a full-time basis?

People in Household	2017		
	Tenants	Homeowners	Total
Sample Size	37	63	100
1	30%	6%	7%
2	54%	65%	65%
3	5%	14%	14%
4+	5%	14%	14%
Refused	5%	-	-

D7. What is your age group?

Age of Respondent	2017		
	Tenants	Homeowners	Total
Sample Size	37	63	100
18 to 24	-	2%	2%
25 to 34	5%	10%	9%
35 to 44	5%	11%	11%
45 to 54	11%	19%	19%
55 to 64	14%	29%	28%
65 or over	59%	30%	31%
Refused	5%	-	-

D8. What is the highest grade of schooling completed by the head of your household?

Level of Education	2017		
	Tenants	Homeowners	Total
Sample Size	37	63	100
Less than high school graduation diploma	11%	6%	7%
High school graduate diploma and/or some post-secondary education	41%	33%	34%
Trades certificate/diploma	5%	6%	6%
College certificate/diploma	16%	21%	20%
University degree/certificate/diploma	16%	33%	33%
Others	3%	-	-
Don't know/Refused	8%	-	-

D9. Which of the following income categories best describes your total annual household income before taxes in 2016?

Household Income	2017		
	Tenants	Homeowners	Total
Sample Size	37	63	100
Less than \$15,000	-	-	-
\$15,000 - \$24,999	16%	5%	5%
\$25,000 - \$34,999	19%	5%	5%
\$35,000 - \$49,999	22%	14%	15%
\$50,000 - \$69,999	14%	22%	22%
\$70,000 - \$79,999	5%	6%	6%
\$80,000 or more	3%	21%	20%
Don't know/Refused	22%	27%	27%

D9. Gender?

Gender	2017		
	Tenants	Homeowners	Total
Sample Size	37	63	100
Male	41%	43%	43%
Female	59%	57%	57%

Appendix XVIII

EPI: ON-SITE VISIT SAMPLING METHODOLOGY AND PROTOCOL

Sampling Methodology

For the 2017 EPI impact evaluation, 110 on-site visits were conducted with participants. Four sampling plans that respectively involved 25 (spring), 50 (summer), 25 (fall), and 10 (fall) sampled participants were developed between March and November 2017 using the most up-to-date tracking data available. The samples selected included EPI participants from January through September 2017.

The first three sampling plans (25 in spring, 50 in summer and 25 in fall) were focused on including a representative number of participants served by every delivery agent (DA) and a representative mix of low-income and non-low-income participants who met the product installation criteria. The criteria for selecting the participants were that at least 10 LEDs were installed (only applied to the first sample in spring) and at least three different types of measures were installed (applied to all three samples). To establish an installation rate with an acceptable margin of error, 55 participants who received smart power controllers were included in the sample.

In the fall, 10 additional visits were made to those participants whose smart power controllers were installed by a particular DA as a result of a recurrent installation problem caused by this particular DA.

On-site Visit Protocol

The on-site visits were conducted to verify the number of products installed and recorded in the tracking system. The on-site observation protocol has been developed to serve two main purposes: (1) to establish the installation rates of the products, and (2) to determine whether any products had been removed, and, if any, the reasons for their removal. The Evaluator then validated the assumptions used to calculate each product type's unitary savings value by collecting the following types of information during the visits:

- › the types of lamps replaced and their respective wattages;
- › the locations of the new lamps (indoors or outdoors);
- › the domestic hot water (DHW) heating source and the tank size;
- › the number of faucets and showerheads in a home;
- › the faucet aerator locations and their respective flow rates; and
- › the number and types of appliances plugged into the smart power controller.

The Evaluator also collected information about the space-heating source and the use of an air-conditioner. This information was useful for determining the impact of the installed lighting measures' interactive effects.

On-site Visit Data Collection Form**1 General Information**

Date of Visit:	_____
Tracking Number:	_____
Delivery Agent ID:	_____
Address:	_____
Contact Name:	_____
Telephone:	_____
Owner or Tenant:	_____
Landlord Name:	_____
Landlord Telephone:	_____
Type of Dwelling:	_____
Rate Code:	_____
Main Heat Type:	_____
DHW Heat Type:	_____
AC Used in Home	Yes ☐ No ☐

2 Product Installation Information

Lighting Products

(Based on on-site observations and the contact's statement)

Product	Quantity in Tracking Sheet	Quantity On Site	Explanation, If Different	Wattage of Existing Product	Indoors or Outdoors
9 W LED					
9.5 W LED					
10 W LED					
10.5 W LED					
11 W LED					
18 W LED					
7 W GU10 LED					
G25 LED					
E12 LED Chandelier					
LED Nightlight					

Notes:

Domestic Hot Water (DHW) Related Products

(Based on on-site observations and the contact's declaration)

Product	Quantity in Tracking Sheet	Quantity On Site	Explanation, If Different	Tank Size (Gal.) or Flow Rate
Hot Water Tank Wrap				
Pipe Insulation				
Kitchen Faucet Aerators				
Bathroom Faucet Aerators				
Low-flow Showerheads				

Notes:

Smart Power Controllers

(Based on on-site observations and the contact's declaration):

Product	Quantity in Tracking Sheet	Quantity On Site	Quantity of AV Equipment Plugged In	Quantity of Home Office Equipment Plugged In	Changes since Installation
Embertec					

Notes:

Appendix XIX

EPI: DETAILED CALCULATIONS OF UNITARY SAVINGS VALUES

This appendix presents the detailed calculations and assumptions used to establish the revised unitary savings.

LED Lamps

Table 3 lists the parameters and their values used in Equation 1 below for LED lamps installed through EPI in 2017 and the resulting unitary savings values for each pairing of the base and the new lamp wattages. The parameters are identical for single-family homes and apartments.

$$\text{Annual Unitary Savings} \left[\frac{\text{kWh}}{\text{yr}} \right] = \frac{(\text{Old Wattage} - \text{New Wattage})[\text{W}] \times \text{HOU} \left[\frac{\text{h}}{\text{day}} \right] \times 365 \left[\frac{\text{day}}{\text{yr}} \right]}{1000 \left[\frac{\text{W}}{\text{kW}} \right]} \quad (1)$$

Table 3: Revised Unitary Savings Values by LED Category

Type of LED	Old Wattage (W)	New Wattage (W)	Displaced Wattage (W)	Operating Hours (hrs/day)	Unitary Savings Value for Single-family Homes (kWh/year)	Unitary Savings Value for Apartments (kWh/year)
9 W replacing 40 W	40	9	31	2.7	30.6	30.6
9 W replacing 60 W	60	9	51	2.7	50.3	50.3
9 W replacing 100 W	100	9	91	2.7	89.7	89.7
9.5 W replacing 40 W	40	9.5	30.5	2.7	30.1	30.1
9.5 W replacing 60 W	60	9.5	50.5	2.7	49.8	49.8
9.5 W replacing 100 W	100	9.5	90.5	2.7	89.2	89.2
11 W replacing 60 W	60	11	49	2.7	48.3	48.3
18 W replacing 75 W	75	18	57	2.7	56.2	56.2
18 W replacing 100 W	100	18	82	2.7	80.8	80.8
7 W GU10 replacing 35 W	35	7	28	2.7	27.6	27.6
7 W GU10 replacing 50 W	50	7	43	2.7	42.4	42.4
7 W G25	40	7	33	2.7	32.5	32.5
5 W Chandelier E12	40	5	35	2.7	34.5	34.5

LED Nightlights

Table 4 below lists the parameters and their values applied in Equation 1 for LED nightlights installed through EPI in 2017 and the resulting unitary savings values.

Table 4: Revised Unitary Savings Values for LED Nightlights

Parameter	Value for Single-family Homes	Value for Apartments
Old Wattage [W]	7	7
New Wattage [W]	0.5	0.5
Average Displaced Wattage [W]	6.5	6.5
Hours of Operation [hrs/day]	12	12
Unitary Savings [kWh/year]	28.5	28.5

LED Holiday Lights

Table 5 below lists the parameters and their values applied to calculate the unitary savings value for LED holiday lights installed through EPI in 2017.

Table 5: Revised Unitary Savings Values for LED Holiday Lights

Parameter	Value	Source
Proportion of Old Large Incandescent Sets Returned (35 lamps per set)	37 %	Tracking Report
Proportion of Old Mini Incandescent Sets Returned (50 lamps per set)	32 %	Tracking Report
Proportion of Old Mini Incandescent Sets Returned (20 lamps per set)	31 %	Tracking Report
Wattage of Old Large Incandescent Sets (35 lamps per set)	$7 \text{ W/lamp} \times 35 \text{ lamps/set} = 245 \text{ W/set}$	Literature
Wattage of Old Mini Incandescent Sets (50 lamps per set)	$0.4 \text{ W/lamp} \times 50 \text{ lamps/set} = 20 \text{ W/set}$	Literature
Wattage of Old Mini Incandescent Sets (20 lamps per set)	$0.4 \text{ W/lamp} \times 20 \text{ lamps/set} = 8 \text{ W/set}$	Literature
Average Old Wattage (incandescent sets)	$(37\% \times 245 \text{ W}) + (32\% \times 20 \text{ W}) + (31\% \times 8 \text{ W}) = 99.6 \text{ W/set}$	Calculation
Wattage of New LED Sets (70 lamps per set)	$0.08 \text{ W/lamp} \times 70 \text{ lamps/set} = 5.6 \text{ W/set}$	ENS
Displaced Wattage (per exchange)	$(99.6 \text{ W} - 5.6 \text{ W}) = 94.0 \text{ W}$	Calculation
Annual Hours of Operation	$5.8 \text{ h/day} \times 40 \text{ days/yr} = 232 \text{ h/year}$	Literature and 2013 participant survey
Number of new LED sets used to replace the 2 old sets returned	2	Tracking report
Unitary Energy Savings Value (per exchange)	$2 \text{ sets} \times 94.0 \text{ W} \times 232 \text{ h/yr} = 43.6 \text{ kWh/year}$	Calculation

Faucet Aerators

The following equations are used to calculate the annual unitary savings value for the faucet aerators installed through EPI.

$$\begin{aligned} & \text{Annual Unitary Savings} \left[\frac{kWh}{yr} \right] \\ &= \frac{(DHW_{base} - DHW_{efficient}) \left[\frac{gal}{day} \right] \times Cp_{H_2O} \left[\frac{BTU}{lb^{\circ}F} \right] \times \rho_{H_2O} \left[\frac{lb}{ft^3} \right] \times \Delta T_{H_2O} [^{\circ}F] \times 365 \left[\frac{days}{yr} \right] \times \frac{1}{3412} \left[\frac{kWh}{BTU} \right] \times 0.1337 \left[\frac{ft^3}{gal} \right]}{\eta} \end{aligned} \quad (2)$$

The base domestic hot water consumption value (DHW_{base}) is calculated by dividing the product of the consumption of domestic hot water per person (DHW_{person}) and the number of people per single-family home or apartment (n_{people}) by the number of faucets per single-family home or apartment ($n_{faucets}$), as shown in the following equation:

$$DHW_{base} \left[\frac{gal}{day} \right] = \frac{DHW_{person} \left[\frac{gal}{day \cdot person} \right] \times n_{people} [person]}{n_{faucets}} \quad (3)$$

The efficient domestic hot water consumption value ($DHW_{efficient}$) is calculated by applying the baseline flow rate (q_{base}), the low-flow rate (q_{low}) and the base domestic hot water consumption value, as shown in the following equation:

$$DHW_{efficient} \left[\frac{gal}{day} \right] = DHW_{base} \left[\frac{gal}{day} \right] \times \left(1 - \frac{q_{base} - q_{low}}{q_{base}} \right) \quad (4)$$

Table 6 below lists the parameters and values applied in Equations (2), (3) and (4) for faucet aerators installed through EPI in 2017 and the resulting unitary savings values.

Table 6: Revised Unitary Savings Values for Low-flow Faucet Aerators

Parameter	Symbol	Value for Single-family Homes	Value for Apartments	Source
Baseline Flow Rate [gpm]	q_{base}	1.2	1.2	2003 Aquacraft Study ²
Low-flow Rate [gpm]	q_{low}	0.94	0.94	2003 Aquacraft Study ³
Number of People per Household [person]	n_{people}	2.4	1.4	EPI 2017 October Tracking Report
DHW Used per Person for Total Number of Faucets [gpd]	DHW_{person}	8.6	8.6	CBEEDAC ⁴
Number of Faucets per Household	$n_{faucets}$	3.3	2	Single-family homes: EPI 2017 site visits. Apartments: assumption.
Specific Heat of Water [Btu/lb°F]	C_{pH_2O}	1	1	Convention
Density of Water [lb/ft ³]	ρ_{H_2O}	62.43	62.43	Convention
Temperature Rise in Electric Water Heater [°F]	ΔT_{H_2O}	79	79	2011 OPA
Electric Water Heater Efficiency	η	97%	97%	Pennsylvania TRM ⁵
Unitary Savings [kWh/year]	-	98	95	Calculation

Low-flow Showerheads

The equation below is used to determine the annual unitary savings values for the low-flow showerheads installed through EPI. The difference between the base and the efficient domestic hot water consumption levels is established by applying the following parameters: the baseline flow rate (q_{base}), the low-flow rate (q_{low}), the number of people per household (n_{people}), the percentage of hot water used in showers ($\%_{DHW}$), the showering time (t_{shower}), the number of showers per day per person (n_{shower}) and the number of showers in the household ($n_{showerheads}$).

$$\begin{aligned}
 & \text{Reduction in DHW consumption } (DHW_{base} - DHW_{efficient}) \left[\frac{gal}{day} \right] \\
 &= (q_{base} - q_{low}) [gpm] \times n_{people} [person] \times \%_{DHW} \times t_{shower} \left[\frac{min}{shower} \right] \times n_{shower} \left[\frac{shower}{day \cdot person} \right] \quad (5) \\
 &\times \frac{1}{n_{showerheads}}
 \end{aligned}$$

² Aquacraft, Inc. Water Engineering and Management, *Residential Indoor Water Conservation Study*, July 2003.

³ *Ibid.*

⁴ Canadian Building Energy End-Use Data & Analysis Centre, *Domestic Water Heating and Water Heater Energy Consumption in Canada*, April 2005, page 29.

⁵ Pennsylvania Public Utility Commission, *Technical Reference Manual*, State of Pennsylvania, June 2013, page 174.

Table 7 below lists the parameters and their values applied in Equation (5) for low-flow showerheads installed through EPI in 2017 and the resulting unitary savings values.

Table 7: Revised Unitary Savings Values for Low-flow Showerheads⁶

Parameter	Symbol	Value for Single-family Homes	Value for Apartments	Source
Baseline Flow Rate [gpm]	Q_{base}	Variable (2.0 gpm, 2.25 gpm or 2.5 gpm)	Variable (2.0 gpm, 2.25 gpm or 2.5 gpm)	Tracking sheet
Low-flow Rate [gpm]	Q_{low}	1.5	1.5	On-site visits
Number of People per Household [person]	n_{people}	2.4	1.4	EPI 2017 October Tracking Sheet
Average Number of Showers per Day per Person [shower/day/person]	n_{shower}	0.67	0.67	Mayer and Oreo ⁷
Number of Showerheads per Household [showers]	$n_{showerheads}$	1.5	1	Single-family homes: EPI 2017 site visits. Apartments: assumption.
Average Shower Time per Person [min/shower]	t_{shower}	8.3	8.3	Mayer and Oreo ⁸
Percentage of Hot Water Used in Showers	$\%_{DHW}$	73%	73%	CBEEEDAC ⁹
Specific Heat of Water [Btu/lb°F]	C_{pH_2O}	1	1	Convention
Density of Water [lb/ft ³]	ρ_{H_2O}	62.43	62.43	Convention
Temperature Rise in Electric Water Heater [°F]	ΔT_{H_2O}	79	79	2011 OPA
Electric Water Heater Efficiency	η	97%	97%	Pennsylvania Public Utility Commission TRM ¹⁰
Unitary Savings [kWh/year]	Flow rate reduction of 0.5 gpm	236	207	
	Flow rate reduction of 0.75 gpm	354	310	
	Flow rate reduction of 1 gpm	472	413	

⁶ Pennsylvania Public Utility Commission, *Technical Reference Manual*, State of Pennsylvania, June 2013, pp. 45 – 48.

⁷ Mayer, P. W., W. B. Oreo et al., *Residential End Uses of Water*, published by the AWWA Research Foundation, 1999, pp. 99-102.

⁸ *Ibid.*

⁹ Canadian Building Energy End-Use Data & Analysis Centre, *Domestic Water Heating and Water Heater Energy Consumption in Canada*, April 2005, p. 29.

¹⁰ Pennsylvania Public Utility Commission, *Technical Reference Manual*, State of Pennsylvania, June 2013, p. 174.

Pipe Insulation

The annual unitary savings value for the pipe insulation installed through EPI in single-family homes and apartments has been found among the OPA's 2011¹¹ values and amounts to 12.7 kWh for each linear foot unit.

Hot Water Tank Wrap

The following equations are used to determine the annual unitary savings associated with the hot water tank wrap installed through EPI. The energy savings are equal to the difference in heat losses associated with the tank's circumference before (Q_{tank}) and after the addition of the tank wrap ($Q_{\text{tank+RSI 1.21}}$). The heat losses are calculated using the following formulas of heat transfer in an insulated cylinder:

$$R_{\text{layer}} = \frac{\ln(r_e/r_i)}{2\pi k} \quad (6)$$

$$R_{\text{cyl}} = R_{\text{layer1}} + R_{\text{layer2}} \quad (7)$$

$$Q_{\text{cyl}} = \frac{T_i - T_e}{R_{\text{cyl}}} L \quad (8)$$

$$Q_{\text{top}} = \frac{A_{\text{top}} \times (T_i - T_e)}{R_{\text{top}}} \quad (9)$$

$$Q_{\text{total}} = Q_{\text{cyl}} + Q_{\text{top}} \quad (10)$$

$$\text{Annual energy consumption} = \frac{(Q_{\text{total}}) \cdot \text{HOU}}{\eta_{\text{heater}}} \quad (11)$$

¹¹ Ontario Power Authority (OPA), *OPA Prescriptive Measures and Assumptions List*, December 2010.

Where:

R_{layer} : thermal resistance of a layer of material in the cylinder (e.g., insulation inside the tank, and tank wrap) [$\text{m} \cdot ^\circ\text{C}/\text{W}$]

r_e : external radius of the layer [m]

r_i : internal radius of the layer [m]

k : thermal conductivity of the layer [$\text{W}/\text{m} \cdot ^\circ\text{C}$]

R_{cyl} : overall thermal resistance of the cylinder [$\text{m} \cdot ^\circ\text{C}/\text{W}$]

Q_{cyl} : heat transfer through the cylinder [W]

T_i : temperature at the internal radius of the cylinder

T_e : temperature at the external radius of the cylinder

L : length of the cylinder [m]

Q_{top} : heat transfer through the top of the tank [W]

A_{top} : area of the top of the tank [m^2]

R_{top} : thermal resistance of the top of the tank [$\text{m} \cdot ^\circ\text{C}/\text{W}$]

HOU: hours of use

η_{heater} : thermal efficiency of the heating element

The typical tank is an entry-level domestic water heater with a capacity of 60 imperial gallons. This tank capacity was established based on the on-site visits conducted by the Evaluator; the majority of participants visited had a tank of this capacity.

The following table lists the values applied in Equations (6), (7), (8), (9), (10) and (11) shown above to obtain the unitary savings for the tank wraps installed in 2017.

Table 8: Revised Unitary Savings Values for Hot Water Tank Wraps

Parameter	Symbol	Value for Single-family Homes	Value for Apartments	Source
Layer 1: Interior Insulation of Tank				
External Radius of the Layer [m]	r_e	0.300	0.280	Giant ¹²
Internal Radius of the Layer [m]	r_i	0.249	0.229	Idem
Thermal Conductivity of the Layer [W/m·°C]	k	0.024	0.024	Idem
Thermal Resistance of a Layer of Material in the Cylinder (e.g., insulation inside the tank, and tank wrap) [m·°C/W]	R_{layer}	1.228	1.333	Calculation
Thermal Resistance of the Top of the Tank [m·°C/W]	R_{Top}	2.113	2.113	Giant
Layer 2: Tank Wrap				
External Radius of the Layer [m]	r_e	0.351	0.331	Estimated from Frost King Insulation Blanket specifications ¹³
Internal Radius of the Layer [m]	r_i	0.300	0.280	Giant
Thermal Conductivity of the Layer [W/m·°C]	k	0.042	0.042	Estimated from Frost King Insulation Blanket specification
Thermal Resistance of a Layer of Material inside the Cylinder (e.g., insulation inside the tank, and tank wrap) [m·°C/W]	R_{layer}	1.821	1.967	Calculation
Thermal Resistance of the Top of the Tank [m·°C/W]	R_{Top}	3.323	3.323	Calculation
Heat Transfer				
Length of the Cylinder [m]	L	1.52	1.22	Giant
Area of the Top of the Tank [m ²]	A_{top}	0.283	0.246	Calculated from Giant's data
Temperature at the External Radius of the Cylinder [°C]	T_e	21	21	Assumption for standard ambient temperature indoors

¹² Giant Inc., *Engineering Submittal Data Sheet 172ETE Models*, <<http://www.giantinc.com/tech-data/FT-172E-An.pdf>> (Last accessed February 18, 2015).

¹³ Frost King Weatherization Products, *Water Heater Insulation Blanket*, <<http://www.frostking.com/water-heater-insulation-blanket/>> (Last accessed January 4, 2014)

Parameter	Symbol	Value for Single-family Homes	Value for Apartments	Source
Temperature at the Internal Radius of the Cylinder [°C]	T_i	60	60	OPA Prescriptive Measures and Assumptions 2011
Hours of Use [h/year]	HOU	8,760	8,760	Assumption
Thermal Efficiency of Heating Element	η_{heater}	97%	97%	Pennsylvania Public Utility Commission ¹⁴
Heat Transfer through the Tank [W]	Q_{tank}	53.5	40.2	Calculation
Heat Transfer through the Insulated tank [W]	Q_{tank}	35.9	27.1	Calculation
Unitary Savings for Tank Wrap [kWh/year]	-	159	118	Calculation

Smart Power Controller for Audiovisual Equipment

The unitary savings value associated with the use of a smart power controller has been established at 411 kWh per year based on a study of 15 South African households.¹⁵

¹⁴ Pennsylvania Public Utility Commission, *Technical Reference Manual*, State of Pennsylvania, June 2013, p. 174.

¹⁵ Karebo Systems, *Audiovisual Standby Power Controller: Energy Savings Field Trial, South Africa - June-August 2012*, Field trial data analysis, March 6, 2013.

Appendix XX

EPI: RESIDENTIAL LIGHTING METERING STUDY REPORT

RESIDENTIAL LIGHTING METERING STUDY

EFFICIENCY NOVA SCOTIA

Final Report

December 14, 2017



ECONOLER

ABBREVIATIONS

EPI	Efficient Product Installation
HOU	Hours of use
LED	Light-emitting diode
RDI	Residential Direct Install
UMP	Uniform Methods Project

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EXECUTIVE SUMMARY

Econoler was commissioned by Efficiency Nova Scotia (ENS) to conduct a metering study of LED lamps' usage patterns to improve the accuracy of the energy and peak demand savings calculations for residential lighting measures.

Specifically, the study's main objective was to estimate the average daily hours of use (HOU) of LED lamps and their coincidence with the peak demand period of the electricity grid in Nova Scotia. To do so, a sample of participants was selected from the Residential Direct Installation (RDI) and Efficient Product Installation (EPI) program components. The study's purpose within the broader evaluation process is to inform the accuracy of energy and peak demand savings estimation for the residential lighting measures in the ENS portfolio.

This study was conducted with a sample of participants selected from RDI and EPI. The methodology was developed and implemented based on the main principles laid out in the Uniform Methods Project's (UMP) Residential Lighting Evaluation Protocol and the best practices established by past metering studies of other jurisdictions. Data collection devices were installed in 75 households, each for an average duration of three months, from September 2016 to August 2017.

Data cleaning was necessary to eliminate possibly erroneous data that could skew the results. The Evaluator paid close attention to device installation and retrieval issues, corrupted data files and potential outliers. This process resulted in 434 of the 526 installed devices being kept for the result analysis.

The UMP chapter on residential lighting evaluation recommends annualizing the metering data to capture the effect of the number of daylight hours on HOU. The most widely used method in past metering studies is sinusoidal modelling. The Evaluator attempted to use this method. However, the model proved unsuccessful in establishing a variation between daylight hours and HOU. Therefore, a simple mean approach was used to establish the average daily HOU of each data collection device. Because the three metering periods were staggered and covered almost an entire year (mid-September 2016 to mid-August 2017), the average daylight hours during the metering periods was almost identical to the number of daylight hours at the equinox. This suggests that the data obtained is representative of usage over the entire year.

The households' number of sockets capable of using LEDs was counted during the installation visit and used to weigh the average daily HOU per room type. Overall, the average hours of use of LED lamps was found to be 2.48 hours. Table below shows the daily HOU results by room type.

Table 1: Results Summary for Daily HOU

Room Type	Weight	Average HOU	Relative Margin of Error	Range of Possible Values for HOU	
				Minimum	Maximum
Basement	12%	1.54	68%	0.49	2.59
Kitchen	12%	4.45	19%	3.62	5.27
Living Room/TV Room/Play Room	13%	3.99	16%	3.36	4.63
Bathroom	13%	2.07	18%	1.69	2.45
Hallway/Staircase	10%	1.47	37%	0.93	2.01
Bedroom	20%	1.75	18%	1.44	2.06
Dining Room	6%	3.96	29%	2.82	5.10
Closet/Storage Area/Walk-in	4%	0.54	58%	0.23	0.86
Other	10%	2.14	23%	1.65	2.63
Weighted Overall HOU	100%	2.48	9%	2.37	2.84

To properly translate LEDs' HOU values into peak demand savings, the Evaluator analyzed the HOU values specifically occurring during the peak demand period. These HOU values were converted into a peak-demand-to-energy ratio (PDER) for each data collection device. This ratio multiplied by the annual energy savings value yields the peak demand savings value. Overall, 257 data collection devices' data were used in this analysis; all these devices had metered at least 10 days between December 1, 2016 and February 28, 2017. The average PDER thus established is 0.161 W/kWh, which is much lower than the value of 0.249 W/kWh currently applied by ENS to residential lighting measures. Table below shows the PDER results by room type.

Table 2: Peak-demand-to-energy Ratios by Room Type

Room Type	Average PDER (W/kWh)	Number of Data Collection Devices	Room Type Weight	Margin of Error	Relative Error
Basement	0.204	18	12%	0.083	41%
Bathroom	0.104	40	13%	0.024	23%
Bedroom	0.128	49	20%	0.044	34%
Closet/Storage Area/Walk-in	0.155	4	4%	0.100	65%
Dining Room	0.138	16	6%	0.051	37%
Hallway/Staircase	0.183	33	10%	0.049	27%
Kitchen	0.204	37	12%	0.039	19%
Living Room/TV Room/Play Room	0.173	33	13%	0.044	25%
Other	0.171	27	10%	0.054	32%
Weighted Average	0.161	257	100%	0.016	10%

In conclusion, the daily HOU value of 2.48 hours/day established is comparable to the value of 2.7 hours/day previously applied to LED lamps installed through EPI. This latter value was taken from a large metering study conducted by the NMR Group, the Northeast Residential Lighting Hours-of-Use Study. Considering that this Northeast study was conducted with a much larger sample involving both indoor and outdoor lamps and that its average HOU value is within the present study's margin of error, the Evaluator recommends continuing using this HOU value of 2.7 hours/day.

Based on the results of this metering study, the average PDER value has been established at 0.161 W/kWh $\pm$ 0.016 W/kWh, thus indicating that the PDER (0.249 W/kWh) previously applied to residential lighting measures was overestimated. The Evaluator recommends applying this new value (0.161 W/kWh $\pm$ 0.016 W/kWh) to lamps installed indoors. As for lamps installed outdoors, which were not included in the sample, a value of 0.228 W/kWh can be applied, which has been estimated based on typical usage during winter nights.

INTRODUCTION

Light-emitting diode (LED) lamps are the technology that provides the most energy savings in Efficiency Nova Scotia's (ENS's) residential programs. In the past, metering data collected in other jurisdictions was used to estimate energy savings of LED lamps in Nova Scotia. Considering the high proportion of ENS energy savings associated with this technology, and that the Uniform Methods Project (UMP) chapter on residential lighting evaluation¹⁶ favors collecting primary data through metering studies to establish annual operating hours, Econoler was commissioned by ENS to conduct a metering study of LED lamps.

The study's main objective is to estimate the average daily hours of use (HOU) of residential LED lamps installed in Nova Scotia and their coincidence with the peak demand period of the electricity grid. To do so, a sample of participants was selected from the Residential Direct Install (RDI) and Efficient Product Installation (EPI) program components. The results of this study are expected to help improve the accuracy of energy and peak demand savings estimation in the EPI and Instant Savings program components, as well as for Codes & Standards.

To carry out this assignment, Econoler collaborated with Equilibrium Engineering. Econoler was in charge of developing the methodology, conducting the analysis and preparing the final report. Equilibrium Engineering conducted the on-site visits to install and retrieve the data collection devices and assisted with data treatment. Throughout this report, this team is referred to as the Evaluator.

This metering study methodology was developed and implemented based on the main principles of the Residential Lighting Evaluation Protocol of the UMP and the best practices of past metering studies conducted in other jurisdictions. This report details the methodology employed, the analyses performed and the resulting HOU values and peak-demand-to-energy ratios obtained.

¹⁶ National Renewable Energy Laboratory. (2015). *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 21: Residential Lighting Evaluation Protocol*. Retrieved from <https://energy.gov/sites/prod/files/2015/02/f19/UMPCchapter21-residential-lighting-evaluation-protocol.pdf>

1 DATA COLLECTION

This section describes the steps taken to complete the data-collection process.

The EPI program component structure allows every participant to have all the incandescent lamps in use at their home replaced by LED lamps, but only some halogen reflector lamps are eligible to be replaced by LED lamps. Therefore, the data-collecting devices were installed only on LED lamps for three main reasons: (1) EPI participants would not have a significant number of incandescent and halogen lamps to be representative of a typical home; (2) the residential lighting products offered by ENS are mainly LED lamps and (3) since EPI participants have all of their eligible lamps replaced by LED lamps, the results yielded by metering those LED lamps are applicable to most lighting sockets in residential buildings. The data about LED lamp usage obtained from metering the LEDs used in those homes participating in EPI can be applied in EPI's savings calculations. This data can also be applied in the savings calculations of the Instant Savings program component because, as part of the evaluation of Instant Savings, a sample of its participants were questioned about their lamp usage. This point is further discussed in the 2017 Instant Savings evaluation report.

1.1 Participant Recruitment

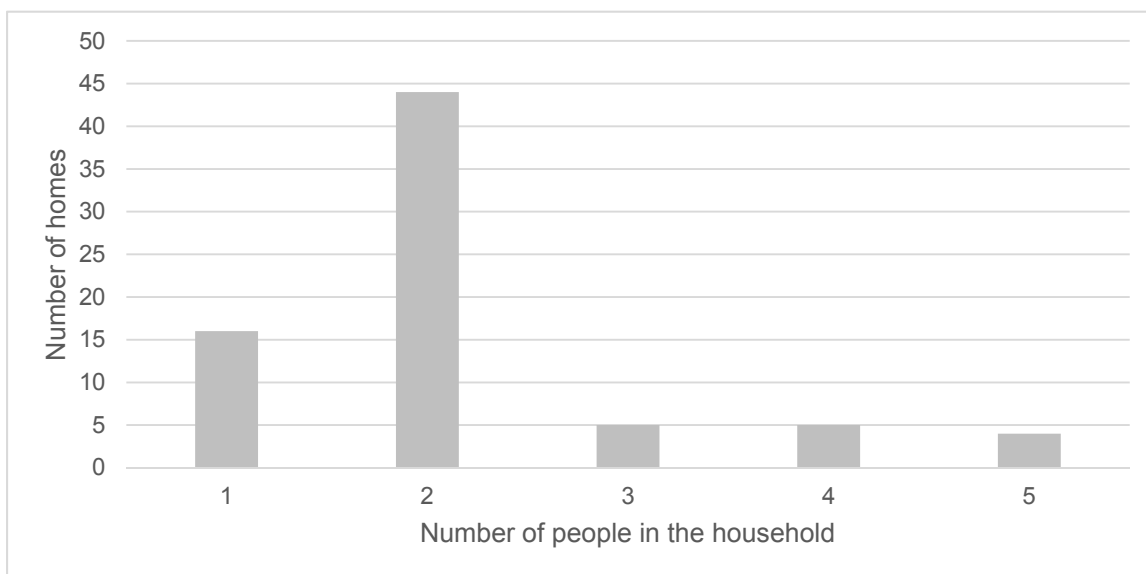
Participants of the RDI and EPI program components were recruited for this metering study. The participants selected for this metering study were also included in the sample for the annual evaluation's site visits. Equilibrium Engineering contacted them over the phone when booking site visits for the RDI 2016 and EPI 2017 evaluations. The participants were selected randomly but had to meet two criteria to be considered for the metering study: (1) have at least 10 LED lamps installed to ensure that enough data collection devices could be installed in each home; and (2) have at least 3 different types of RDI or EPI measures installed so that the visit was worthwhile for the purposes of the annual impact evaluation.

In total, 75 participants were selected for the metering study (with 50 participants from RDI 2016 and 25 from EPI 2017). Participants who agreed to take part in the metering study were offered a \$50 incentive. This incentive was paid to the participant if all the installed data collection devices were retrieved at the end of the metering period. This strategy was quite successful, since most participants kept their data collection devices in place throughout the duration of the study, except for only one case, where the participant removed a single data collection device before the metering period ended.

1.1.1 Overview of Participants Sampled

Figure 1 below shows a breakdown of the metered participating households by household size (the number of people per household). The average household size of the metered sample was 2.1 people, which is similar to the average of all EPI participants in 2017 (2.2 people). Each of the metered participating homes was a single-family home.

Figure 1: Distribution of Metered Homes by Household Size



Of the 75 households metered, 51 percent were identified as low-income; this was slightly higher than the percentage of low-income households (40 percent) among all EPI participants. However, because other studies (including the one conducted by the Northeast Energy Efficiency Partnerships) have found that the differences in HOU measured against the income levels or dwelling type were not statistically significant, the Evaluator has concluded that the income levels of the households do not affect the validity of this metering study's data or findings.

1.2 Metering Period

Data collection took place from September 15, 2016 through August 22, 2017 ("the metering period"). The 75 participants were separated into three rounds of data collection. Up to eight data-collecting devices were installed in each home to cover a variety of rooms. The data-collecting devices were installed in all types of rooms, but none were installed outdoors, because the photo-sensor technology used on these metering devices cannot distinguish between daylight and lamp light. A total of 526 devices were installed during the metering period and were kept in place over a period ranging from 59 days to 122 days, averaging 92 days.

The Uniform Methods Project Protocol for Residential Lighting Evaluation¹⁷ states that metering several weeks before and after an equinox is an appropriate method to obtain HOU representative of the annual average. This was not possible for this metering study, in part because the metering took place in three rounds spanning almost a full year. Additionally, the Evaluator wanted to obtain data during the electricity demand peak period in Nova Scotia, which is between 5 p.m. and 7 p.m. from December to February on non-holiday weekdays. Therefore, metering was conducted over about eleven months; for such cases, the UMP recommends applying an annualization method, which is discussed in more detail in Section 3.1.

Table below shows the metering schedule followed. The start and end dates in the table respectively indicate the days when the data collection devices were installed and the day the last one was removed. Since it took up to two weeks to install and retrieve the data collection devices, not all of them recorded data throughout the entire periods shown in the table below.

Table 3: Schedule of the Metering Periods

Round	Start of Metering Period	End of Metering Period	Number of Households
1	September 15, 2016	January 20, 2017	26
2	December 13, 2016	May 2, 2017	25
3	March 27, 2017	August 22, 2017	24

1.3 Data Collection Devices

The data collection devices used were the TOU Smart Logger model from DENT Instruments. These devices are equipped with a light sensor that detects whether the lamp is in use. Every 15 minutes, the devices record the percentage of time for which the lamp was in use. Their memory capacity is 32,576 transitions and data recorded can be exported into a .csv format.¹⁸ The participants were informed about the devices' sensitivity and advised to avoid moving it or changing its settings. Figure 2 below is a photo of the model of data collection device used in this study.

¹⁷ National Renewable Energy Laboratory. (2017). *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 6: Residential Lighting Evaluation Protocol*. Retrieved from <https://www.nrel.gov/docs/fy17osti/68562.pdf>

¹⁸ DENT Instruments. (2012). *TOU SMARTLogger & SMARTware 11 Software Operator's Guide*. Retrieved from https://www.dentinstruments.com/hs-fs/hub/472997/file-2378653977-pdf/Pdf_Files/SMARTware_manual.pdf

Figure 2: Smart Logger from DENT Instruments



Source: Datalogger Store

2 DATA-CLEANING

Data cleaning involved carefully reviewing the data collected (either by the devices or the site visit technicians) to remove instances that might be erroneous. There were three major categories of events that required removing recorded data from the results: (1) retrieval problems, (2) corrupted data, and (3) outliers. Initially, 526 data collection devices were installed.

2.1 Data Collection Device Retrieval Problems

Two metered lamps were removed from the sample due to problems with the data collection devices found at the time of retrieval. In the first case, the data collection device was removed by accident before the metering period ended. In the second case, the device stopped working before the metering period ended.

2.2 Corrupted Data

There were 30 metered lamps whose recorded data was partially or completely corrupted. This problem was found in the data extracted from the .csv format; instead of showing the expected dates and times recorded, the files contained indecipherable characters.

2.3 Outliers

The data recorded in every remaining metered lamp was carefully reviewed to identify potential outliers that could skew the results.

Data collection devices recorded the total amount of time over which the lamp was in use and the total duration of the metering period. These two values were used to establish an approximate daily HOU value for every lamp metered by dividing (1) the total amount of time over which the lamp was recorded as in use by (2) the total number of days over which the meter was operating. It should be mentioned that this daily HOU value is a preliminary result because it is not annualized.

Using this value, three tests were performed to identify potential outliers. The data from metered lamps that failed one or more of these tests were flagged and considered for removal. These tests were based on best practices found in past metering studies^{19,20,21} and the guidelines for data integrity provided in the UMP²².

2.3.1 Extremely High or Low HOU Values

The first and second tests involved checking whether the data had extremely high or extremely low measured HOU values. However, the data found in either case was not all removed simply because it met one of the two criteria listed in Table below; instead, they were reviewed and compared with the participants' estimated HOU values so as to identify data collection devices that might have malfunctioned, thereby recording the abnormal HOU values.

For those cases showing extremely high HOU values, one possible explanation was that the data collection devices might have been affected by daylight, thereby recording the lamps as being in continuous use during the day. To address this issue, all the lamps registering a daily HOU value higher than eight hours were reviewed. After this review and a comparison with the participants' estimated HOU values were made, 13 lamps were removed from this study.

As for those cases showing extremely low HOU values, different criteria were set for different types of rooms. For instance, as can be expected, some rooms (such as closets) have lower HOU values than others (such as kitchens). Data from devices installed in rooms believed to have low HOU values were checked to determine whether their recorded daily HOU values were lower than 0.05 hours. Data from devices installed in rooms believed to have high HOU values were checked to determine whether their recorded daily HOU values were lower than 0.3 hours. These two criteria were applied unless the participant had reported some information that had convinced the Evaluator that the contrary would be reasonable. For example, some participants specified that some lamps were used "very rarely" or "only when people come over". A summary of these criteria by room type is presented in Table . A total of 44 lamps were removed from this study because their data met one of these criteria.

¹⁹ Pennsylvania Public Utilities Commission. (2014). *2014 Commercial & Residential Light Metering Study*. Retrieved from <http://www.neep.org/sites/default/files/resources/1340978.pdf>

²⁰ NMR Group, Inc. (2014). *Northeast Residential Lighting Hours-of-Use Study*. Retrieved from <http://www.neep.org/sites/default/files/resources/Northeast-Residential-Lighting-Hours-of-Use-Study-Final-Report1.pdf>

²¹ NMR Group, Inc. (2015). *Efficiency Maine Retail Lighting Program Overall Evaluation Report*. Retrieved from <https://www.efficiencymaine.com/docs/Efficiency-Maine-Retail-Lighting-Program-Evaluation-Report-2015.pdf>

²² National Renewable Energy Laboratory. (2017). *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 6: Residential Lighting Evaluation Protocol*. Retrieved from <https://www.nrel.gov/docs/fy17osti/68562.pdf>

Table 4: Criteria by Room Type for Identifying Metered Lamps with Extremely Low HOU Values

Room Use Category	Criterion	Room Type
High-use	Considered extremely low if under 0.3 hours a day	Kitchen
		Dining Room
		Living Room / Play Room
		Bedroom
		Bathroom
		Garage
		Office
		Other
Low-use	Considered extremely low if under 0.05 hours a day	Closet / Storage / Walk-in
		Basement
		Hallway / Staircase

2.3.2 Wide Differences from Participants' Estimated HOU Values

A third test was performed to check whether the measured HOU values were widely different from the HOU values that the participants estimated when data collection devices were installed. The UMP has made no recommendation about this issue. Yet, some past studies^{4,5} included this quality-control step in their data-cleaning methodologies. In these studies, if the difference between the measured and the estimated HOU values was over 300%, the lamp was flagged. Although this threshold may seem high and perhaps less effective for detecting outliers, it is generally difficult for participants to accurately estimate their lamps' HOU values, so it is reasonable to use a lenient threshold. The Evaluator applied this threshold of 300% when comparing the measured and the estimated HOU values. In total, 3 lamps exceeding this criterion were removed from this study. However, it should be mentioned that some outliers had already been detected through the extremely-low/extremely-high test, and as a result, this number was lower than it would have been if this difference-threshold test had been the only data quality-control test.

2.4 Consolidating Room Types

To meet the objective of determining an overall HOU value representative of the different usage patterns of LED lamps, data collection devices were installed in several types of rooms in every participating home. In other words, this approach was followed in order to ensure that the average HOU value reflects the various usage patterns which are expected to vary according to occupant behaviour in different types of rooms in a home.

Although the objective of this metering study is to gain insight on the overall average HOU of LED lamps used in households, it is also valuable to assess the average HOU of each room type. This information about the average HOU by room type can help utilities improve the design of their residential lighting programs by targeting high-usage rooms. As described in the following paragraphs, several changes were made to the room type classification so as to create more robust categories (i.e. larger samples), and help gain more in-depth insight about the LED lamp usage patterns by room type.

The Evaluator combined the original “Master Bedroom” and “Other Bedroom” categories into one single category simply called “Bedroom” based on the following rationale: it is reasonable to assume there is no significant difference in usage. Furthermore, it could be expected that guest bedrooms have lower HOU than regular bedrooms. In the original room type classification, guest bedrooms were not included in the room type called “Other Bedrooms”, but were included in the “Other” room type. Therefore, the proposed room combination presumably only affected rooms occupied on a daily basis. As a result, the 48 “Master Bedroom” lamps and 34 “Other Bedroom” lamps remaining after data cleaning were all grouped into this consolidated “Bedroom” room type, totalling 82 lamps. This consolidation created a larger sample of data collection devices installed in bedroom-type rooms, thereby helping decrease the margin of error in estimating the average HOU of bedroom LED lamps.

Additionally, such consolidation was made to the remaining lamps in the “Office”, “Garage” and “Other” categories, respectively with, 14, 10 and 18 lamps after data cleaning; as a result, these original room types were combined into a single “Other” category. This decision was supported by the category-consolidation decisions with similar motivations in other metering studies, notably by the Pennsylvania Public Utilities Commission’s 2014 metering study and the Northeast study. The new “Other” category included 50 lamps after data cleaning.

Because of the low number of lamps in the “Closets” category in the sample, the option of adding the “Closets” category to the “Other” category was also considered. However, since the HOU values of LED lamps in closets were believed to be lower than those in offices, garages, and other types of rooms in the original “Other” category, this option was dismissed.

2.5 Remaining Metered Lamps After Data-cleaning

The following table summarizes the data-cleaning process completed. Overall, the data of 82.5 percent of the initially metered lamps was retained after careful analysis.

Table 5: Summary of Remaining Lamps after Data-cleaning

Room Type	Number of Lamps where Data Collection Devices were Installed	Retrieval Problems	Corrupted Data	Extremely Low HOU	Extremely High HOU	Widely Different from Estimated HOU	Number of Remaining Lamps
Basement	52	1	2	2	8	1	38
Kitchen	73	0	2	6	1	1	63
Living Room/TV Room/Play Room	74	0	4	7	1	1	61
Bathroom	74	1	4	2	1	0	66
Hallway/Staircase	58	0	2	6	1	0	49
Bedroom	105	0	6	16	1	0	82
Dining Room	28	0	2	0	0	0	26
Closet/Storage Area/Walk-in	14	0	3	4	0	0	7
Other	48	0	5	1	0	0	42
Total	526	2	30	44	13	3	434
Total (%)	100%	0.4%	5.7%	8.4%	2.5%	0.6%	82.5%

3 HOURS OF USE ANALYSIS

Since data collection devices were kept in use on average for three months after their installation, the measured daily HOU values are not necessarily representative of the annual average. The UMP recommends annualizing the recorded data for each lamp to determine the influence of the number of daylight hours on lamp usage. In the literature examined^{23,24,25,26,27}, the most common annualization method is sinusoidal modelling. This methodology and the associated results obtained are discussed below in Subsection 3.1; as detailed in this subsection, the results were unsatisfactory. As a result, a simple mean approach was adopted; the detailed description is given in Subsection 3.2.

3.1 Sinusoidal Modelling Approach

Annualization using the sinusoidal model was performed only for the room types where lamp usage was suspected to be affected by daylight, namely all room types except basements and closet or storage areas.

3.1.1 Model

As previously mentioned, the UMP recommends annualizing the recorded data so that it is representative of the lamps' usage over an entire year. Sinusoidal modelling is widely used in the metering studies reviewed by the Evaluator. As detailed in the 2014 *California Upstream and Residential Lighting Impact Evaluation*²⁸, the sinusoid shape is almost indistinguishable from the variation in the number of daylight hours in a day over the course of a year. Therefore, this type of equation is considered ideal to model the HOU per day, for every day of the year. Moreover, the equation's intercept (α) corresponds to the average hours of use of the entire year.

Using *Stata*, a software tool for performing statistical analysis, a sinusoidal regression was computed to fit the data from each lamp with the following equation:

$$HOU_d = \alpha + \beta \sin(\theta_d) + \varepsilon_d$$

²³ NMR Group, Inc. (2014). *Northeast Residential Lighting Hours-of-Use Study*. Retrieved from <http://www.neep.org/sites/default/files/resources/Northeast-Residential-Lighting-Hours-of-Use-Study-Final-Report1.pdf>

²⁴ Pennsylvania Public Utilities Commission. (2014). *2014 Commercial & Residential Light Metering Study*. Retrieved from <http://www.neep.org/sites/default/files/resources/1340978.pdf>

²⁵ Navigant. (2015). *EmPOWER Maryland. Residential Lighting Program: Hours of Use/Metering Study Final*.

²⁶ NMR Group, Inc. (2015). *Efficiency Maine Retail Lighting Program Overall Evaluation Report*. Retrieved from <https://www.efficiencymaine.com/docs/Efficiency-Maine-Retail-Lighting-Program-Evaluation-Report-2015.pdf>

²⁷ Kema. (2014). *California Upstream and Residential Lighting Impact Evaluation. Work Order 28 (WO28) Final Report*. Retrieved from http://www.calmac.org/publications/WO28_-_California_Upstream_and_Residential_Lighting_Impact_Evaluation_Final_Report.pdf

²⁸ Ibid.

Where:

- › HOU_d is the number of hours of use on day d ;
- › α and β are the regression coefficients;
- › θ_d is the angle for day d ; and
- › ε_d is the error.

For the variable θ_d , each day of the year has a specific angle. Spring and fall equinoxes correspond to $-\pi$ and 0, and summer and winter solstices to $-\pi/2$ and $\pi/2$. The remaining days of the year are spread out evenly among these angles. With these angles, the hypothesis is that the average hours of use value over the course of a year occurs at the equinoxes, and that the highest and lowest hours of use values in a year occur at the winter and summer solstices, respectively.

The metering studies from California²⁸, Maine⁶, Pennsylvania⁴ and the Northeast⁵ all used the same criteria to determine whether or not the equation obtained for each lamp with sinusoidal regression was a good fit. The same criteria were used for this study, which are the following:

- › The absolute value of the sine coefficient (β) must be lower than 10;
- › The standard error of the sine coefficient (β) must be lower than 1;
- › The intercept (α) must be higher than or equal to 0; and
- › The intercept (α) must be lower than 24.

The data analysis and statistical software tool, *Stata IC 12*, was used to perform the sinusoidal regression.

A file for each lamp was formatted to contain the following inputs for the *regress* function, for every day over which the data collection device was kept in use in the household:

- › the number of hours the lamp was in use (HOU_d),
- › the corresponding sine value for that date ($\sin \theta_d$).

The *regress* function used the values for HOU_d and $\sin \theta_d$ to define the regression coefficients (α and β), as well as the error term. Statistical parameters related to the correlations were also obtained, such as the t-statistic and the coefficient of determination (R^2). Additional details about these parameters are given in 0.

3.1.2 Results

All those lamps whose regression results met all the criteria detailed in Subsection 3.1.1 were considered a good fit. This was the case for 272 lamps.

All those lamps that did not meet one or more of these criteria were considered a poor fit for sinusoidal modelling. This was the case for 117 lamps, thus indicating that the metered lamps' usage was not correlated with the number of daylight hours. Therefore, the annualization results obtained through sinusoidal modelling for these lamps had to be discarded; instead, for these lamps it is more appropriate to use a simple mean of daily HOU without any adjustments for annualization.

Table summarizes the results obtained using the annualization process for those lamps each found to be "a good fit".

Table 6: Summary of the Sinusoidal Modelling Results

Number of Lamps Deemed "a Good Fit"	Average R^2	Intercept (α)			Sine Coefficient (β)		
		Average Intercept	Average Error	Lamps with a t-Statistic above 1.64	Average Sine Coefficient	Average Error	Lamps with a t-Statistic above 1.64
272	0.069	2.609	0.341	90%	-0.212	0.498	23%

Both regression coefficients were analyzed to determine the validity of the model. In the case of the sine coefficient (β), the magnitude of the average error was higher than the average sine coefficient, which shows that the sine coefficient value is not significant. Furthermore, the t-statistic for this coefficient was above the minimum value of 1.64 (indicating a confidence level of at least 90%) in only 23 percent of the cases. While the statistical parameters defining the intercept (α) were satisfactory, the intercept is meaningless without the sine coefficient (β) because it is this portion of the correlation that allows for controlling variations in HOU due to the period of the year when metering occurred.

Furthermore, the values of R^2 were extremely low, even in the cases of lamps for which the model was determined as being a good fit for predicting the HOU. Regressions are aimed at obtaining an R^2 value closer to 1, which indicates that the model is 100% successful at predicting the HOU. Low R^2 values show that only a small proportion of the variation in the HOU is due to the daylight hours, which in turn explains that high error obtained for the sine coefficient. Based on these findings, the Evaluator decided that the sinusoidal model was not statistically significant, and that no correlation could be established between days of the year and the HOU. These results were therefore discarded, and a simple mean approach was employed.

It is difficult to know whether similar poor statistical results also occurred in past metering studies because most of these studies did not report their detailed statistical results.

3.2 Simple Mean of Daily HOU Approach

Because the sinusoidal model was ineffective in calculating the annual daily HOU, the Evaluator chose to calculate a simple mean for each lamp. Since the span of the three metering rounds covered almost the entire year (from mid-September 2016 to mid-August 2017), it was reasonable to consider that the data reflected changes in lamp usage throughout the year. To demonstrate this, the Evaluator calculated the average value of $(\sin\theta_d)$ of each lamp during their respective metering periods, as well as the average value of $(\sin\theta_d)$ for all lamps. As shown in Table , the resulting value was close to 0, indicating that the data was representative of what occurs at the equinox. As explained in Subsection 3.1.1, in theory, the lamp usage at the equinox corresponds to the annual average.

Table 7: Average $\sin(\Theta)$ Values for Lamps during the Metering Period

Room Type	Number of Lamps	Average $\sin(\Theta_d)$ Value of All Lamps
Basement	38	-0.04
Kitchen	63	0.13
Living Room/TV Room/Play Room	61	0.02
Bathroom	66	0.07
Hallway/Staircase	49	0.01
Bedroom	82	0.17
Dining Room	26	0.06
Closet/Storage Area/Walk-in	7	0.05
Other	42	0.06
Overall Weighted Average²⁹	434	0.06

3.2.1 HOU per Lamp

The simple mean HOU of each lamp during the metering period was calculated using the following equation:

$$\overline{HOU}_{lamp} = \frac{\sum HOU_d}{n}$$

Where:

- › HOU_d is the number of HOU on day d;
- › n is the total number of days in the metering period; and
- › $\overline{HOU}_{lamp}$ is the mean daily HOU for this lamp.

²⁹ Weighting methodology is detailed in Subsection 3.2.4.

3.2.2 HOU by Room Type

For each room type, the average HOU was calculated using the following equation:

$$\overline{HOU}_{room\ type} = \frac{\sum \overline{HOU}_{lamp\ i}}{n}$$

Where:

- › $\overline{HOU}_{room\ type}$ is the average HOU for all rooms in a room type category (e.g., the average HOU of bathrooms)
- › $\overline{HOU}_{lamp\ i}$ is the average HOU of a metered lamp in this room type category; and
- › n is the number of lamps in this room type category (e.g., 66 bathrooms).

3.2.3 Overall Average HOU

To calculate the overall average HOU for all room types, the following equation was used:

$$\overline{HOU}_{all\ rooms} = \sum \overline{HOU}_{room\ type\ i} \times weight_{room\ type\ i}$$

Where:

- › $\overline{HOU}_{all\ rooms}$ is the average HOU for all room types;
- › $\overline{HOU}_{room\ type}$ is the average HOU of a room type category; and
- › $weight_{room\ type}$ is the weight of the room type as determined in Subsection 3.2.4.

3.2.4 Weighting

The UMP recommends that the overall HOU reflect the distribution of lighting products by room type. Therefore, it was necessary to assign weight to the average HOU value obtained for each room type. The following methodology is based on these recommendations.

During the site visits, Equilibrium Engineering counted the number of sockets capable of receiving LED lamps in every participating home. While the data collected this way does not necessarily reflect the total number of LEDs in each household at the moment of the visit, this data shows the distribution of potential sockets for EPI participants, since this program component is aimed at replacing most of the total lamps with LED bulbs.

The proportion of LED lamps for each room type was calculated using the following equation:

$$Room\ Type\ Weight = \frac{Total\ Number\ of\ Sockets\ in\ All\ Homes\ in\ This\ Room\ Type}{Total\ Number\ of\ Sockets\ in\ All\ Homes}$$

Table summarizes the weight attributed to each room type.

Table 8: Weight Assigned to Room Types

Room Type	Number of Sockets	Room Type Weight
Basement	371	12%
Kitchen	375	12%
Living Room/TV Room/Play Room	389	13%
Bathroom	388	13%
Hallway/Staircase	317	10%
Bedroom	621	20%
Dining Room	186	6%
Closet/Storage Area/Walk-in	118	4%
Other	313	10%
Total	3,078	100%

3.3 Results

The overall HOU value for all room types combined has been established at 2.48 hours per day. The average HOU for every room type as well as the overall average HOU are listed in Table below.

Table 9: HOU for All Room Types and Overall HOU

Room Type	Average HOU	Absolute Margin of Error	Relative Margin of Error	Range of Possible Values for HOU	
				Minimum	Maximum
Basement	1.54	1.05	68%	0.49	2.59
Kitchen	4.45	0.83	19%	3.62	5.27
Living Room/TV Room/Play Room	3.99	0.64	16%	3.36	4.63
Bathroom	2.07	0.38	18%	1.69	2.45
Hallway/Staircase	1.47	0.54	37%	0.93	2.01
Bedroom	1.75	0.31	18%	1.44	2.06
Dining Room	3.96	1.14	29%	2.82	5.10
Closet/Storage Area/Walk-in	0.54	0.31	58%	0.23	0.86
Other	2.14	0.49	23%	1.65	2.63
Weighted Average HOU	2.48	0.24	10%	2.37	2.84

3.3.1 Margin of Error

Calculating margins of error is useful for establishing ranges in which the true values of the results are found. The detailed methodology for calculating the margins of error is presented in 0. The margin of error for some room types was quite high, which can be explained by the size of the samples and the different habits among the participants. For example, although there were 38 metered lamps in the sample for basements, the margin of error was 69 percent. This was especially striking when compared with the similar size of the category “Other” (42 lamps), which had a margin of error of only 22 percent.

However, because the distribution of lamps by room type is very close to the weight of each room type, the error margin can be calculated for the total number of lamps installed. Considering the large number of lamps included in the calculation of the weighted average HOU, the overall margin of error is about 10 percent, which suggests that the results are conclusive.

3.3.2 Comparison with Past Studies

The value of the overall HOU of metered homes is very similar to the results from the metering studies of other jurisdictions: Northeast set it at 2.7 hours per day³⁰; Pennsylvania at 2.5 hours per day³¹; Maryland³² at 2.46 hours per day for efficient bulbs; and Massachusetts³³ at 2.66 hours per day for low-income households. Therefore, this metering study’s results are within the range found in the literature. The comparison with the Northeast Study was analyzed in further detail since this study is the current source for the HOU value applied for residential lighting calculations.

³⁰ NMR Group, Inc. (2014). *Northeast Residential Lighting Hours-of-Use Study*. Retrieved from <http://www.neep.org/sites/default/files/resources/Northeast-Residential-Lighting-Hours-of-Use-Study-Final-Report1.pdf>

³¹ Pennsylvania Public Utilities Commission. (2014). *2014 Commercial & Residential Light Metering Study*. Retrieved from <http://www.neep.org/sites/default/files/resources/1340978.pdf>

³² Navigant. (2015). *EmPOWER Maryland. Residential Lighting Program: Hours of Use/Metering Study Final*.

³³ The Cadmus Group. (2014). *Massachusetts Low Income Metering Study*. As cited in Northeast Energy Efficiency Partnerships. (2014). *Northeast Residential Lighting Strategy: 2014-2015 Update December 2014*, p. 17.

Northeast Energy Efficiency Partnerships Study

In the Northeast Energy Efficiency Partnerships lighting metering study, 5,730 lamps were metered in 848 households in Connecticut, Massachusetts, New York, and Rhode Island. The sample included: single-family homes and apartments; low-income and non-low-income households; as well as inefficient and efficient lamps. One major difference between this present study and the Northeast metering study is that in the Northeast study, participants were not selected from a residential lighting program database; instead, participants were selected from the general population. This explains why the Northeast study sought to estimate the HOU for two subgroups of bulbs: efficient lamps and all lamps. The reasons for distinguishing between these two subcategories were the following: if participants purchase and install efficient bulbs themselves, they would probably not replace all their old lamps; they would select those sockets for installing efficient lamps based on the sockets' levels of usage; therefore they would tend to use their efficient lamps more often than their non-efficient ones. Because EPI installs LED lamps in all sockets previously occupied by incandescent lamps and almost all the lamps in the home become efficient ones through the program component, the efficient lamp installation behaviour just mentioned does not result in any difference in the efficient lamps' hours of use. Consequently, the HOU value of "all lamps" in the Northeast study was selected and applied in the calculations of EPI's energy savings.

In this Northeast study, the data-collecting devices were installed between November 2012 and March 2013 and were retrieved between June 2013 and August 2013. Lamps were metered on average for 143 days, and 84 percent of lamps were metered for at least 121 days. After data-cleaning, 4,642 lamps remained in the sample. Six room types were included in the sample: bedrooms (913); bathrooms (700); kitchens (751); living spaces (742); dining rooms (401); and exterior (184). An additional "other" category was created for rooms that did not fit any of the preceding room types.

To assess the annual average daily HOU value, data was annualized using the sinusoidal modelling approach. Then, a weighted regression analysis was performed to calculate the HOU of each room type for each region.

An average of 2.7 hours per day, with a margin of error ± 0.1 hours/day was obtained for all metered lamps. The results were provided for room types as well, and all had a margin of error between ± 0.15 hours/day and ± 0.3 hours/day.

The study did not find statistically significant disparities in HOU when comparing home types (i.e., single-family vs. apartments) or income levels. It did, however, find that the HOU values were higher for efficient bulbs than for non-efficient bulbs. The study's definition of efficient bulbs included LEDs, compact fluorescent lamps (CFLs), and fluorescent lamps. Halogens and incandescent lamps were considered inefficient. It should be noted that this disparity should not be expected for the metering study conducted with EPI, since LEDs were systematically installed in all those sockets where incandescent lamps were previously found.



The Northeast study included 184 exterior lamps in its sample (representing 4% of all the metered lamps, which was the same proportion as with EPI in 2017), which were found to have an average daily HOU value of 5.6 hours/day. This could partly explain why the overall result of 2.7 hours is slightly higher than the result obtained in this study, since those exterior lamps increased the overall average HOU value by 0.1 hour/day in the Northeast study.

4 PEAK DEMAND SAVINGS ANALYSIS

Peak demand savings correspond to the demand savings that coincide (in time) with the peak demand period of the electricity system. The projected electricity demand peak period in Nova Scotia is between 5 p.m. and 7 p.m. in the months of December to February on a non-holiday weekday.

To estimate how the HOU values of LEDs translate into peak demand savings, the Evaluator analyzed the HOU values occurring specifically during the peak demand period. For each data collection device, the average HOU value of all the 15-minute intervals between 5 p.m. and 7 p.m. during the peak period was calculated and then summed up to establish the average daily HOU value for the peak period. Those results were used to obtain a peak-demand-to-energy ratio for each device. This ratio was then multiplied by the annual energy savings value to arrive at the peak demand savings value. The following equation was used to obtain the peak-demand-to-energy ratio.

$$PDER = \frac{Peak\ DS[W]}{ES[kWh]} = \frac{\Delta W \times HOU_{daily\ peak} \div Peak\ Duration}{\Delta W \div 1000 \times HOU_{annual}} = \frac{1000 \times PCF}{HOU_{annual}}$$

Where:

- › Peak DS is the peak demand savings in W;
- › ES is energy savings in kWh;
- › ΔW is the wattage displaced by the efficient lamp;
- › $HOU_{daily\ peak}$ is the average daily HOU of a given data collection device during the peak;
- › Peak duration is the number of hours between 5 p.m. and 7 p.m (2 hours);
- › HOU_{annual} is the annual HOU of a given data collection device;
- › PCF is the peak coincidence factor, also defined as the percentage of time of the peak period during which savings occur.

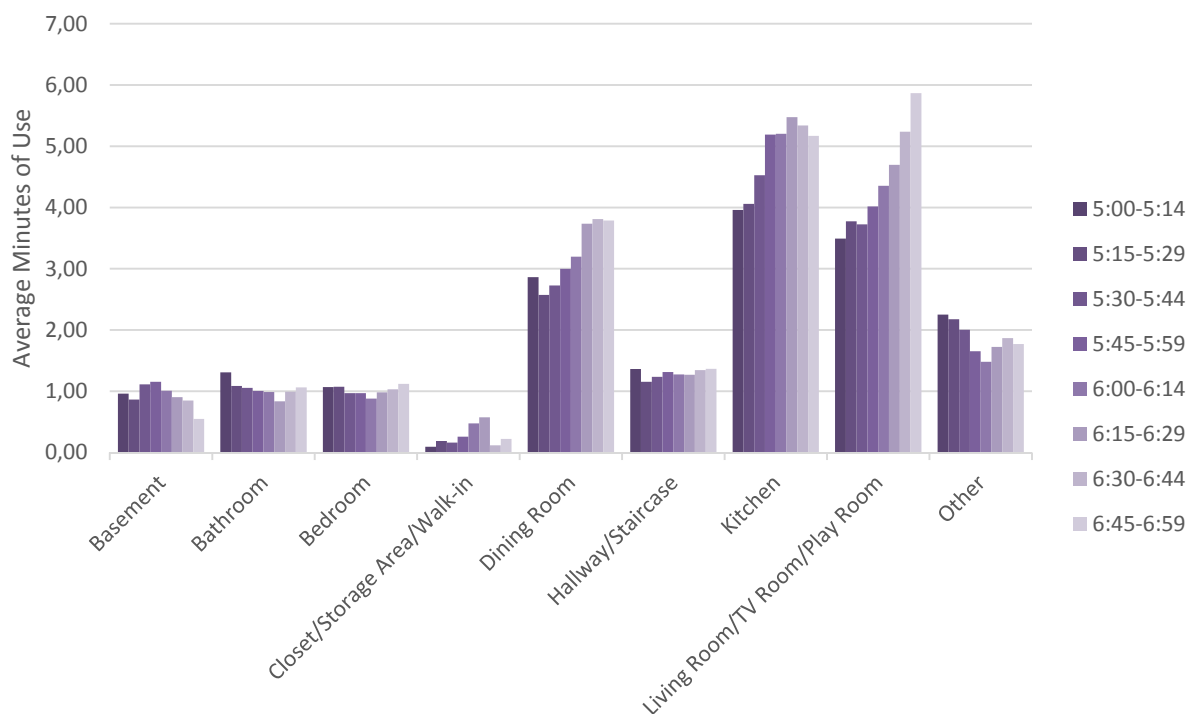
A total of 286 loggers metered data between December 1 and February 28. The Evaluator chose to exclude those loggers with fewer than 10 days during that period to avoid obtaining peak-demand-to-energy ratios that were based on $HOU_{daily\ peak}$ values that might not be representative because they were based on too few readings. Table below shows the results by room type for the remaining 257 loggers.

Table 10: Peak-demand-to-energy Ratios by Room Type

Room Type	Average PDER (W/kWh)	Number of Data Collection Devices	Room Type Weight	Margin of Error	Relative Error
Basement	0.204	18	12%	0.083	41%
Bathroom	0.104	40	13%	0.024	23%
Bedroom	0.128	49	20%	0.044	34%
Closet/Storage Area/Walk-in	0.155	4	4%	0.100	65%
Dining Room	0.138	16	6%	0.051	37%
Hallway/Staircase	0.183	33	10%	0.049	27%
Kitchen	0.204	37	12%	0.039	19%
Living Room/TV Room/Play Room	0.173	33	13%	0.044	25%
Other	0.171	27	10%	0.054	32%
Weighted Average	0.161	257	100%	0.016	10%

The average peak-demand-to-energy ratio of 0.161 W/kWh is significantly lower than the ratio of 0.249 W/kWh currently applied by ENS to residential lighting measures. This latter ratio was established by Navigant based on modelled system coincident peak demand savings and energy savings for a projected deployment of measures for the 2016-2018 DSM plan. The margin of error of about 10 percent means that, at a confidence level of 90%, the maximum value obtained in this study is 0.177 W/kWh, which is still significantly lower than Navigant's ratio.

Figure 3 illustrates the evolution of usage pattern during the peak demand period of 5 p.m. to 7 p.m. by room type.

Figure 3: Lamp Use Pattern during the Peak Period by 15-minute Interval


The above figure shows that the lamps in the main living areas (dining rooms, kitchens and living rooms) are gradually used more from 5 p.m. to 6:30 p.m. Between 6:30 and 7 p.m., lamp usage declines in the kitchen but increases in the living room, which seems reasonable.

One element that could explain a portion of the difference between the ratio obtained by the Navigant model and this metering study is that this metering study excluded the lamps installed outdoors from the study. Indeed, based on the two assumptions that (1) lamps are turned on at least half of the time between 5 p.m. and 7 p.m. on weekdays in winter and (2) they are used about 6 hours per day, the peak-demand-to-energy ratio has been established at 0.228 W/kWh. It would, therefore, seem reasonable to apply a different peak-demand-to-energy ratio to outdoor lamps which are tracked separately from the lamps installed indoors in the EPI tracking report.

CONCLUSIONS

This study aimed to examine the average HOU of LED lamps in the homes of RDI and EPI program component participants and determine the peak coincidence factor of demand savings. To achieve these goals, three separate rounds of metering were conducted from September 2016 through August 2017 in a total of 75 households. Data collection devices installed on a total of 526 lamps recorded the relative duration of a single lamp's use every fifteen minutes. After data cleaning, the data from 83 percent of these lamps were used in the analysis.

To calculate the average HOU per day, the following steps were taken. Based on the recommendations of the UMP, the Evaluator attempted to annualize the data to reflect the variation in use according to the number of daylight hours. This was first performed with a sinusoidal model, but the results were statistically insignificant and discarded. A simple mean of daily HOU was then calculated for each lamp. The Evaluator finds this method sufficiently accurate because the metering periods were adequately staggered throughout the year to be representative of the annual average use. The resulting HOU values were weighted for each room type and an overall value of 2.48 hours/day was established, with a margin of error of ± 0.24 hours/day.

This value is comparable to the value of 2.7 hours/day previously used for LED lamps installed through the EPI program component, which was taken from a large metering study conducted by the NMR Group, the Northeast Residential Lighting Hours-of-Use Study. Considering that this Northeast value is within the margin of error of the Nova Scotia metering study described in this report, the Evaluator recommends continuing using the values from the Northeast Residential Lighting Hours-of-Use Study. Furthermore, in the Northeast study, four percent of the metered sample were outdoor lamps; this percentage is the same as the proportion of outdoor lamps installed through EPI. The metering study conducted by the Evaluator did not include outdoor lamps, which usually have higher HOU values and would have increased the average HOU value.

An analysis of the HOU values was specifically done for the peak demand period of the electricity system for each room type. The results showed that the peak-demand-to-energy ratio previously used for residential lighting (0.249 W/kWh) was overestimated, since the average value was established at 0.161 W/kWh ± 0.016 W/kWh. The Evaluator recommends applying this new value to lamps installed indoors. For lamps installed outdoors, an estimate of 0.228 W/kWh made based on typical usage during winter nights is recommended to be applied.

Figure 4: Site Visit Protocol - Data Collection Device Installation (1/3)

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[illegible]

[illegible]

[illegible]

Figure 8: Site Visit Protocol – Socket count (1/3)

A	B	C
Participant Information		
RDI Participant ID	Nb of people living in house	Nb of bedrooms in house

Figure 9: Site Visit Protocol – Socket count (2/3)

D	E	F	G	H	I	J	K	L	M	N	O
Lighting Information											
Total number of sockets capable of receiving LED (including sockets with LED lights already installed)											
Kitchen	Dining Room (if not part of kitchen)	Living Room / Play Room	Master Bedroom	Other Bedrooms (occupied, not guest rooms)	Bathrooms (all if more than one)	Hallways & Staircases	Closets, Storage & Walkins	Office	Garage	Basement	Other

Figure 10: Site Visit Protocol – Socket count (3/3)

P	Q	R	S	T
Outdoor Survey				
Nb of LED installed outdoor	Nb of sockets outdoor	Participant estimate of outdoor light HOU (h/day)	Nb of LED installed by participant since RDI participation	% LED outdoor

APPENDIX II

OVERVIEW OF STATISTICAL PARAMETERS

According to the International Performance Measurement and Verification Protocol³⁴, regression coefficients are statistical estimates of the relationship between two variables. The relationship to be studied in this case was the variation of HOU as a function of the number of daylight hours. The accuracy of the coefficient estimation can be measured with the coefficients' standard error and t-statistic. R² measures the accuracy of the overall model.

Regression Coefficient Accuracy: Standard Error and t-statistic

The standard error for each regression coefficient (α and β) is calculated using the following equation:

$$SE_{coefficient} = \sqrt{\frac{\sum(HOU_d - \widehat{HOU}_d)^2 / (n - 2)}{\sum(\sin\theta_d - \overline{\sin\theta_d})^2}}$$

Where:

- › HOU_d is the metered value of HOU associated with a number of daylight hours ($\sin\theta_d$);
- › $\widehat{HOU}_d$ is the predicted value of HOU from the regression model;
- › n is the number of days in the metering period;
- › $\sin\theta_d$ is the sine value associated with each day d during the metering period; and
- › $\overline{\sin\theta_d}$ is the average of sine values associated with each day d during the metering period.

The t-statistic is calculated using the following equation:

$$t - statistic = \frac{Value\ of\ Regression\ Coefficient}{SE_{coefficient}}$$

Where:

The obtained t-statistic is then compared to a critical value depending on the number of data points in the sample, the desired confidence interval and the number of regression coefficients. In this case, for a confidence interval of 90%, the t-critical value is 1.64. If the absolute value of the t-statistic exceeds this critical value, the estimate can be considered statistically relevant.

³⁴ Efficiency Valuation Organization. (2012). *International Performance Measurement and Verification Protocol. Concepts and Options for Determining Energy and Water Savings Volume 1*. Retrieved from http://www.eepperformance.org/uploads/8/6/5/0/8650231/ipmvp_volume_i_2012.pdf

Model Accuracy: Coefficient of Determination R^2

R^2 is the coefficient of determination and also provides insight into the model's accuracy in predicting the HOU as a function of the daily number of daylight hours. The ideal result is to have a model that brings this parameter close to 1, which indicates that the model can predict the same HOU as the values actually observed and measured. The equation for calculating R^2 is the following:

$$R^2 = \frac{\text{Explained Variation in HOU}}{\text{Total Variation in HOU}} = \frac{\sum(\widehat{HOU}_d - \overline{HOU})^2}{\sum(HOU_d - \overline{HOU})^2}$$

Where:

- › $\widehat{HOU}_d$ is the model's predicted value of HOU for a particular number of daylight hours $\sin(\theta_d)$;
- › $\overline{HOU}$ is the mean of the measured HOU; and
- › HOU_d is the metered value of HOU associated with a number of daylight hours ($\sin \theta_d$).

APPENDIX III

RELATIVE MARGIN OF ERROR

Relative margins of error were calculated for each room type's HOU, and for the overall HOU, using the formulas shown below, which are found in the IPMVP.³⁴ The confidence interval is set at 90% and the population size as infinite. The resulting margins of error are reported in Subsection 3.3. This calculation is useful to provide a range in which the true value of HOU is found.

At first, it was necessary to use the sample mean of each room type.

$$\overline{HOU}_{room\ type} = \frac{\sum \overline{HOU}_{lamp\ i}}{n}$$

The following formula was used to calculate the sample's standard deviation (s).

$$s = \sqrt{\frac{\sum (\overline{HOU}_{lamp\ i} - \overline{HOU}_{room\ type})^2}{n - 1}}$$

Afterwards, the absolute margin of error was calculated for each room type using the equation below. The value of t depends on the sample size. For those room types with more than 30 metered lamps, this value corresponds to 1.64. The sample size was lower than 30 lamps for closet areas (n=7) and dining rooms (n=26). The t value for these room types were respectively 1.94 and 1.71.

$$Absolute\ Margin\ of\ Error = \frac{s \times t}{\sqrt{n}}$$

Then, the relative margin of error was calculated by applying the absolute margin of error and the sample mean, and using the following equation:

$$Relative\ Margin\ of\ Error = \frac{Absolute\ Margin\ of\ Error}{\overline{HOU}_{room\ type}}$$

Finally, the relative margin of error of the estimated HOU of all room types was calculated using the same methodology because the weights assigned to the room types were similar to the respective proportions of the room types in the sample. Therefore, it was not necessary to adjust the error calculation to account for this difference.

Appendix XXI

EPI: ALGORITHM FOR FREE-RIDERSHIP CALCULATION

The figure below presents the algorithm for calculating the free-ridership level. The participant survey questionnaire included questions designed to assess the planning, quantity, efficiency, period, cost and influence of the program component. Questions were also asked to quantify cross-influence. This corresponds to the level of influence that previous participation in one of ENS's energy efficiency program components or ENS's efforts to raise energy efficiency awareness had on the decision to implement the energy efficiency measure. Each group of questions was transposed into a level of program component attribution, which was used to calculate the free-ridership level associated with each participant.

FR2. If ENS had not installed these LED bulbs at no charge as part of the EPI Service, would you have paid the full cost of the LED bulbs, which is approximately \$6 per bulb? (Scale 0 to 10)	FR2 = Answer x 10% IF DK OR REF: FR2 = EMPTY
FR3a. If the service had <u>not been</u> offered, what is the likelihood that you would have taken the initiative to purchase LED bulbs at a store and then install them yourself in your home? (Scale 0 to 10)	FR3a = Answer x 10% IF DK OR REF: FR3a = EMPTY
PA1 Score:	MEAN VALUE OF (FR2 ; FR3a)
FR1. Did you or anyone in your household have specific plans to purchase and install LED bulbs prior to learning about the EPI Service?	IF 1. Yes: Use FR1a IF 2. No OR DK OR REF: FR1a = 0%
FR1a. I just want to make sure I understand - Before you learned about the EPI Service, you had already made the decision to purchase and install LED bulbs in your home?	IF 1. Yes: FR1a = 100% IF 2. No OR DK OR REF: FR1a = 0%
PA2 Score:	FR1a
FR4. Level of influence (Scale 0 to 10)	FR4 = MAX(a ; b)
PA3 Score:	(10 – FR4) x 10%
FR3b. [IF FR3a ≥ 5] If the service had not been offered, what is the likelihood that you would have postponed replacing your bulbs with LEDs by at least one year? (Scale 0 to 10)	FR3b = (10 – Answer) x 10% IF DK OR REF: EMPTY
PA4 Score:	FR3b

FR3c. If the service had not been offered, what is the likelihood that you would have purchased and installed all the LED bulbs that were installed through EPI? (Scale 0 to 10)	FR3c = Answer x 10% IF DK OR REF: EMPTY
PA5 Score:	FR3c
Inconsistency Test PA1	IF ABS(FR2 – FR3a) ≥ 50%: PA1 = MIN (FR2 ; FR3a)
Inconsistency Test PA2	IF FR1a = 100% AND IF FR2 < 70% OR FR3a < 70%: PA2 = EMPTY
Free-Ridership	MEAN VALUE OF: (PA1 ; PA2 ; PA3 ; PA4; PA5)
CI2/CI4. [Your previous participation in an ENS program or service and what you learned by participating in this program]/[The energy efficiency promotional materials distributed by ENS] greatly influenced your decision to have energy-efficient products installed in your home (Scale 0 to 10)	CI = MAX (CI2 ; CI4)
Revised Free-Ridership	IF CI ≥ 7 AND CI < 9, Revised FR*75% IF CI ≥ 9, Revised FR*50%

Appendix XXII

EPI: INTERNAL SPILLOVER METHODOLOGY

Internal spillover was measured using a participant survey. Participants were asked whether following their participation in the program component, they bought and implemented any additional energy efficiency measures, without benefitting from any rebates offered by ENS program components. If a participant did admit to having implemented additional measures, they were asked a set of questions designed to identify the additional energy efficiency measures implemented and to quantify their associated savings. Subsequently, another question was asked to quantify the level of influence the program component had on the participant's decision to implement these additional measures. The value established regarding this level of influence was used to determine the portion of the additional savings attributable to the program component.

Then, the level of internal spillover was established by dividing the total quantity of the additional savings attributable to the program component by the total quantity of savings achieved by the program component for all the survey respondents.

The figure below illustrates the methodology used to calculate the internal spillover level.

SO1. Since the time that you participated in EPI Service, have you installed any additional energy-efficient products or retired any old appliances on your own ?	IF 1. Yes: CONTINUE IF 2. No OR DK OR REF : END
SO2. I just want to make sure I understand - After you participated in the EPI Service, you installed additional energy-efficient products or retired old appliances on your own. Is that correct?	IF 1. Yes: CONTINUE IF 2. No OR DK OR REF: END
SO3. Have you received financing or rebates from any other ENS programs for these additional energy-efficient products or retirement of appliances?	IF 2. No: CONTINUE IF 1. Yes OR DK OR REF : END
SO4. Which additional energy-efficient products or retired old appliances have you installed on your own after participating in EPI Service?	SO4 = SUM (kWh associated with each upgrade)
Additional Products and Retirement Savings:	SO4
SO5. How influential was your experience with EPI Service on your decision to install these additional energy-efficient products or retire these appliances on your own? (Scale 0 to 10)	SO5 = Answer x 10% IF DK or REF: SO5 = EMPTY
Attribution Level:	SO5
Spillover Savings:	SO4 x SO5
Final Spillover Level = $\frac{\text{SUM of (SO4 x SO5) for All Respondents}}{\text{SUM of Program Savings for All Respondents}}$	



ECONOLER

NEW RESIDENTIAL PROGRAM

2017 DSM EVALUATION

EFFICIENCY NOVA SCOTIA

Final Report

March 15, 2018



ABBREVIATIONS

CRA	Corporate Research Associates
DA	Delivery agent
DSM	Demand-side management
EA	Energy advisor
EISA	Energy Independence and Security Act
ENS	Efficiency Nova Scotia
EUL	Effective useful life
GHG	Greenhouse gas
HEA	Home Energy Assessment
LED	Light-emitting diode
NBC	National Building Code
NHC	New Home Construction
NTGR	Net-to-gross ratio
PHPP	Passive House Planning Package
TRM	Technical reference manual

DEFINITIONS

Accuracy	Reflects the proximity of measurements to the true value.
Adjustment ratio	The ratio of evaluated results to tracked results. This ratio expresses the adjustment made to tracked savings or other tracked values such as effective useful life.
Base case	To determine gross savings, a base case is established providing detailed information about the reference (e.g. pre-existing or standard) measure or equipment chosen to be compared with the efficient measure or equipment. For the reference measure or equipment, the base case may include such information as the hours of operation, wattage and the base consumption.
Bias	Systematic deviations of measurements from the true value.
Billing calibration	An activity that consists of adjusting the expected energy savings based on the relative difference between the results of the energy simulations and the actual energy consumption of the building or system.
Confidence interval	The estimated range of values which is likely to include the unknown population parameters.
Displaced wattage	The displaced wattage is defined as the difference between the wattage values of the baseline equipment or product and the efficient equipment or product.
EnerGuide rating	An EnerGuide (official brand of Natural Resources Canada) rating is a standard measure of the home's energy performance. It is a measure of the efficiency of the building only and does not take into account occupant behaviour. It shows how energy efficient the home is through modelled heat losses of the home, based on several factors including building envelope characteristics, heated volume, heating systems and air leakage.
Effective useful life	The period a measure is expected to be in service and provide both energy and peak demand savings. This value combines the equipment life and the measure persistence, which includes factors such as business turnover or early retirement.
Equipment life	The number of years installed equipment will operate before it fails.
Equivalent CO ₂	A unit of measurement indicating the amount of carbon dioxide to which various kinds of emitted greenhouse gases are equivalent in terms of warming effects. In this report, the gases' global-warming potential is estimated over a timescale of 100 years.
Equivalent effective useful life	The number of years by which the first-year savings estimate is multiplied to obtain lifetime energy savings. This value takes into account variations in annual energy savings throughout the effective useful life due to increased baselines.

Evaluated savings	Gross and net savings calculated by the Evaluator using the parameters (unitary savings values, installation rates, interactive effects, net-to-gross ratio, etc.) validated or measured during the evaluation process. Unless otherwise specified, the evaluated savings are the first-year savings.
Evaluation plan	The evaluation plan summarizes the program description, objectives, base cases, documentation, evaluation methodology, budget and schedule.
First-year savings	The first full year of energy savings generated by an energy efficiency measure.
Free-ridership	Percentage of gross savings attributable to participants who would have implemented the same or similar energy efficiency measures, with no change in timing, in the absence of the program.
Gross energy savings	Energy savings generated by energy efficiency measures, before applying the net-to-gross ratio.
Induced consumption	Energy consumption of appliances that would have been unplugged and not replaced by participants in the absence of the program.
Interactive effects	Effects on the energy consumption of other systems in the building (such as heating and cooling) due to the installation of an energy efficiency measure.
Internal spillover	Savings attributable to participants who continue to implement the energy efficiency measure introduced by a program after participating in it once, without participating in the program a second time.
In-service rate	The proportion of incentivized products that are installed and operating. This rate is usually applied to programs through which rebates are offered in-store and products are likely to be stored for a certain period before being installed, such as LED bulbs.
Lifetime energy savings	The energy savings that occur over the lifetime of an energy efficiency measure. Lifetime energy savings account for a measure's effective useful life and any increase in the baseline efficiency level (which reduces attributable annual savings) over its lifetime.
Line loss factor	The multiplier to convert savings at the customer meter to savings at the utility generator. It accounts for the electrical losses of the transmission and distribution system.
Margin of error	The amount of random sampling error.
Market effects	The impact of the program on the market (such as increased product availability, practices, and prices) that extends beyond changing the program participants' behaviour. This includes spillover among non-participants.
Net energy savings	Energy savings that can be reliably attributed to a program. This includes effects, such as free-ridership and spillover, that negatively or positively affect the energy savings attributable to a program.
Net-to-gross ratio	The ratio of net energy savings to gross energy savings.

Non-sampling error	Errors arising during the course of all survey activities other than sampling. Non-sampling errors tend to lead to bias in measurements and are very difficult to quantify.
Peak coincidence factor	The percentage of measure demand savings that coincide in time with the annual peak demand of the entire electricity system.
Peak demand savings	The demand savings that coincide in time with the expected annual peak demand period of the entire electricity system.
Precision	The extent to which repeated measurements agree with one another.
Random sampling error	The error in measurement due to the fact that measurements are taken from a subset of the population and not the entire population.
Sample size	The number of observations or replicates included in a statistical sample.
Secondary market impacts	Energy consumption of appliances that would have been transferred to the secondary market if said appliances had not been retired.
Tracked savings	Gross and net savings calculated by ENS in the tracking system, based on various parameters such as number of participants, unitary savings values, installation rates, interactive effects, and the net-to-gross ratio.
Unitary savings	Energy or peak demand savings established on a unitary basis. This unit can either be a product (e.g., an 8 W LED lamp), a capacity (e.g., one-ton capacity of an air-source heat pump) or a participant (e.g., one participant taking part in a behaviour-based program).

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EXECUTIVE SUMMARY

This report presents the demand-side management (DSM) results for the 2017 evaluation of the New Residential program. This program is comprised of one component: New Home Construction (NHC); the 2017 evaluation also included the Passive House pilot.

Table 1 below lists the number of participants, gross savings and net savings for NHC, the Passive House pilot and the whole program.

Table 1: Overall Participation and Savings for New Residential

	Participation Level	Gross Savings	NTGR	Net Savings
NHC				
Energy Savings	420 participants	3.162 GWh	1.06	3.351 GWh
Lifetime Energy Savings		94.849 GWh	1.06	100.540 GWh
Peak Demand Savings		0.895 MW	1.06	0.948 MW
Passive House Pilot				
Energy Savings	6 participants	0.050 GWh	0.39	0.020 GWh
Lifetime Energy Savings		1.801 GWh	0.39	0.702 GWh
Peak Demand Savings		0.014 MW	0.39	0.006 MW
Total				
Energy Savings		3.212 GWh		3.371 GWh
Lifetime Energy Savings ¹		96.650 GWh		101.242 GWh
Peak Demand Savings		0.909 MW		0.954 MW

NHC Overview

NHC encourages homeowners and builders to exceed energy efficiency building code requirements for new homes. Participation in NHC involves completing the following steps: (1) reviewing a home's plans using the HOT2000 simulation software; (2) providing the builder or the homeowner with a report which contains the simulation results and some energy-efficiency recommendations on how to make the home meet NHC eligibility requirements; (3) once the home is built, having an energy advisor (EA) conduct a final inspection and an air-tightness (blower door) test to verify the new home's energy-efficiency level.

¹ Throughout this report, energy savings always refer to first-year energy savings rather than lifetime energy savings, unless otherwise specified.

Over the last few years, various changes were made to NHC's incentive structure. The current incentive structure was introduced on May 1, 2017. Since September 1, 2017, NHC has adopted a new EnerGuide rating system and discontinued using the 0-100 rating system to enable estimating the annual energy use in gigajoules. NHC's incentive structure has since been adapted to accommodate this change by using this new EnerGuide rating system, but the rebate amounts have remained the same.

In October 2016, Efficiency Nova Scotia (ENS) launched a Passive House pilot to encourage builders and homeowners to build or buy homes that are even more energy-efficient and the savings from this pilot were evaluated separately from the savings from traditional 2017 NHC participants.

The 2017 evaluation was conducted based on a program component documentation review, an in-depth interview with the program manager, two rounds of telephone surveys with one conducted with 13 participants and the other with 59 builders, as well as four interviews with participants from the Passive House pilot.

Key Findings

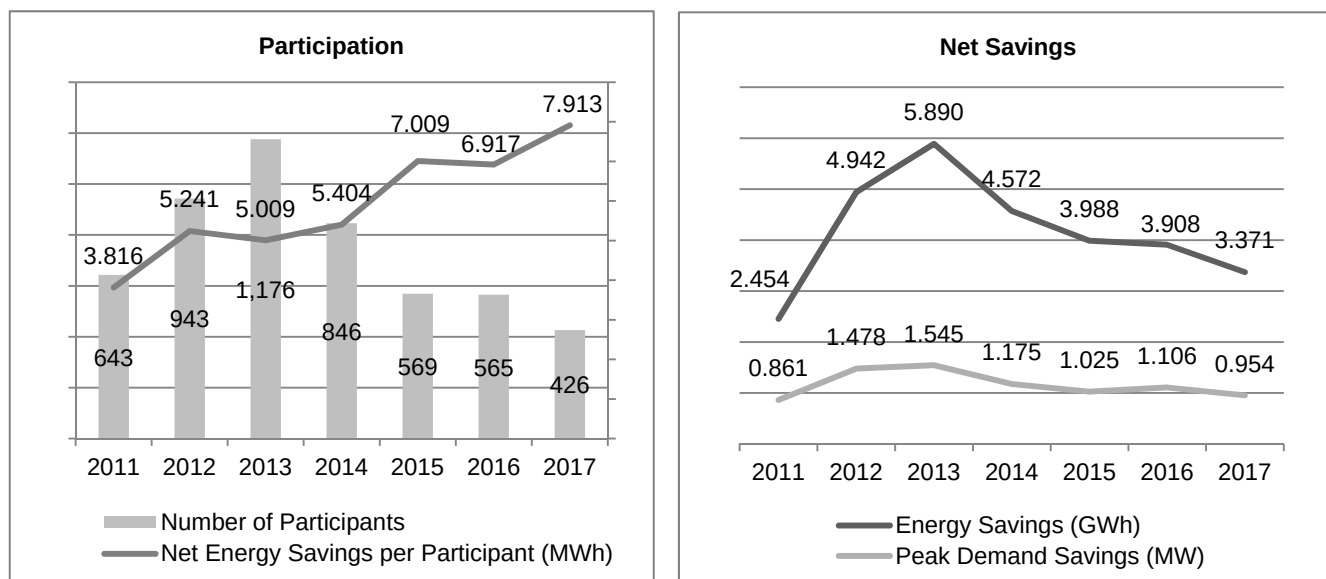
NHC Performance

NHC and the Passive House pilot combined aimed to achieve 4.0 GWh in net energy savings and 0.9 MW in net peak demand savings at the generator for 2017. The Evaluator found that they achieved 3.371 GWh in net energy savings (3.351 GWh for NHC and 0.020 GWh for Passive House) and 0.954 MW in net peak demand savings (0.948 MW for NHC and 0.006 MW for Passive House) at the generator in 2017. A total of 420 participants completed projects and generated electrical savings under NHC in 2017. Six participants completed one or more projects through the Passive House pilot.

Figure 1 below illustrates NHC's evolution in participation levels, as well as net energy and peak demand savings from 2011 to 2017. The 2017 figures also include the Passive House pilot. In 2017, participation in NHC was the lowest since it was launched in 2011.

The net energy and peak demand savings achieved in 2017 were lower than the annual figures from 2012 through 2016. Nonetheless, in 2017, NHC managed to achieve the highest per-participant net energy savings result since 2011, with 7.913 MWh per participant.

Figure 1: Performance Overview of NHC (2011-2017²) and Passive House (2017)



Market Evaluation Highlights

The participants and builders interviewed expressed moderately high satisfaction ratings for NHC, respectively averaging 6.6 and 7.2 on a 10-point scale, where 1 means “not at all satisfied” and 10 means “completely satisfied”. Compared to last year, satisfaction among builders remained stable, whereas satisfaction was lower among participants. The main reason for dissatisfaction among both participants and builders was that the rebate was too low. Builders also highlighted that there was not enough information about NHC and its process, and the long wait time it took to receive the rebate. Although half of the participants did not provide any recommendations on how to improve NHC, some suggested making the participation process simpler as one of the main recommendations.

Noteworthy is that all 19 surveyed non-participant builders had participated in NHC in the past. The main reasons mentioned for not participating in NHC in 2017 were that the rebate was not worth the effort and that the program component was too complicated.

² Until 2013, the level of participation in the program was measured and calculated by including all the participants who generated electrical savings. Starting from 2013, the method for measuring and calculating participation was changed to include participants who not only generated electrical savings, but also used electricity as their main heating source. This is why the 2011 and 2012 numbers of participants reported in the 2013, 2014 and 2015 evaluation reports are different from those reported in the 2011 and 2012 evaluation reports.

Energy Savings

The objective of the 2017 impact evaluation was to establish the net energy and peak demand savings for both NHC and the Passive House pilot. The Evaluator reviewed the contents of the 2017 tracking sheet and used the same method as employed by ENS to calculate gross savings. For NHC, most participants' gross energy savings were calculated by determining the difference between the to-code and the as-built modelled energy consumption values. For the small number of participants who did not have a to-code energy consumption value, the difference between the baseline average EnerGuide rating and the as-built EnerGuide rating, and an average savings value per EnerGuide point increase were applied.

To calculate the Passive House pilot's energy savings, first, the baseline energy consumption values were established by using a linear regression analysis of the to-code energy consumption values of 2016 and 2017 NHC participants. Then, the as-built energy consumption values were established by multiplying the treated floor area values by the as-built energy consumption per square footage values, which were determined with the Passive House Planning Package (PHPP) or WUFI®, two software tools commonly used by specialists to perform passive house modelling. Finally, the Passive House pilot's energy savings were calculated by comparing the baseline energy consumption values with the as-built energy consumption values.

In the 2015 evaluation, an overestimation ratio of 16 percent was established based on HOT2000 simulations. To adjust NHC's gross energy savings in 2017, this ratio was applied. The same overestimation ratio was also applied to the to-code energy consumption values used for the linear regression analysis to establish the baseline energy consumptions values of the Passive House pilot.

NHC's net savings were determined using the net-to-gross ratio (NTGR), which considers free-ridership and spillover (in the form of market effects). For 2017, the Evaluator established NHC's free-ridership at 29 percent, a level similar to 2016 (27%), and the market effects factor at 35 percent, which represents an high increase compared to 2016 (20%). The Evaluator established the Passive House pilot's free-ridership at 61 percent.

Based on the free-ridership and market effects levels established, the NTGRs for NHC and the Passive House pilot were established at 1.06 and 0.39 respectively, as shown in Table 2 below, and were used to determine the net savings.

Table 2: Net-to-gross Ratios

	NHC	Passive House pilot
Free-ridership Level	29%	61%
Market Effects	35%	-
Net-to-gross Ratio	1.06	0.39

The net energy and peak demand savings were respectively established at 3.351 GWh and 0.948 MW at the generator for NHC and respectively at 0.020 GWh and 0.006 MW at the generator for the Passive House pilot. Table 3 below compares overall tracked and evaluated savings at the generator.

Table 3: Overall Comparison of Tracked and Evaluated Savings at the Generator for New Residential

	Initial Gross Savings	Adjusted Gross Savings	NTGR	Net Savings
Energy Savings				
Tracked Savings from ENS	3.845 GWh	3.217 GWh	0.93	2.992 GWh
Evaluation Results	3.838 GWh	3.212 GWh	1.05	3.371 GWh
Peak Demand Savings				
Tracked Savings from ENS	1.088 MW	0.911 MW	0.93	0.847 MW
Evaluation Results	1.086 MW	0.909 MW	1.05	0.954 MW

The evaluated gross energy and peak demand savings are slightly lower than the tracked savings because of a small change to the line loss factor. As for its net energy and peak demand savings, the evaluated savings are 13 percent higher than those tracked by ENS. This difference is due to an increase in the NTGR value compared to the 2016 value for NHC participants. This increase in the NTGR value is mainly due to an increase in the market effects in 2017 (35% compared to 20% in 2016).

Recommendations

Like last year, the 2017 evaluation revealed that NHC achieved moderately high levels of satisfaction among participants and builders. In 2017, NHC reached the planned peak demand savings, but not its planned net energy savings. Additionally, the 2017 NHC participation level was at its lowest since 2011. In addition to the general recommendations presented for all ENS program components in the 2017 DSM Programs Evaluation Executive Summary, the Evaluator has the following recommendations to make for NHC. These recommendations can also be found in Appendix I.

- 2017 NHC-R1. Conduct a process evaluation for NHC in 2018.** During the 2017 evaluation, participants and builders made certain criticisms about NHC, especially on incentive levels and the participation process. Also, the NHC participation level continued to decrease. In light of these findings and the substantial changes made to NHC in 2017, the Evaluator recommends conducting a process evaluation of NHC next year to determine if current program component processes, parameters and model of delivery are optimized to meet market needs. The process evaluation's scope could include a benchmarking study of other Canadian or North American jurisdictions to compare NHC to other similar programs, and an in-depth consultation with builders and other key actors involved in the residential new construction market to find the most effective ways to generate more projects through a simple and straightforward participation process. Market data should also be collected to obtain insights about market forces that may be influencing the decline in NHC participation.
- 2017 NHC-R2. Conduct a billing analysis to review the overestimation ratio.** The current overestimation ratio was obtained from a billing analysis of Home Energy Assessment participant data. In past years, no billing analyses were conducted with NHC participants since only a few participants had their as-built energy consumption value available. Now that energy consumption is available for more participants and a new version of HOT2000 is being used to calculate energy savings, the Evaluator recommends conducting a new billing analysis in the next evaluation to establish an overestimation ratio specific to new houses under NHC and the new version of HOT2000.

INTRODUCTION

Efficiency Nova Scotia (ENS) is a franchise held by EfficiencyOne³ and is responsible for helping Nova Scotians improve the energy efficiency of their homes and workplaces. ENS designs, markets and delivers energy efficiency and conservation programs for various segments of the population. ENS receives funding for its activities from Nova Scotia Power and the Province of Nova Scotia. The funds received from Nova Scotia Power cover the costs of activities designed to help reduce electricity consumption, whereas funds from the Province of Nova Scotia are primarily used for activities designed to help reduce the use of other fuels by households with lower incomes.

Econoler was commissioned to evaluate ENS's 2017 demand-side management (DSM) program portfolio comprised of six electricity efficiency programs and assess the impact of energy efficiency codes and standards introduced in Nova Scotia. To carry out this assignment, Econoler collaborated with Research Into Action, Equilibrium Engineering and Corporate Research Associates (CRA).

Econoler served as team leader in the 2017 evaluation and was involved in every aspect of the evaluation. Specifically, Econoler was in charge of coordinating and supervising all activities, conducting final reviews of all data collection instruments, performing impact evaluation calculations, as well as preparing and reviewing the evaluation reports. Research Into Action carried out the process evaluations, while Equilibrium Engineering conducted the on-site visits and contributed to some impact evaluation analyses. CRA conducted the interviews and surveys with participants and partners, as well as analyzed and reported on the data collected from these activities. Throughout this report, this team is referred to as the Evaluator.

For each program, the Evaluator prepared a DSM evaluation report presenting the general findings, electrical first-year and lifetime energy savings, peak demand savings and avoided greenhouse gas (GHG) emissions.

Table 4 below lists the various programs assessed as part of the 2017 evaluation and indicates their respective components and the types of evaluations conducted. In this table, "C" means a complete evaluation, and "R" indicates that reduced evaluation activities were performed, as compared to 2016. Section 1 of the DSM Programs Evaluation Executive Summary presents the scope of work in further detail, along with the rationale for the types of evaluations performed for each program component. The 2017 evaluation scope was the same as in 2016 for New Home Construction (NHC).

³ On January 1, 2015, ENS became a franchise owned by the Province of Nova Scotia and was licensed to the new not-for-profit organization EfficiencyOne.

Table 4: Types of Evaluations Conducted for Each Program Component

Program	Program Component	2016			2017		
		Process	Market	Impact	Process	Market	Impact
Residential Efficient Product Rebates Program	Appliance Retirement		C	C			R
	Instant Savings		C	C		R	R
Existing Residential Program	Home Energy Assessment		C	C		C	C
	Green Heat		C	C	C	C	C
	Efficient Product Installation		C	C		C	C
New Residential Program	New Home Construction		C	C		C	C
Efficient Product Rebates Program	Business Energy Rebates		C	C		C	R
Custom Incentives Program	Custom		C	C	C*	C	R
	Energy Management Information Systems	C	C	C		C	C
	Strategic Energy Management**	C	C	C			
Direct Installation Program	Small Business Energy Solutions	C	C	C		C	C
*The process evaluation specifically targets the Retrofit service of the Custom program component. ** Due to the start date of the latest Strategic Energy Management (SEM) cohort, SEM did not have any participants who achieved savings in 2017; therefore, no evaluation was conducted for 2017.							

This evaluation report is for the New Residential program, which is comprised of one component: NHC. The program component description, evaluation methodology and main evaluation findings are presented in the following sections.

1 NHC OVERVIEW

This section describes the NHC program component, follows up on 2016 evaluation recommendations and presents participation history.

1.1 Description

NHC is meant to encourage homeowners and builders to exceed building code requirements for energy efficiency in new homes, thus increasing the number of energy-efficient dwellings in the province. Since October 2015, NHC has been fully funded through DSM funds. In the past, the Province of Nova Scotia funded measures implemented in non-electrically heated homes. However, provincial funding came to an end on October 20, 2015, and any funding beyond that date was provided only to participants registered before the aforementioned date. Since then, only electrically-heated households have been eligible.

Once a new home is registered, an energy analysis tool developed by the federal government (HOT2000)⁴ is used to model the energy efficiency of the home to calculate energy consumption based on both the building code and house plans before construction begins. House plans are evaluated by energy advisors (EAs) who work for the delivery agents (DAs) hired by ENS to implement NHC across Nova Scotia. This review of house plans is meant to inform participants of the expected performance level of the home and provide recommendations to meet NHC requirements. The recommendations can consist of a certification (ENERGY STAR® Canada or R2000) or an improvement beyond the National Building Code's (NBC) minimum requirements. Once the home is built, a final assessment and a blower door test are completed by an EA to verify the energy efficiency performance.

Various changes were made to the NHC incentive structure over the last few years. The current incentive structure was introduced on May 1, 2017. The following incentives are currently available to NHC participants:

- › An incentive of \$2,000 is provided for homes that achieve: (1) ENERGY STAR certification (or an EnerGuide rating of 85 to 87), or (2) an energy use level 30 percent better than required by the NBC for homes no bigger than 1,200 ft², or (3) an energy use level 45 percent better than required by the building code for homes bigger than 1,200 ft².
- › An incentive of \$5,000 is provided for homes that achieve: (1) R2000 certification (or an EnerGuide rating of 88 or above), or (2) an energy use level 45 percent better than required by the NBC for homes no bigger than 1,200 ft², or (3) an energy use level 60 percent better than required by the building code for homes bigger than 1,200 ft².

⁴ This software was developed by the Housing, Buildings, Communities and Simulation Group of CanmetENERGY, a division of NRCan: http://198.103.48.154/eng/software_tools/hot2000.html. (Last accessed October 31, 2016).

On September 1, 2017, NHC transitioned to a new EnerGuide rating system, thereby retiring the 0-100 rating system in favour of an estimated annual energy use in gigajoules. The incentive structure was adapted to accommodate this change by using this new EnerGuide rating system, but the rebate amounts remained the same. This new version of the rating system and HOT2000 are meant to provide homeowners with more useful information about their new homes' energy performance.

ENS launched a Passive House pilot in October 2016 to encourage builders and homeowners to build or buy homes that are even more energy efficient. Participants who meet the Passive House requirements get a \$10,000 incentive. To be eligible, a project must either be Passive House certified or meet a heating demand of 7.1 kBtu/ft²/yr or lower. Projects that do not meet these requirements are transferred to NHC. The Passive House pilot was available to a limited number of projects (20), and all spaces were filled by December 2016. All enquiries from builders or homeowners after this time were placed on a waiting list should the pilot become a program component.

Combined, NHC and the Passive House pilot aimed to achieve 4.0 GWh in net electricity savings and 0.9 MW in net peak demand savings at the generator for 2017.

1.2 Follow-up on the 2016 Evaluation Report Recommendations

The Evaluator evaluated NHC in 2016 and made improvement recommendations. Table 5 below provides a brief summary of the implementation status of each recommendation presented in the executive summary section of the 2016 evaluation report.

Table 5: Implementation Status of the Recommendations in the 2016 Executive Summary

2016 Recommendations	Status
2016 NHC-R1. Continue conducting project reviews to assess the evolution of the quality of simulation files.	Implemented
2016 NHC-R2. Ensure that all required documentation is included in participant files.	Implemented

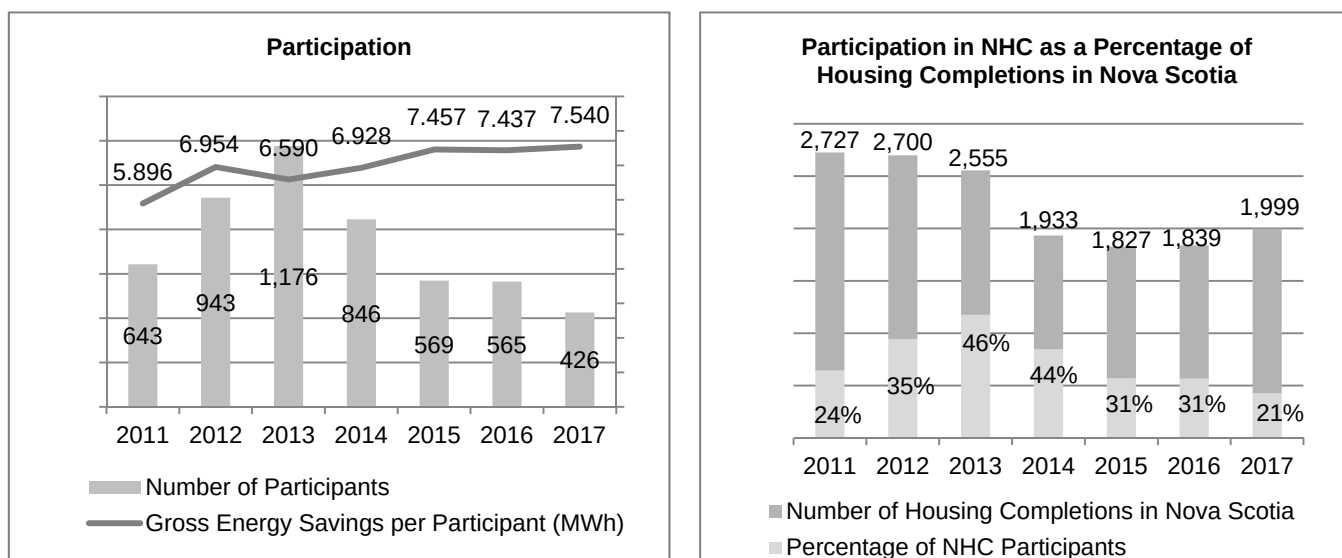
Both recommendations were made after the Evaluator had observed some missing information and differences in the quality of the simulation files during the 2016 evaluation. Since then, ENS has continued reviewing projects, especially since the transition to the new rating system in September 2017, and required that DAs provide all the participant documentation needed. Additionally, a training file was sent to the DAs and their EAs to ensure consistency in the information that is entered in the simulations and how it is entered. This process also included a review of and training on how DAs and EAs model and recommend upgrades.

1.3 Participation History

Figure 2 below illustrates NHC's evolution in participation levels as well as in net energy and peak demand savings from 2011 to 2017. The 2017 figures also include the results from the Passive House pilot evaluation. In 2017, a total of 420 participants completed a project under NHC (and generated electrical savings), and six participants completed one or more projects through the Passive House pilot. In 2017, participation in NHC was lower than in previous years. Despite lower participation, new registrations for NHC increased in 2017 over 2016 and 2015. A factor influencing participation in NHC was the total number of new houses in the market. Although slightly higher than in 2016, Nova Scotia's total number of housing completions in 2017 was much lower than in the early years of NHC, as highlighted in Figure 2 below.

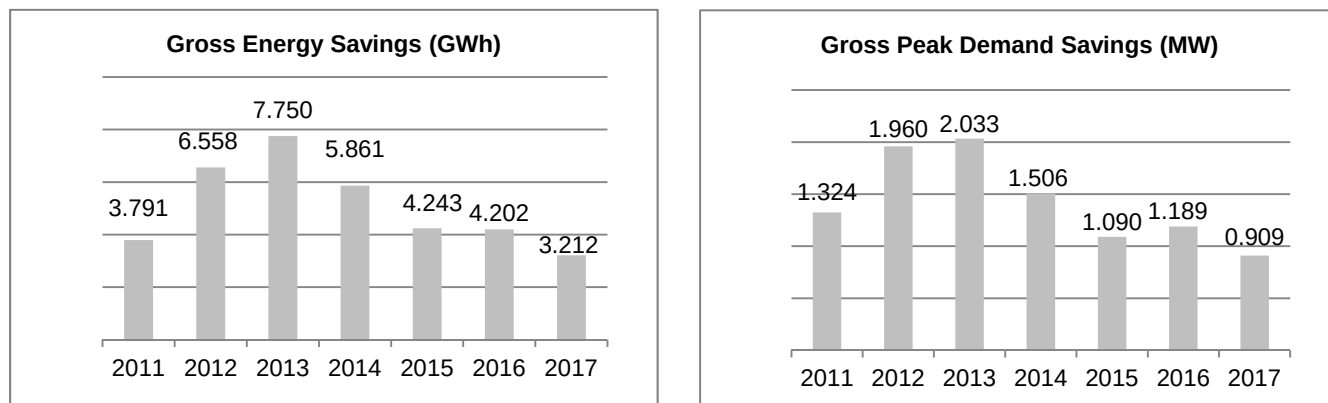
In terms of the gross energy and peak demand savings, 2017 results were lower than in previous years. In 2017, NHC achieved 3.212 GWh (3.162 GWh for NHC and 0.050 GWh for Passive House) and 0.909 MW (0.895 MW for NHC and 0.014 MW for Passive House) respectively, as shown in Figure 3 below. Nonetheless, the per-participant gross energy savings value has never been higher.

Figure 2: Summary of Participation in NHC (2011-2017) and Passive House (2017)⁵



⁵ The number of participants shown in the figures refer to those participants who not only generated electrical savings, but also used electricity as a main heating source. These numbers include participants from both Performance Plus and NHC. The 2011-2017 housing completion numbers were found on the Canada Mortgage and Housing Corporation website using the Housing Market Information Portal at: <https://www03.cmhc-schl.gc.ca/hmiportal/en/#Profile/12/2/Nova%20Scotia>. (Consulted January 29, 2018).

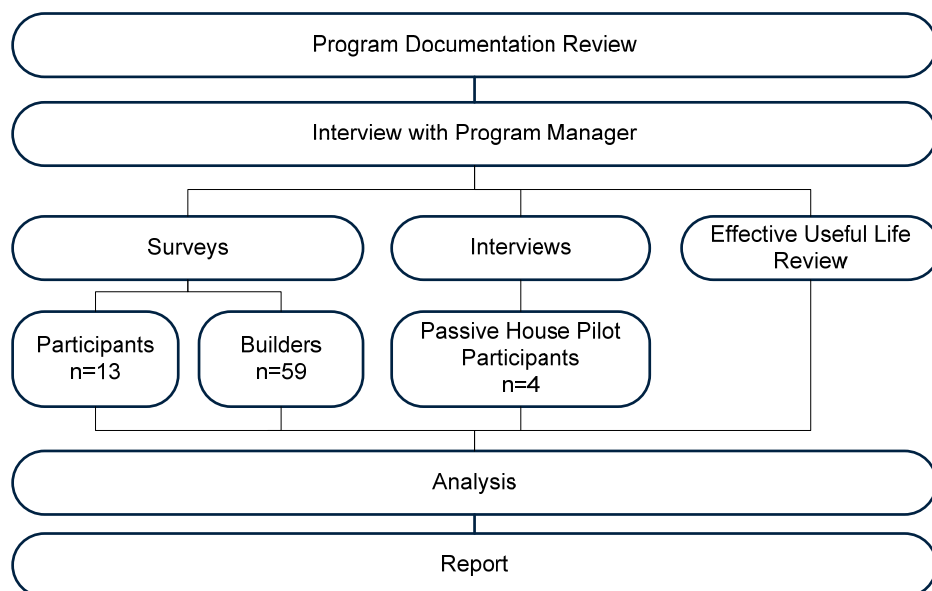
Figure 3: Summary of Gross Savings for NHC (2011-2017) and Passive House (2017)



2 NHC EVALUATION METHODOLOGY

This section presents the methodology used and the activities carried out for the 2017 NHC evaluation. As illustrated in Figure 4, various data collection activities were used throughout the evaluation.

Figure 4: Methodological Model



The Evaluator first reviewed the program component documentation and then met the program manager in August 2017 to verify the implementation status of the previous evaluation recommendations and learn about the program component changes made in 2017. Based on the information obtained from this meeting, the Evaluator prepared a list of questions and topics to be included in the data collection instruments.

Once the program manager meeting and the program component documentation review were completed, specific evaluation activities were undertaken, as described in the following subsections.

For evaluation activities that yield quantitative results based on a sample, the Evaluator aimed to achieve a maximum margin of error of 10 percent at a confidence level of 90 percent. This means that if measurements were conducted many times with different samples, the data would be within 10 percentage points above or below the percentage reported 90 percent of the time. Thus, the margin of error indicates the relative level of precision⁶ of the measurement, while its associated confidence level indicates the probability of a measure falling within this margin of error.⁷

⁶ Precision refers to how reproducible a set of measurements is. It does not take into account, however, how close the measured values are to the true values, since this refers to accuracy.

⁷ As part of this evaluation, the confidence level and the margin of error only take random sampling errors into account; they do not reflect non-sampling errors or biases such as data entry errors, inaccurate responses from respondents or the inability to contact certain people.

As part of this evaluation, the Evaluator calculated the margins of error for survey samples and free-ridership levels. The margins of error are presented alongside the results in the relevant sections further below. An example of the calculation used to establish the margin of error for survey samples is also presented in Appendix II of the 2017 DSM Programs Evaluation Executive Summary.

Participant Survey

In November 2017, CRA conducted a telephone survey with a total of 13 NHC homeowner participants using computer-assisted telephone interviewing technology. The average length of the survey was 20 minutes. The questionnaire and the complete survey results are presented in Appendix II and Appendix III respectively. All appendices are presented in the New Residential Program – Appendices.

The participant survey was meant to collect feedback on the following aspects:

- › Participation motivations
- › Satisfaction with NHC
- › Free-ridership (including the cross-influence of ENS promotion and other ENS programs)
- › Barriers to implementing upgrades
- › Recommendations for improvement
- › Demographics

Among the 420 projects that generated electrical savings in 2017, 57 applications were made by homeowners and 363 by builders, as per the applicant column in the tracking sheet. At the time of conducting the survey in the fall of 2017, the contact information for only 27 homeowners was available for the survey (after removing duplicates). Due to this small population, a census attempt was undertaken rather than using a sampling approach, resulting in 13 completed interviews out of the 27 available contacts. Drawing a random sample of 13 from a population of 57 would yield a margin of error of 20.9 percent at a 90 percent confidence level.

Builder Survey

In November 2017, CRA conducted a telephone survey with a total of 59 builders across Nova Scotia. The average length of the builder survey was 7.5 minutes. Of the 59 builders, 40 participated in NHC in 2017 (participant builders) and 19 did not (non-participant builders). Two separate sets of questions were asked, depending on whether builders were participants or non-participants.

The purpose of the builder survey was to assess free-ridership (among participant builders only) and spillover (in the form of market effects). The survey questionnaire also included questions on builder participation motivations, satisfaction with NHC, and improvement recommendations.

The survey questionnaire and results are presented in Appendices IV and V respectively. The survey contact list included 242 builders. With a total of 59 surveyed builders, the corresponding margin of error is ± 9.3 percent at a 90 percent confidence level.

Passive House Pilot Participant Interviews

In December 2017, CRA conducted interviews with four participants from the Passive House pilot (accounting for five projects). Three of the four interviewed participants were homeowners, and one was a builder. The main purpose of the interviews was to assess free-ridership.

The interview guide and results are presented in Appendices VI and VII.

Effective Useful Life Review

As part of the 2017 evaluation, to examine the effective useful life (EUL) values used by ENS to calculate lifetime energy savings, the Evaluator conducted a thorough literature review by consulting technical reference manuals (TRMs), evaluation reports and relevant studies.

3 NHC MARKET EVALUATION

This section presents participant and builder perspectives on NHC.

3.1 Participant Perspectives

A survey of 13 participant homeowners was conducted as part of the NHC evaluation. Since no homeowners had completed projects under the current NHC incentive structure at the time of the survey, all 13 surveyed participants were from previous versions of NHC which had lower incentive levels.

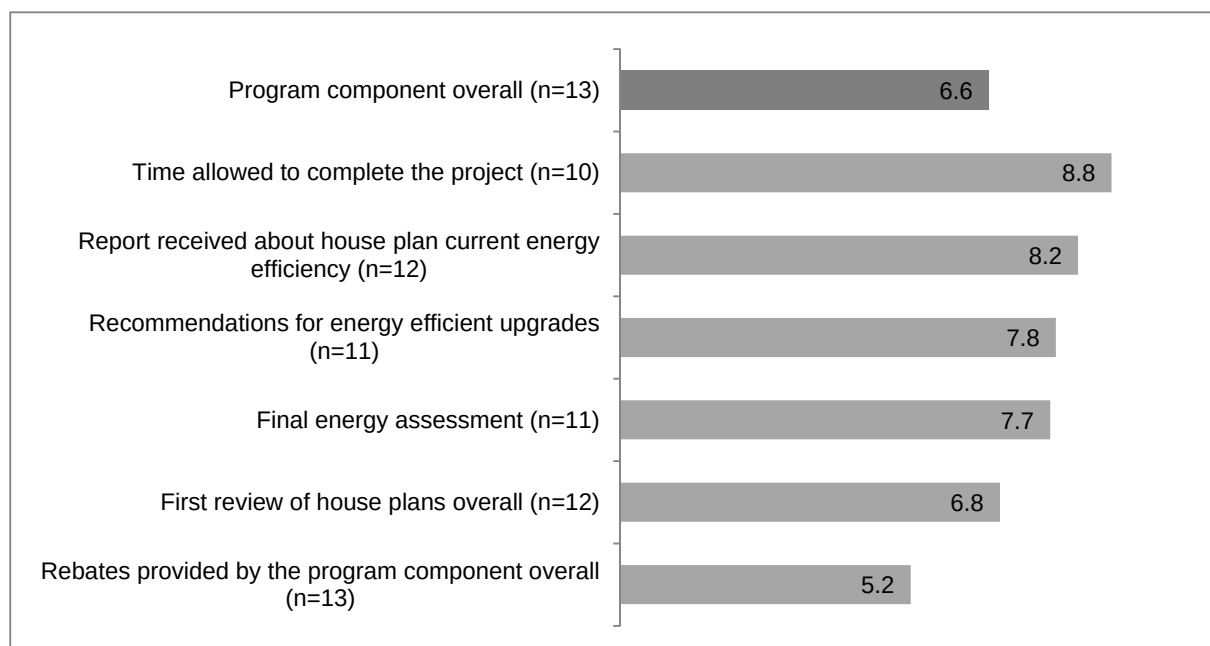
In all cases, homeowners were involved in the decision to both participate in NHC and determine which energy efficiency measures to install. The most important reasons for participation were to have a house that would save on energy costs/bills or to obtain rebates.

When asked about what they consider important when choosing equipment or measures to be included in their new home, participants placed high importance on reducing energy costs (9.8 on a 10-point scale where 1 is “not at all important” and 10 is “extremely important”) and reducing energy consumption (9.5 out of 10). Increasing the value of their home (7.0) and using lowest-cost options for building choices (5.0) were important, but to a lesser degree. Participants were asked if any other considerations were important for them when choosing equipment or measures. Participants also identified recommendations from a builder, friends or family, as well as the longevity of equipment, and functionality as other important considerations (each was mentioned by 2 participants).

The 13 surveyed participants expressed moderate satisfaction with NHC overall, with an average rating of 6.6 on a 10-point scale where 1 is “not at all satisfied” and 10 is “completely satisfied.” Reasons for dissatisfaction include the rebates being too low (5 mentions), the information or advice given by NHC changed during the participation process (2 mentions), and it took too long to receive the rebates (1 mention). The main improvement recommendations include increasing rebates (4 mentions), making the participation process simpler (2 mentions), and offering more upgrades eligible for rebates (2 mentions). Finally, it is important to note that half the participants were unable to make any recommendations.

As demonstrated in Figure 5 below, satisfaction with NHC aspects varies. Participants reported fairly high levels of satisfaction with: (1) the time allowed to complete the project (8.8); (2) the report on current home energy efficiency (8.2); (3) the upgrade recommendations (7.8); and (4) the final energy assessment (7.7). Meanwhile, the first review of the house plans (6.8) and the rebates provided by the program component (5.2) received lower ratings.

Figure 5: Participant Satisfaction with NHC (10-point Scale)



3.2 Builder Perspectives

A survey of 40 participant builders and 19 non-participant builders was conducted as part of the NHC evaluation.

Most surveyed participant builders (83%) said they usually make the decision to participate in the program component, while 13 percent usually jointly decide with the homeowner. The main reasons for participating in NHC in 2017 were to reach the certification or energy efficiency level promoted by the program component (39%), obtain rebates for upgrades that had already been planned (26%), or build a house that would save energy costs for homeowners (26%).

Builders are moderately satisfied with NHC (average of 7.2 on a 10-point scale). The main reasons for not being more satisfied with the program component include: (1) the rebates were too low (55%); (2) not enough information about NHC and the process (14%); or (3) it took too long to receive the rebate (14%). The main NHC improvement recommendation was to increase incentives (33%), while two or fewer participant builders made mention of other aspects (see Appendix V for more details).

All 19 surveyed non-participant builders had either participated in NHC or its previous version (Performance Plus) at least once. The main reasons mentioned for not participating in NHC in 2017 were that the rebate was not worth the effort and that the program component was too complicated.

4 NHC IMPACT EVALUATION

The objective of the 2017 NHC impact evaluation is to determine the NHC and Passive House pilot gross and net electrical energy savings and peak demand savings.

4.1 Gross Savings

The gross savings correspond to the change in energy consumption resulting from the energy efficiency reached in the new homes by NHC and Passive House pilot participants, regardless of why they participated.⁸ The Evaluator revised the gross savings that ENS tracked by reviewing the modelled gross energy savings calculations, overestimation ratio, and peak demand savings.

The methodology for evaluating these elements is described in the following subsections.

4.1.1 Gross Energy Savings Calculation for NHC

The final tracking system provided by ENS for 2017 contained data for a total of 420 participants who generated electrical savings. To establish the modelled gross energy savings associated with each participant, two methods were used. Since 2015, to-code and as-built modelled energy consumption values have been available in the tracking system for most participants and were used for the savings calculation. For participants who registered in NHC before 2015, the to-code energy consumption value was not available, so the old savings calculation method was used. The old calculation method consists of applying the average savings per EnerGuide point increase to the difference between the baseline EnerGuide rating (established at 78) and the as-built EnerGuide rating. For the 2017 evaluation, this old method was used for only four participants.

As of October 2015, only participants who use electricity as their main heating type are eligible for NHC.⁹ In these cases, all savings are claimed as electrical regardless of the share of electricity delivering heat throughout the year.

⁸ Definition adapted from National Renewable Energy Laboratory, *The Uniform Methods Project Chapter 23: Estimating Net Savings: Common Practices*, September 2014, p. 3. http://energy.gov/sites/prod/files/2015/02/f19/UMChapter23-estimating-net-savings_0.pdf. (Last accessed November 21, 2016).

⁹ ENS considers a home to be “electrically heated” when the home heating system(s) provides all or most of the heating from electricity.

Method 1: Modelled Energy Consumption

The modelled gross energy savings are calculated by comparing the to-code and as-built modelled energy consumption levels resulting from the HOT2000 simulations. The to-code energy consumption represents the value of the baseline, i.e. the energy consumption of the house built according to the current building code. For this method, the modelled gross energy savings are calculated with the following equation:

$$\text{Gross Energy Savings (kWh)} = [EC(kWh)_{\text{To-Code}} - EC(kWh)_{\text{As-Built}}]$$

Where EC corresponds to the total energy consumption of the house.

Electrical heating systems must provide all or most of the home heating. When a non-electrical heating system is used as backup, the baseline heating system modelled in the to-code simulation corresponds to 100 percent electrical baseboards. However, the total as-built modelled energy consumption of the house is subtracted from this scenario even if a portion of energy consumption is non-electrical. This ensures a conservative estimate in the savings calculation and avoids accounting for fuel-switching savings. It should also be noted that this situation is not frequent; only 10 percent of participating homes had a non-electrical backup heating system installed, accounting for less than 18 percent of the total energy consumption of all 2017 participating homes.

The Evaluator considers this method as appropriate and should be favoured whenever the as-built consumption value is available.

Method 2: Savings per EnerGuide Point

For 2017, the savings per EnerGuide point method is used for those participants who do not have a to-code energy consumption value. The savings calculation is here based on the following equation:

$$\text{Gross Energy Savings (kWh)} = [ER_{\text{As-Built}} - ER_{\text{Baseline}}] \times \text{Savings per EnerGuide Point (kWh)}$$

Where ER corresponds to the EnerGuide rating.

The average baseline EnerGuide rating is established at 78. This value is based on Revision 2012 of the NBC (Part 9) adopted in July 2013 by Nova Scotia.¹⁰ The requirements of the NBC Revision 2012 have been in effect in Nova Scotia since December 31, 2013; these requirements indicate that an average EnerGuide Rating of 78 should be used when modelling is performed using HOT2000 Version 10. In addition, the average value of the available to-code EnerGuide rating in the 2017 tracking system is between 78 and 79. The Evaluator therefore considers an EnerGuide baseline of 78 as still valid for 2017 and appropriate for the current market.

¹⁰ Nova Scotia, Building Code Regulation, “Nova Scotia Building Code Regulation – Users Version, 2014”, pp. 88-89, available at: <https://novascotia.ca/dma/firesafety/buildingcode/docs/141020FINALUSERSNSBCR141231.pdf> (Last accessed December 11, 2017).

The savings per EnerGuide point value currently used in the tracking system, i.e. 1,521 kWh, is drawn from the 2015 NHC Evaluation Report. This value is based on the average savings per EnerGuide point of 2015 NHC participants for whom savings had been calculated using the modelled energy consumption values and whose final EnerGuide ratings were available.

The number of participants using the EnerGuide point method in the 2017 evaluation is very small (four participants). Since October 2015, all NHC participants have had a modelled to-code energy consumption value. Given this small number and because the participants still using the EnerGuide point method this year had registered for NHC prior to 2017, the Evaluator maintained the 2015 savings value of 1,521 kWh per EnerGuide point to calculate the savings of these participants.

4.1.2 Gross Energy Savings Calculation for Passive House Pilot

Savings for the Passive House pilot are calculated by comparing the baseline energy consumption and as-built energy consumption using the following formula:

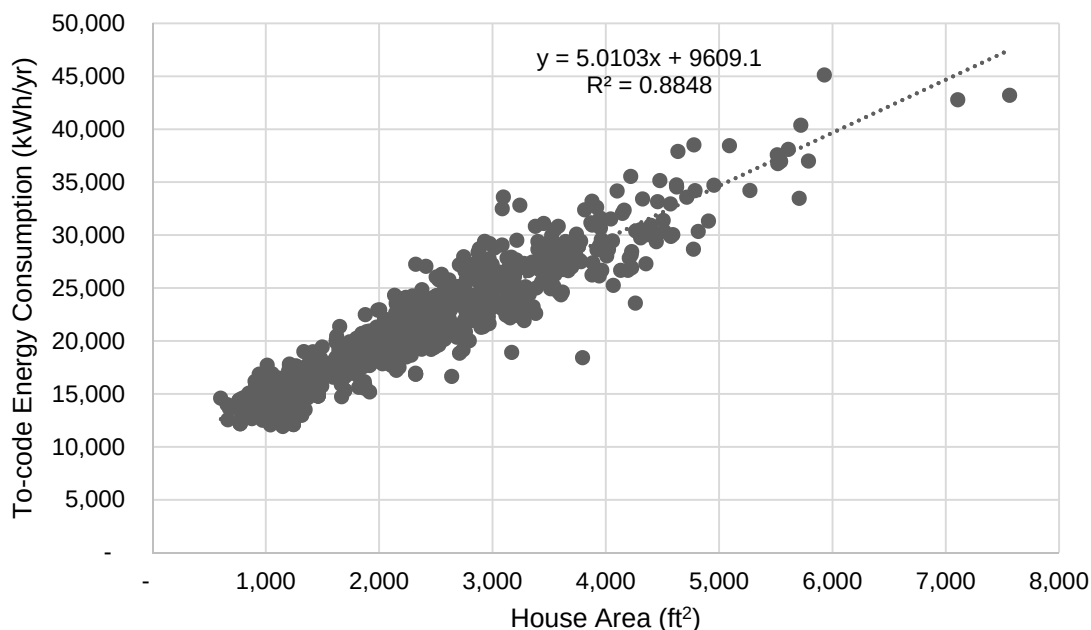
$$\text{Gross Energy Savings (kWh)} = [EC(kWh)_{\text{Baseline}} - (EC(kWh/ft^2)_{\text{As-Built}} * TFA(ft^2))]$$

Where:

- › EC_{Baseline} is the baseline energy consumption (kWh)
- › $EC_{\text{As-built}}$ is the as-built energy consumption per square footage (kWh/ft²)
- › TFA is the treated floor area (ft²)

Baseline energy consumption values were calculated using a linear regression analysis based on the to-code energy consumption and house area values of 2016 and 2017 NHC participants who use electricity as a primary heating source. Both to-code energy consumption and built house area values were tracked in the NHC tracking sheet. Figure 6 illustrates the results of the linear regression analysis along with the linear equation used to estimate the baseline energy consumption versus the house area.

Figure 6: Linear Regression Analysis Between the To-code Energy Consumption and House Area



The linear regression analysis was established using 911 points (one point per participant). The resulting coefficient of determination (R^2) of 0.8848 means that the regression is statistically acceptable. Based on the linear equation obtained from this regression, the common floor area values of the Passive House pilot participants were then used to calculate the baseline energy consumption values of each participant. The common floor area values were calculated from the building plans of participant houses and represent interior floor areas of all heated space within the envelope. This floor area definition is also how HOT2000 defines a house floor area for modelling.

As-built energy consumption per square footage values were calculated using either Passive House Planning Package (PHPP) or WUFI®, which are well-known software applications used by specialists in passive house modelling. All passive house projects must be modelled under either software to determine whether the project is eligible for the Passive House pilot or not. To be eligible, projects must meet a heating demand of 7.1 kBtu/ft²/yr or lower.

PHPP and WUFI® use the treated floor area values which are different from the house floor area values used in HOT2000. For the treated floor area values, areas such as stairs with more than three steps, garages, chimneys, walls, and interior columns are excluded. Rooms must have a height of 6.6 ft or higher. Furthermore, only 50 percent of the floor area is considered for rooms with a height between 3.3 and 6.6 ft. Finally, 60 percent of the floor area of storage and mechanical rooms are included in the simulation. As-built energy consumption is established for each Passive House pilot participant by multiplying the treated floor area value and the as-built energy consumption per square footage value.

This method was developed by ENS and used in the tracking system for all participants of the Passive House pilot. Upon reviewing all participant simulation files, the Evaluator validated that the values inputted in the energy modelling and the results obtained were accurate. The ENS methodology to calculate energy savings generated by passive houses is considered appropriate. Therefore, the Evaluator used the same approach to calculate 2017 Passive House pilot savings.

4.1.3 Overestimation Ratio

The overestimation ratio is used to adjust the modelled energy consumption values generated by the HOT2000 software because it tends to slightly overestimate the savings. For the 2017 evaluation, the Evaluator continued using the overestimation ratio of 16 percent obtained from the billing analysis conducted in the 2015 evaluation.

This billing analysis was conducted with Home Energy Assessment (HEA) participants for the three years from 2013 to 2015. The analysis for the period before the upgrades was performed for 305 participants, while the analysis for the period after the upgrades was performed for 208 participants.

Most efficiency measures under HEA relate to space heating consumption. The participant heating consumption calculated by HOT2000 was compared with the actual space heating consumption obtained from electrical billing data for each full year pre- and post-upgrades. A regression analysis was performed to isolate the portion of electrical energy consumption that varies according to outdoor temperature and corresponds to electricity consumption due to space heating. An average deviation of 16 percent was obtained for both pre and post-upgrade periods between the heating consumption levels from the HOT2000 simulations and the actual consumption of participants.

The Evaluator believes the overestimation ratio calculated for HEA participants can be easily applied to total energy consumption of NHC houses. The fact that the majority of the savings achieved through NHC and the Passive House pilot also relate to measures affecting space heating consumption justifies applying the HEA overestimation ratio to the total energy consumption.

It should be noted that the energy savings of a small proportion (3%) of NHC participants were calculated with a new version of HOT2000. It is expected that this proportion will increase in 2018. In past years, no billing analyses were conducted with NHC participants since as-built energy consumption values were available for only a small proportion of participants. Since a new version of HOT2000 is now being used to calculate energy savings and most of the NHC participants now have their as-built energy consumption value available, the Evaluator recommends conducting a billing analysis with NHC participants to estimate a new overestimation ratio.

Using the overestimation ratio, the NHC gross energy savings obtained under both methods mentioned in Section 4.1.1 are adjusted as per the following equation:

$$\text{Adjusted Gross Energy Savings (kWh)} = \text{Initial Gross Energy Savings (kWh)} \times (1 - 16\%)$$

It should also be noted that for the savings for the Passive House pilot, the same overestimation ratio was applied to the to-code energy consumption values from HOT2000 used for the linear regression analysis.

4.1.4 Interactive Effects

No additional interactive effects are considered in the NHC savings calculation since they were already taken into account in the HOT2000 simulations.

For the Passive House pilot, the interactive effects were already considered in the savings calculation since the calculations are also based on simulation models.

4.1.5 Peak Demand Savings

The peak demand savings correspond to the demand savings that coincide in time with the peak demand of the electricity system. The projected electricity demand peak period in Nova Scotia is between 5 p.m. and 7 p.m. from December to February on a non-holiday weekday.

For both NHC and the Passive House pilot, peak demand savings were calculated using the on-peak demand-to-energy ratio of 0.283 MW/GWh established by Navigant in the 2016-2018 DSM Plan. This ratio was established using modelled system-coincident peak demand savings and energy savings for a projected deployment of measures. Navigant also used local data to establish this ratio. The Evaluator thinks that the approach used by Navigant is valid and therefore used it to estimate peak demand savings for NHC and the Passive House pilot.

4.1.6 Effective Useful Life

As part of the 2017 evaluation, the Evaluator reviewed the EUL values used by ENS in the calculations of energy savings that will persist over time.

For NHC and the Passive House pilot, the EUL values were reviewed based on the findings of a literature review. When establishing the EUL for a new or passive house, the Evaluator considered the most common values found in TRMs, evaluation reports or relevant studies. Table 6 summarizes the tracked and revised EUL values.

Table 6: Summary of Effective Useful Life Values for NHC

Measure	ENS Tracked EUL	Revised Equivalent EUL	Reference
New Home Construction	34.9	30.0	Weighted average EUL of insulation, heating system and lighting measures
Passive House Pilot	34.9	36.0	Weighted average EUL of insulation, heating system and lighting measures

The literature review revealed that most jurisdictions use EUL values between 20.0 and 25.0 years for new home constructions that include similar measures. However, while a new construction as a whole is considered a measure, it is composed of various measures. ENS currently calculates the EUL for new home constructions by using a simple average of the EUL for insulation, efficient lighting and heating systems.

The Evaluator agrees that these three measures contribute the most to the savings of NHC projects, but considers that each measure has a different weight on the savings. However, the weight of each of these measures is unknown since they are all simultaneously inputted in the building simulations, so the savings attributed to each measure type are not available.

Thus, the Evaluator estimated the weight of each measure on the savings for an average NHC project. This estimation is based on Evaluator experience with building efficiency and potential savings resulting from the different building components (insulation, heating system, air conditioning, lighting, appliances, etc.). The Evaluator believes that, for each project, the largest portion of savings is generated by the insulation measure. While efficient heating systems such as heat pumps generate a similar amount of savings as increased insulation, the Evaluator assumed that almost all participants installed insulation while efficient heating systems are installed by fewer participants. Finally, savings from efficient lighting should also be less than savings generated by insulation. Therefore, the Evaluator respectively established the weight of insulation, efficient heating systems and efficient lighting at 50, 25 and 25 percent for NHC projects.

Each of the Passive House projects are mainly composed of the same category of measures. Each of these categories of measures was assigned a specific weight according to the share that this category accounted for in the Passive House pilot's total savings. One key parameter differentiating the Passive House pilot projects was that the requirements for insulation level were even higher, thus increasing the share of insulation savings among total savings. Therefore, of all the Passive House pilot projects, insulation, efficient heating systems and efficient lighting were respectively assigned a weight of 70, 15 and 15 percent.

In addition to using a weighted average, the Evaluator revised the EUL values of these three measure categories based on a literature review. Table 7 below lists the tracked and the revised EUL values by measure category.

Table 7: Summary of Effective Useful Life Values for Measures in NHC and Passive House Projects

Measure	ENS Tracked EUL	Revised EUL	Reference
Insulation	70.0	45.0	Regional Technical Forum, <i>UES Measures – Built Green Washington</i> ¹¹
Heating System	18.0	18.0	GDS Measure Life Report, Table 1; value for heat pump
Efficient Lighting	16.7	13.0	Analysis of EE regulations (see the explanation below)

ENS currently uses an EUL value of 70.0 years for insulation in a new construction. The Evaluator considered this value too high compared to what is used in other jurisdictions. In fact, the literature review revealed that most jurisdictions use a value of 25.0 years based on the GDS Associates Measure Life Report.¹² Considering that high quality new constructions such as those incentivized by NHC are likely to have a longer EUL, the Evaluator decided to use a value of 45.0 years based on the Regional Technical Forum value.¹³

For heating systems, ENS uses a value of 18.0 years. The vast majority of participants who had savings related to a heating system had installed heat pumps. Thus, the tracked value of 18.0 years was considered adequate for the heating system measures since it is the value used by most jurisdictions who all refer to the GDS Report.

For efficient lighting, ENS currently uses an EUL value of 16.7 years. The Evaluator estimated the equipment life of light-emitting diode (LED) lamps at 25.0 years based on rated lifetime hours of 25,000 and assuming annual hours of use of 986 hours. Driven by government regulations, the LED lamp market is evolving rapidly. LEDs installed today might become the baseline since LED technologies are advancing quickly and prices are falling (i.e. a growing number of customers will choose to purchase LEDs over all other products). Some jurisdictions have already applied reduced equivalent EUL values to residential lighting savings by adopting an increased baseline to represent savings in future years. In other words, the LED baseline increases over the lifetime of the product, which in turn reduces the equivalent EUL value that is applied to the first-year savings to obtain the lifetime energy savings. That is the case in Illinois, where LED savings are considered nil after 10.0 years, and baselines are adjusted throughout the EUL to match changes in regulations. For instance, the 60 W incandescent baseline is revised to a 43 W halogen incandescent after the end of the remaining useful life, and it is revised again

¹¹ Regional Technical Forum, *UES Measures – Built Green Washington*, <https://rtf.nwcouncil.org/measure/built-green-washington> (Last accessed February 15, 2018)

¹² GDS Associates, Inc., *Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures*, report prepared for the England State Program Working Group, June 2007, Table 1, pp. 1-3, https://energy.mo.gov/docs/default-source/energy_division/measure-life-report-2007.pdf.

¹³ Regional Technical Forum, *UES Measures – Built Green Washington*, <https://rtf.nwcouncil.org/measure/built-green-washington> (Last accessed February 15, 2018)

to the minimum efficiency CFL level required by the U.S. Energy Independence and Security Act (EISA) that will come into force in 2021.¹⁴ Massachusetts also uses a similar methodology and has set the adjusted EUL value at nine years for LED bulbs, which takes into account baseline increases that will occur because of EISA 2020.¹⁵

The Canadian market may change less quickly than the American market because Canadian regulations generally lag a few years behind the American ones; so, limiting the EUL value to 10.0 years, as done by Illinois, is too conservative. Consequently, the Evaluator used the equipment life of 25.0 years aforementioned as the EUL. Similar to the approach used in Illinois and Massachusetts, the Evaluator applied a double baseline for efficient lamps over their 25-year lifetime to account for the next anticipated U.S. regulation. The U.S. EISA of 2007 mandates that general service light bulbs must achieve 45 lumens per watt as of January 1, 2020.¹⁶ Considering that the Canadian residential lighting market is also evolving rapidly and closely follows trends in the U.S. market, the Evaluator considers it advisable to pay close attention to the anticipated U.S. legislation in establishing the baseline wattage. Natural Resources Canada intends to update the general service lamp minimum energy performance requirement in Amendment 16 of Canada's Energy Efficiency Regulations which is scheduled for pre-consultation in 2019¹⁷ and is therefore expected to come into force within a few years thereafter. For general-service lighting products, the intent is to align the Canadian regulations with the requirements in force or soon to be in force in the United States, namely EISA 2020. This regulation would effectively ban the import and fabrication of efficient incandescent lamps, as a result of the minimum acceptable efficiency level being higher than halogen incandescent technology efficiency. It is expected that these incandescent lamps would still be available in retail outlets for up to two years after the legislation is implemented before stocks are depleted. Since no information is available on the type and wattage of efficient lighting installed through NHC, the Evaluator assumed the average lamp installed in a new construction has a wattage of 43 W, which is the wattage of a halogen incandescent lamp corresponding to a 60 W incandescent. The displaced wattage values of 43 W for replaced light bulbs during the EUL of LEDs and the annual average displaced wattage values thereof are presented in Table 8 below.

¹⁴ Illinois Energy Efficiency Stakeholder Advisory Group, *Illinois Statewide Technical Reference Manual for Energy Efficiency Version 6.0, Volume 3*, February 2017, p. 258.

¹⁵ Massachusetts Electric and Gas Energy Efficiency Program Administrators, *Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures, 2016-2018 Program Years – Plan Version*, October 2015, p. 151.

¹⁶ US EPA. "Summary of the Energy Independence and Security Act. Public Law 110-140 (2007)."

Online: www.epa.gov/laws-regulations/summary-energy-independence-and-security-act.

¹⁷ Natural Resources Canada. *Forward Regulatory Plan 2017-19*, <http://www.nrcan.gc.ca/energy/regulations-codes-standards/18318> (Last accessed January 24, 2018).

Table 8: Baseline Evolution During the Effective Useful Life of LED Lamps

Typical Efficient Lamp (W)	Halogen Incandescent Baseline – Canadian Legislation ^{18,19} 7 Years (2017-2023)		CFL Equivalent Baseline – American Legislation ²⁰ 18 Years (2024-2041)	
	Baseline (W)	Displaced Wattage (W)	Baseline (W) ²¹	Displaced Wattage (W)
9	43	34	20	11

The following equation was used to establish the average equivalent EUL value to be applied to the first-year savings to determine the lifetime energy savings.

$$\text{Equivalent EUL} = \frac{(\Delta W_{\text{Halogen}} \times 7 \text{ years}) + (\Delta W_{\text{CFL}} \times 18 \text{ years})}{\Delta W_{\text{Halogen}}}$$

The equivalent EUL value has been established at 13.0 years.

Using the weights listed above and the corresponding revised EUL values, the Evaluator established the revised equivalent EUL at 30.0 years for NHC projects and at 36.0 years for Passive House pilot projects.

4.1.7 Revised Gross Savings

The annual gross savings for NHC and the Passive House pilot are presented in Table 9 and Table 10 below.

The gross savings at the generator were calculated using a Nova Scotia Power line loss factor of 1.098 and 1.100 between the meter and the generator for NHC and the Passive House participants respectively. The value of 1.098 was established by calculating a weighted average of the line loss factors of NHC projects according to their rate codes. The residential code has a line loss factor of 10 percent while the municipal rate code has a line loss factor of 4.6 percent. Overall, the revised gross energy and peak demand savings at the generator amounted to 3.162 GWh and 0.895 MW for NHC and 0.050 GWh and 0.014 MW for the Passive House pilot. Based on an EUL value of 30.0 years for NHC and a value of 36.0 years for the Passive House pilot, the lifetime energy savings have been established at 94.849 GWh and 1.801 GWh for NHC and the Passive House pilot respectively.

¹⁸ Natural Resources Canada. "Energy Efficiency Regulations. General Service Lamps and Modified Spectrum Incandescent Lamps." Online: www.nrcan.gc.ca/energy/regulations-codes-standards/products/6869.

¹⁹ Also equivalent to Incandescent Equivalent 1st Tier EISA 2007.

²⁰ As required by U.S. federal legislation. Incandescent Equivalent 2nd Tier EISA 2007.

²¹ Baseline wattage values were established based on the minimum efficiency level of 45 lumens/watts required by the EISA regulation and on the assumed levels of 550 lumens for 40 W lamps, 800 lumens for 60 W lamps and 1,600 lumens for 100 W lamps.

Table 9: Revised Gross Energy and Peak Demand Savings for NHC

	Modelled Energy Savings	EnerGuide Point Savings	Total
Number of Participants	414	6	420
Energy Savings			
Total Number of Delta EnerGuide Points	-	42	-
Unitary Energy Savings (kWh)	-	1,521	-
Initial Gross Energy Savings (GWh)	3.364	0.064	3.428
Overestimation Ratio	0.84	0.84	-
Total Gross Energy Savings – at the Meter (GWh)	2.826	0.054	2.879
Line Loss Factor	1.098	1.098	-
Total Gross Energy Savings – at the Generator (GWh)	3.103	0.059	3.162
Effective Useful Life (years)	30.0	30.0	-
Gross Lifetime Energy Savings – at the Generator (GWh)	93.082	1.768	94.849
Peak Demand Savings			
Demand-to-energy Ratio (MW/GWh)	0.283	0.283	-
Total Gross Peak Demand Savings – at the Meter (MW)	0.800	0.015	0.815
Line Loss Factor	1.098	1.098	-
Total Gross Peak Demand Savings – at the Generator (MW)	0.878	0.017	0.895

Table 10: Revised Gross Energy and Peak Demand Savings for the Passive House Pilot

Parameter	Value
Number of Participants	6
Energy Savings	
Total Gross Energy Savings – at the Meter (GWh)	0.045
Line Loss Factor	1.100
Total Gross Energy Savings – at the Generator (GWh)	0.050
Effective Useful Life (years)	36.0
Gross Lifetime Energy Savings – at the Generator (GWh)	1.801
Peak Demand Savings	
Demand-to-energy Ratio (MW/GWh)	0.283
Total Gross Peak Demand Savings – at the Meter (MW)	0.013
Line Loss Factor	1.100
Total Gross Peak Demand Savings – at the Generator (MW)	0.014

4.2 Net-to-gross Ratio

The net-to-gross ratio (NTGR) serves to determine net savings, i.e. the energy savings that can be reliably attributed to a program component. More precisely, the NTGR represents the positive or negative effects on gross savings. Two effects are considered for NHC, free-ridership and spillover in the form of market effects.

4.2.1 Free-ridership

Free-ridership occurs when participants or builders would have still implemented energy efficiency measures in the absence of the program component. The assessment of the NHC free-ridership level is based on a self-report approach which involves asking participating homeowners and builders a set of questions during telephone surveys. The free-ridership level for the Passive House pilot is established by using the same methodology as NHC. The questions assess the likelihood for participants to have built a house beyond the energy building code requirements in the absence of the program component or a passive house in the absence of the pilot. The questionnaire includes questions for all applicable variables of the decision-making process including planning, efficiency, timing and cost. For NHC, additional questions were asked to determine whether participant decisions to install measures had been influenced by either previous participation in one of ENS's energy efficiency programs or by ENS efforts to increase energy efficiency awareness.

The feedback collected from the surveys was converted into an overall free-ridership level using algorithms which are presented in Appendix VIII.

The 2017 NHC survey results revealed an overall free-ridership level of 26 percent among homeowners and 29 percent among participant builders. Using the percentages of homeowners (14%) and builders (86%) who participated in NHC, the overall free-ridership level was established at 29 percent for 2017. This result is similar to the results of previous years (27% in 2016, 28% in 2015, 33% in 2014, 32% in 2013, 29% in 2012, and 32% in 2011).

The Passive House pilot's overall free-ridership was established at 61 percent, which can be explained by the fact that three of the four participants interviewed mentioned that they would have built or bought a passive house even if the Passive House pilot had not been offered. With such a low number of participants, free-ridership results can significantly vary from one evaluation to another. Table 11 lists the measured free-ridership levels obtained for each respondent type.

Table 11: Measured Free-ridership Levels

	Average Freeridership Level	Sample Size	Population Size	Margin of Error
NHC – Participants	26%	12	57	8.7%
NHC - Builders	29%	40	66	9.3%
Passive House Pilot - Participants	61%	4	6	14.6%

4.2.2 Spillover (Market Effects)

The NHC builder survey was used to assess spillover in the form of market effects which occur when a builder decides to implement energy efficiency measures in new construction projects without participating in the program component. The spillover assessment involved asking builders a set of questions during a telephone survey. The methodology used to calculate the market effects is presented in Appendix IX.

Based on the 2017 survey results, the market effects level was established at 35 percent, an increase compared to 2016's 20 percent. The program component's level of influence on non-participating new construction projects was similar to last year in terms of the number of houses impacted. However, the percentage obtained by dividing 2017's number of impacted houses by the number of 2017 participating houses was higher than in 2016 because the number of participating houses was lower than in 2016.

4.2.3 NTGR Calculation

The NHC NTGR is calculated using the following equation:

$$NTGR = (1 - \% \text{ free-ridership} + \% \text{ spillover (market effects)})$$

The NTGR value for NHC is estimated at 106 percent.

The Passive House pilot's NTGR was calculated using the same equation as that for NHC, but without applying the spillover percentage. No spillover was considered for the Passive House pilot since this pilot is new in the market and has not yet reached many builders. The Passive House pilot's NTGR was established at 39 percent.

4.3 Net Savings

Net savings represent the savings that can be reliably attributed to the program component. For NHC and the Passive House pilot, net program component savings are calculated by applying the NTGR value calculation above to the revised gross savings, as exemplified in the following equation:

$$\text{Net Savings} = \text{Revised Gross Savings} \times \text{NTGR}$$

This equation was used to calculate both peak demand savings and energy savings.

The net energy and peak demand savings were respectively established at 3.351 GWh and 0.948 MW at the generator for NHC and respectively at 0.020 GWh and 0.006 MW at the generator for the Passive House pilot. Detailed results are presented in Table 12 below. Based on an EUL of 30.0 years for NHC and 36.0 years for the Passive House pilot, the net lifetime energy savings were established at 100.540 GWh and 0.702 GWh for NHC and the Passive House pilot respectively. Using the Nova Scotia-specific factor for GHG emissions generated by electricity production, namely 0.6531 CO₂ eq/kWh, it has been estimated that the net energy savings resulted in 2,189 annual tonnes of avoided CO₂ eq and 13 annual tonnes of avoided CO₂ eq for NHC and the Passive House pilot respectively.

Table 12: Evaluated Net Energy and Peak Demand Savings

Parameter	NHC	Passive House Pilot
Energy Savings		
Revised Gross Energy Savings – at the Meter (GWh)	2.879	0.045
NTGR	1.06	0.39
Total Net Energy Savings – at the Meter (GWh)	3.052	0.018
Line Loss Factor	1.098	1.100
Total Net Energy Savings – at the Generator (GWh)	3.351	0.020
Effective Useful Life (years)	30.0	36.0
Net Lifetime Energy Savings – at the Generator (GWh)	100.540	0.702
Peak Demand Savings		
Revised Gross Peak Demand Savings – at the Meter (MW)	0.815	0.013
NTGR	1.06	0.39
Total Net Peak Demand Savings – at the Meter (MW)	0.864	0.005
Line Loss Factor	1.098	1.100
Total Net Peak Demand Savings – at the Generator (MW)	0.948	0.006

A comparison of the energy and peak demand savings figures established through this evaluation and those calculated by ENS is presented in Table 13 and Table 14 below.

Table 13: Comparison of Tracked and Evaluated Savings at the Generator for NHC

	Initial Gross Savings	Adjusted Gross Savings	NTGR	Net Savings
Energy Savings				
ENS Tracked Savings	3.771 GWh	3.167 GWh	0.93	2.946 GWh
Evaluation Results	3.764 GWh	3.162 GWh	1.06	3.351 GWh
Peak Demand Savings				
ENS Tracked Savings	1.067 MW	0.896 MW	0.93	0.834 MW
Evaluation Results	1.065 MW	0.895 MW	1.06	0.948 MW

Table 14: Comparison of Tracked and Evaluated Savings at the Generator for the Passive House Pilot

	Initial Gross Savings	Adjusted Gross Savings	NTGR	Net Savings
Energy Savings				
ENS Tracked Savings	0.074 GWh	0.050 GWh	0.93	0.047 GWh
Evaluation Results	0.074 GWh	0.050 GWh	0.39	0.020 GWh
Peak Demand Savings				
ENS Tracked Savings	0.021 MW	0.014 MW	0.93	0.013 MW
Evaluation Results	0.021 MW	0.014 MW	0.39	0.006 MW

The savings tracked by ENS were compared with the revised results established by the Evaluator for 2017. For NHC, the evaluated gross energy and peak demand savings are slightly lower than the tracked savings because of a small change to the line loss factor. As for its net energy and peak demand savings, the evaluated savings are 14 percent higher than those tracked by ENS. This difference is due to an increase in the NTGR value compared to the 2016 value. This increase in the NTGR value is mainly due to an increase in the market effects in 2017 (35% compared to 20% in 2016).

For the Passive House pilot, both the net evaluated energy and peak demand savings are 58 percent less than those tracked by ENS because of the low revised NTGR value. This low NTGR value is due to a high free-ridership level of 61 percent.

Table 15 below summarizes the participation level, the gross savings and net savings for the for NHC, the Passive House pilot and the whole program.

Table 15: Overall Participation and Savings for New Residential

	Participation Level	Gross Savings	NTGR	Net Savings
NHC				
Energy Savings	420 participants	3.162 GWh	1.06	3.351 GWh
Lifetime Energy Savings		94.849 GWh	1.06	100.540 GWh
Peak Demand Savings		0.895 MW	1.06	0.948 MW
Passive House Pilot				
Energy Savings	6 participants	0.050 GWh	0.39	0.020 GWh
Lifetime Energy Savings		1.801 GWh	0.39	0.702 GWh
Peak Demand Savings		0.014 MW	0.39	0.006 MW
Total				
Energy Savings		3.212 GWh		3.371 GWh
Lifetime Energy Savings		96.650 GWh		101.242 GWh
Peak Demand Savings		0.909 MW		0.954 MW

CONCLUSION

The New Residential program, including NHC and the Passive House pilot, achieved 3.371 GWh in net energy savings and 0.954 MW in net peak demand savings at the generator, which resulted in 2,202 tonnes of avoided CO₂ eq annually. The net lifetime energy savings amounted to 101.242 GWh. NHC was by far the main contributor to program savings with net energy savings of 3.351 GWh and net peak demand savings of 0.948 MW. A total of 420 participants completed a project with electricity savings under NHC in 2017, and six participants completed one or more projects under the Passive House pilot. NHC participation and net energy and peak demand savings decreased compared to 2016. While the planned peak demand savings were met in 2017, planned energy savings were not.

The 2017 NHC free-ridership level remained stable at 29 percent, while the spillover level increased significantly, surging from 20 to 35 percent compared to 2016. Although the 2017 level of influence of NHC on non-participating homes was similar to that of 2016, the lower number of participating houses resulted in the NHC level of influence being applied to a larger number of non-participating homes, thus increasing spillover.

The Passive House pilot was evaluated for the first time in 2017. One of the main goals of evaluating this pilot was to determine the free-ridership level. Based on interviews with four of the six participants, free-ridership was established at 61 percent, which is fairly high. All but one interviewed participant mentioned that they would have built or bought a passive house even if the Passive House pilot had not been offered.

Participants and builders reported moderately high satisfaction ratings with NHC. Compared to 2016, satisfaction among builders remained stable, whereas satisfaction was lower among participants. The main reason for dissatisfaction among both participants and builders was that the rebate was too low. Builders also highlighted that there was not enough information about NHC and its process and mentioned the long wait time before receiving the rebate. Although half the participants did not provide any recommendations on how to improve NHC, some suggested making the participation process simpler.

LIST OF APPENDICES

The following are presented in the New Residential Program – Appendices.

New Home Construction

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Appendix II - Participant Survey Questionnaire

Appendix III - Participant Survey Results

Appendix IV - Builder Survey Questionnaire

Appendix V - Builder Survey Results

Appendix VI - Passive House Pilot Participant Interview Guide

Appendix VII - Passive House Pilot Participant Interview Results

Appendix VIII - Algorithm for Free-ridership Calculation

Appendix IX - Spillover Methodology



ECONOLER

NEW RESIDENTIAL PROGRAM

2017 DSM EVALUATION

EFFICIENCY NOVA SCOTIA

Appendix Report

March 15, 2018



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Appendix I

2017 RECOMMENDATIONS

This appendix summarizes all the recommendations made by the Evaluator as part of the 2017 evaluation. There were no incomplete 2016 recommendations at the time of evaluation.

Sections	Recommendations
Executive Summary	1. Conduct a process evaluation for NHC in 2018. During the 2017 evaluation, participants and builders made certain criticisms about NHC, especially on incentive levels and the participation process. Also, the NHC participation level continued to decrease. In light of these findings and the substantial changes made to NHC in 2017, the Evaluator recommends conducting a process evaluation of NHC next year to determine if current program component processes, parameters and model of delivery are optimized to meet market needs. The process evaluation's scope could include a benchmarking study of other Canadian or North American jurisdictions to compare NHC to other similar programs, and an in-depth consultation with builders and other key actors involved in the residential new construction market to find the most effective ways to generate more projects through a simple and straightforward participation process. Market data should also be collected to obtain insights about market forces that may be influencing the decline in NHC participation.
	2. Conduct a billing analysis to review the overestimation ratio. The current overestimation ratio was obtained from a billing analysis of Home Energy Assessment participant data. In past years, no billing analyses were conducted with NHC participants since only a few participants had their as-built energy consumption value available. Now that energy consumption is available for more participants and a new version of HOT2000 is being used to calculate energy savings, the Evaluator recommends conducting a new billing analysis in the next evaluation to establish an overestimation ratio specific to new houses under NHC and the new version of HOT2000.

Appendix II PARTICIPANT SURVEY QUESTIONNAIRE

Hello may I please speak with [INSERT NAME]?

- 1 Yes [GO TO INTRODUCTION]
- 2 No [SAY "Perhaps you can help me anyway." GO TO INTRODUCTION]

INTRODUCTION

Hello, my name is _____ and I am with Corporate Research Associates, a Halifax-based survey research company. We are performing an evaluation of energy efficiency services provided by Efficiency Nova Scotia. Our records indicate that you or your household recently participated in Efficiency Nova Scotia's New Home Construction program for new houses. We would appreciate your help in answering questions about your participation in this program. The information you provide will be used to help Efficiency Nova Scotia evaluate and improve the program. Is this a good time for you?

(IF NEEDED: You may have recently been contacted by Corporate Research Associates and by an Efficiency Nova Scotia representative about your experience with the program. This survey is different as it focuses on other aspects of your participation in the program.)

(IF NEEDED: The survey should take about fifteen minutes.)

Verification and Recall (V Series)

- V1. We understand you participated in the New Home Construction program for the house you built at [ADDRESS FROM FILE]. Is that correct?
1. Yes [CONTINUE]
 2. No, does not recall participating [PROMPT: "Are you sure? This program provides rebates for installing energy efficient upgrades in newly constructed houses and residential buildings."] [IF PERSIST AS NO, THANK, TERMINATE AND RECORD]
 98. Don't know/Refused [PROBE: "Is there someone else who would know about having participated in the New Home Construction program?"] [IF YES, ASK TO SPEAK TO THE APPROPRIATE PERSON AND RESTART AT INTRODUCTION. IF PERSISTS AS NO, THANK, TERMINATE AND RECORD.]

[IF REFUSED, ASK "Can we schedule a more convenient time for you to conduct this survey?"]

[SCHEDULED, IF NECESSARY, FOR: _____]

- V2. Are you in the business of building and/or selling homes?
1. Yes [THANK, TERMINATE AND RECORD]
 2. No [CONTINUE]
 98. (Don't know) [THANK, TERMINATE AND RECORD]
 99. (Refused) [THANK, TERMINATE AND RECORD]
- V3. Did you personally take part in the decision to participate in the New Home Construction program? [DO NOT READ. ACCEPT ONE]
1. (Yes)
 2. (No/The Builder made the decision)
 98. (Don't know)
 99. (Refused)
- V4. Did you take part in the decisions regarding the energy efficiency upgrades to install through the New Home Construction program? [DO NOT READ. ACCEPT ONE]
1. (Yes)
 2. (No/The Builder made the decisions)
 98. (Don't know)
 99. (Refused)
- V5. Which of the following statements best describes when you became involved in the decisions about the energy efficiency of your home? Would you say ...: [READ STATEMENTS IN ORDER – CODE ONE ONLY]
1. You were involved from the initial planning and design stage. This is when your home existed only on paper.
 2. You were involved after the plans for your home were finalized but had the option to choose energy efficient upgrades.
 3. You were involved after the energy efficiency upgrades were installed but before the final review of your completed home, or
 4. You were not involved in any of these decisions, or you bought the home after it was completed.
 98. (Don't know)
 99. (Refused)

Reasons for Participating (P Series)

[ASK IF V3=1, OTHERWISE SKIP TO S1]

P1. Now I'm going to ask you to think back to when you decided to participate in the New Home Construction program. What was the SINGLE most important reason you were interested in participating in the program? [ACCEPT ONE RESPONSE; DO NOT READ; PROBE FOR SPECIFIC REASONS]

1. (To have a house that would save on energy costs/bills)
2. (I was thinking about/planning to get energy efficient upgrades in my house anyway)
3. (To find out how energy efficient the new house would be/to get house evaluated)
4. (I am generally interested in energy efficiency and renewable energy)
5. (To get rebates (general))
96. (Other) [SPECIFY _____]
98. (Don't know)
99. (Refused)

P2. [DO NOT ASK IF Don't know or Refused in P1] Were there any other reasons? [SAME LIST AS P1 ABOVE. DO NOT READ. ACCEPT MULTIPLE; PROBE FOR SPECIFIC REASONS]

97 No other reasons

Satisfaction with Program (S Series)

S1. Using a scale from 1 to 10 where 1 is "not at all satisfied" and 10 is "completely satisfied" how would you rate your satisfaction with the New Home Construction program overall? [RECORD NUMBER, 98=Don't know, 99 Refused] DO NOT ACCEPT A RANGE

S2. [IF S1 <8] What was the most important reason you were not more satisfied with the program overall? [PROBE FOR SPECIFIC REASON. ACCEPT MULTIPLE RESPONSE]

96. (RECORD VERBATIM: _____)
98. (Don't know)
99. (Refused)

[IF V5= 4, 98 OR 99, SKIP TO FR SECTION]

S3. On a scale from 1 to 10, where 1= “not at all satisfied” and 10 =“completely satisfied”, please tell me how satisfied you are with your experience with each of the following aspects of the New Home Construction program. Please indicate if any are not applicable to you. [DO NOT RANDOMIZE. DO NOT ACCEPT A RANGE] [97 = Not Applicable, 98 = Don’t know/Don’t recall, 99 = Refused]

[IF V5=1, ASK ALL **A** THRU **F**]

[IF V5=2, ASK ONLY **B** THRU **F**]

[IF V5=3, ASK **D, E AND F**]

- a. The first review of the house plans (This was the review of the house plans, evaluating the house’s energy efficiency with recommended upgrades.)
- b. The report you received about the house plan’s current energy efficiency
- c. Recommendations for energy efficient upgrades
- d. The final energy assessment (This was the final assessment of the house's energy efficiency to determine the rating and confirm the energy efficient upgrades that were installed.)
- e. The rebate amounts provided by the program
- f. The time allowed to complete your new home under the New Home Construction program

Free-Ridership (FR Series)

[ASK FR SECTION IF V3=1 OR V4=1]

Moving along to another topic now....

FR1. Before participating in the New Home Construction program, had you already planned to include in your home design all the energy efficient features that were identified in the New Home Construction program review of your home plans?

1. Yes
2. No
98. (Don’t know)
99. (Refused)

[IF FR1=YES]

FR1a. I just want to make sure I understand - Before you decided to participate in the New Home Construction program, your home design already included all the energy efficient features that were identified in the New Home Construction program review of your home plans?

1. Yes
2. No
98. (Don’t know)
99. (Refused)

[ASK FR2a IF, IN SAMPLE, TOTAL INCENTIVE>0]

FR2a. Efficiency Nova Scotia gave you a rebate of \$[Total incentive] for the energy efficiency level that you achieved in your new house. If you had not received the rebate from Efficiency Nova Scotia, would you have paid for the full cost to reach this energy efficiency level? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely Would Not Have Paid” and a 10 indicating that you “Definitely Would Have Paid.” [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response

- 96. (Did not receive that rebate)
- 97. (Don’t Know)
- 98. (Refused)

[ASK FR2b IF, IN SAMPLE, TOTAL INCENTIVE=EMPTY]

FR2b. Efficiency Nova Scotia funded a portion of the energy assessment that was performed by the energy advisor as part of the program. If Efficiency Nova Scotia had not reduced the cost of the energy assessment, would you have paid for the full cost, which is \$600? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely Would Not Have Paid” and a 10 indicating that you “Definitely Would Have Paid.” [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response

- 97. (Did not receive that rebate)
- 98. (Don’t Know)
- 99. (Refused)

[READ FIRST TIME THROUGH ONLY] Now I would like to ask you to consider what actions you would have taken if the New Home Construction program had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely,” and a 10 indicating that it is “Very Likely.”

[DO NOT ACCEPT A RANGE – ASK FR3 SEQUENCE IN ORDER/DO NOT RANDOMIZE]

FR3a. If the program had not been offered, what is the likelihood that you would have built or bought a house with the exact same level of efficiency?

___ Response ___98 Don't Know ___99 Refused

FR3b. If the program had not been offered, what is the likelihood that you would have built or bought a standard house, designed to code, instead of a house with a high level of efficiency?

___ Response ___98 Don't Know ___99 Refused

FR4. Thinking of all the energy-efficient upgrades you decided to incorporate into your build, how much would you estimate the total cost of these upgrades to be before any rebates from Efficiency Nova Scotia? [RECORD TOTAL COST IN DOLLARS. PROBE TO AVOID ACCEPTING A RANGE.]

___ Response ___98 Don't Know ___99 Refused

FR5. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to build or buy a house with a high level of energy efficiency. Using a scale from 0 to 10 where 0 means "No influence" and 10 means "Great influence", please rate the influence of each of the following in your decision to build or buy a house with a high level of energy efficiency. DO NOT ACCEPT A RANGE

Factor (READ AND RANDOMIZE)	Responses
a. The program rebate	___ Response ___98 Don't Know ___99 Refused
b. Expert information or advice provided by the New Home Construction program Energy Advisor	___ Response ___98 Don't Know ___99 Refused
c. Feedback received from the New Home Construction program review of home plans	___ Response ___98 Don't Know ___99 Refused

Cross-Influence [CI Series]

[ASK CI SECTION IF V3=1 OR V4=1]

READ AND ROTATE (CI1 + CI2a-c) AND (CI3 + CI4a-c) SEQUENCES

CI1. Before participating in the New Home Construction program in [MONTH/YEAR], had you at any time in the past already participated in another Efficiency Nova Scotia program?

1. Yes
2. No
98. (Don't know)
99. (Refused)

For the following statements, please indicate whether you agree or disagree.

CI2a. [IF CI1=1] Your previous participation in an Efficiency Nova Scotia program was a major factor in your decision to build a house with a high level of energy efficiency.

1. Agree
2. Disagree
98. (Don't know)
99. (Refused)

- CI2b. [IF CI1=1] Because of your previous participation in an Efficiency Nova Scotia program and what you learned by participating in the program, you asked for a review of your new home plans.
- 1. Agree
 - 2. Disagree
 - 98. (Don't know)
 - 99. (Refused)
- CI2c. [IF CI1=1] Because of your previous participation in an Efficiency Nova Scotia program and what you learned by participating in the program, you took into account the expected cost savings of energy-efficient upgrades when evaluating different options for your new home.
- 1. Agree
 - 2. Disagree
 - 98. (Don't know)
 - 99. (Refused)
- CI3. Before participating in the New Home Construction program in [MONTH/YEAR], had you already seen Efficiency Nova Scotia promotional materials advertising the benefits of energy efficiency?
- 1. Yes
 - 2. No
 - 98. (Don't know)
 - 99. (Refused)

For the following statements, please indicate whether you agree or disagree.

- CI4a. [IF CI3=1] The energy efficiency promotional materials distributed by Efficiency Nova Scotia were a major factor in your decision to build a house with a high level of energy efficiency.
- 1. Agree
 - 2. Disagree
 - 98. (Don't know)
 - 99. (Refused)
- CI4b. [IF CI3=1] The energy efficiency promotional materials distributed by Efficiency Nova Scotia prompted you to ask for a review of your new home plans.
- 1. Agree
 - 2. Disagree
 - 98. (Don't know)
 - 99. (Refused)

CI4c. [IF CI3=1] The energy efficiency promotional materials distributed by Efficiency Nova Scotia prompted you to take into account the expected cost savings of energy-efficient upgrades when evaluating different options for your new home.

- 1. Agree
- 2. Disagree
- 98. (Don't know)
- 99. (Refused)

Barriers (B Series)

[ASK IF V4=1 OR V5=1 OR 2]

B1a. On a scale of 1 to 10, where 1 is 'not at all important' and 10 is 'extremely important, 'how important, if at all, were the following when deciding what equipment or upgrades would be included in your new home through the New Home Construction Program? [READ AND ROTATE STATEMENTS - CODE ONLY ONE] [98 = Don't know/Don't recall, 99 = Refused]

- A. Reducing energy consumption, that is, increasing the energy efficiency of your household
- B. Reducing energy costs for your household
- C. Using the lowest cost options to upgrade your household features
- D. Increasing the value of your home

B1b. What other considerations, if any, were important in determining what equipment or upgrades would be included in your new home? [RECORD VERBATIM]

- 96. _____
- 97. None
- 98. Don't know
- 99. Refused

B2a. Were there any energy efficiency equipment or upgrades that were recommended to you during the New Home Construction program review of home plans that you chose not to install in your new home?

- 1. Yes
- 2. No
- 98. (Don't recall)

- B2b. [ASK IF B2a=YES] How much of a barrier, if any, were each of the following in preventing you from implementing the energy efficiency equipment or upgrades that were recommended as part of the program? Please answer on a scale of 0 to 10, where 0 means 'not at all a barrier' and 10 means 'a major barrier'. [ROTATE. RECORD RESPONSE BETWEEN 0 AND 10. 98=DON'T KNOW, 99=REFUSED]
- Lack of money
 - Lack of time
 - Lack of information about energy efficiency equipment or upgrades
 - Lack of interest
 - Not convinced of the energy savings

Recommendations for Program Improvements (R Series)

[ASK ALL HOMEOWNERS]

- R1. Do you have any recommendations for improving the New Home Construction program? PROBE: Anything else? [DO NOT READ – ALLOW MULTIPLE RESPONSES]
- (Offer more upgrades eligible for rebates)
 - (Offer more information on the upgrades recommended)
 - (Complete the first review of house plans faster)
 - (More marketing/advertising)
 - (Make participation simpler)
 - (Improve the quality of work of the Energy Advisor)
 - (Faster certification process)
 - (Increase availability of Energy Advisor to answer energy efficiency-related questions)
 - (No recommendation)
 96. (Other [SPECIFY _____])
 97. (Don't know)
 98. (Refused)
- R2. [ASK IF R1=2 – OFFER MORE INFORMATION ON UPGRADES] What type of information on the upgrades being recommended would be helpful? [RECORD VERBATIM]
98. (Don't know)
 99. (Refused)

Demographic Characteristics (D Series)

[ASK ALL HOMEOWNERS]

These final questions are asked for statistical purposes only. The information collected is strictly confidential.

D1. What type of residence do you live in? [READ RESPONSES 1-5; SELECT ONE RESPONSE]

1. Detached single-family home
2. Semi-detached house
3. Mobile home or house trailer
4. Townhouse or duplex which share adjacent walls
5. Row house (Single story apartment building)
96. Other [SPECIFY: _____]
98. (Don't know)
99. (Refused)

D2. How many bedrooms are in your home? [98=DK; Enter zero for a studio apartment with no bedrooms]

D3. Is your home occupied year round, or is it a seasonal home?

1. Year round residence
2. Seasonal/vacation home **[SKIP TO D5]**
96. (Other Specify _____)
98. (Don't know)
99. (Refused)

D4. Including yourself, how many people live in this residence on a full-time basis?

Number of people: _____

[NOTE: DON'T ALLOW ZERO FOR A RESPONSE]

D5. In which age category do you fall? Are you ... [READ]

1. 18 to 24
2. 25 to 34
3. 35 to 44
4. 45 to 54
5. 55 to 64
6. 65 or over
99. (Refused)

- D6. What is the highest level of education you have completed? [DO NOT READ]
1. (Less than high school graduation diploma)
 2. (High school graduation diploma and/or some postsecondary)
 3. (Trades certificate or diploma)
 4. (College certificate or diploma)
 5. (University degree, certificate or diploma)
 98. (Don't know)
 99. (Refused)
- D7. Which of the following income categories best describes your total annual household income before taxes in 2016? Stop me when I reach the right category. [READ LIST; SELECT ONE RESPONSE]
1. Less than \$15,000
 2. \$15,000 - \$24,999
 3. \$25,000 - \$34,999
 4. \$35,000 - \$49,999
 5. \$50,000 - \$69,999
 6. \$70,000 - \$79,999
 7. \$80,000 or more
 98. (Don't know)
 99. (Refused)
- D8. [DO NOT READ] Gender:
1. Male
 2. Female

END: That is all the questions I have for you. Thank you for taking the time to respond to this survey.

Appendix III PARTICIPANT SURVEY RESULTS

The participant survey results are presented in the following tables.

V3. Did you personally take part in the decision to participate in the New Home Construction program?

Homeowner Involved in Decision to Participate in NHC	2015 (%)	2016 (#)	2017 (#)
Sample Size	22	19	13
Yes	100%	16	13
No/The builder made the decision	-	3	-
Don't know	-	-	-

V4. Did you take part in the decisions regarding the energy efficiency measures to install through the New Home Construction program?

Homeowner Involved in Decision to Implement the Energy Efficiency Measures	2015 (%)	2016 (#)	2017 (#)
Sample Size	22	19	13
Yes	95%	17	13
No/The builder made the decision	-	1	-
Don't know	5%	1	-

V5. Which of the following statements would you say best describes when you became involved in the decisions about the energy efficiency of your home? Would you say you were involved...

When Homeowner Became Involved	2015 (%)	2016 (#)	2017 (#)
Sample Size	22	19	13
Initial planning/design stage	95%	13	12
After plan finalization, before measure implementation	5%	3	1
After measures installed, before final review of home	-	3	-
Not involved/bought home after project completion	-	-	-

P1. Now I'm going to ask you to think back to when you decided to participate in the New Home Construction program. What was the SINGLE most important reason you were interested in participating in the program?

P2. Were there any other reasons?

Reasons for Participating – Homeowners	2015 (%)		2016 (#)		2017 (#)	
	Most Important Reason	Other Important Reasons**	Most Important Reason	Reasons	Most Important Reason	Other Important Reasons
Sample Size*	22	22	16	16	13	13
To have a house that would save on energy costs/bills	41%	18%	6	1	6	2
To get rebates	27%	18%	6	4	4	3
Planning to get energy efficient measures in house anyway	5%	9%	-	1	2	1
Interested in getting a better, more energy efficient home	-	5%	1	-	1	-
To save on energy (general)	5%	9%	1	1	-	-
To get rebates for measures that were already in the house I bought	9%	5%	1	-	-	-
To find out how energy efficient the new house would be	5%	14%	-	-	-	1
To get expert advice about what measures to install	5%	-	-	-	-	-
To help the environment	-	5%	-	-	-	-
I am interested in energy efficiency and renewable energy	-	5%	-	-	-	3
Others	5%	-	1	-	-	1
None/no other reasons	-	41%	-	9	-	2
*Base: Homeowners that personally took part in the decision to participate in NHC						
**Multiple responses						

S1. Using a scale from 1 to 10 where 1 is “not at all satisfied” and 10 is “completely satisfied” how would you rate your satisfaction with the New Home Construction program overall?

Satisfaction with NHC Overall - Homeowners		2016	2017
Sample Size		19	13
Mean*		7.1	6.6
*Don't know/Refused excluded from calculations			

S2. What was the most important reason you were not more satisfied with the program overall?

Key Reasons Not More Satisfied - Homeowners	2016 (#)	2017 (#)
Sample Size*	7	7
Rebates were too small	-	5
The information and advice given by the program changed along the way	-	2
Took too long to receive the rebate	-	1
Did not qualify for rebate	4	-
Did not receive enough guidance on measures to implement	1	-
More difficult than expected to go through the program	1	-
Refused	1	-
*Base: Respondents who were less than satisfied with the program (S1 <8)		

S3. On a scale from 1 to 10, where 1= “not at all satisfied” and 10 =“completely satisfied”, please tell me how satisfied you are with your experience with each of the following aspects of the New Home Construction program. Please indicate if any are not applicable to you.

Homeowner Satisfaction with Aspects of NHC*	2015		2016		2017	
	Sample Size	Satisfied	Sample Size	Satisfied	Sample Size	Satisfied
Mean (1=Not at all satisfied, 10=Completely satisfied)						
Time allowed to complete the project**/****/****	-	-	16	8.7	10	8.8
Report received about house plan's current energy efficiency**/****	20	7.6	15	6.9	12	8.2
Recommendations for energy efficient upgrades**/****	18	7.4	13	6.9	11	7.8
Final energy assessment**/****/****	-	-	18	7.6	11	7.7
First review of house plans overall**	18	8.1	11	7.3	12	6.8
Rebates provided by the program overall**/****/****	21	6.3	17	6.4	13	5.2
*Don't know/Refused excluded from calculations **Base: Respondents were involved from the initial planning and design stage ***Base: Respondents who were involved after the plans for home were finalized, but had the option to choose energy efficient upgrades ****Base: Respondents who were involved after the energy efficiency measures were installed, but before the Final Review of the home						

FR1. Before participating in the New Home Construction program, had you already planned to include to your home design all the energy efficient features that were identified in the review of your home plans?

FR1a. I just want to make sure I understand - Before you decided to participate in the New Home Construction program, your home design already included all the energy efficient features that were identified in the review of your home plans?

Already Made Decision to Build House with Energy Efficiency Measures Identified by NHC - Homeowners	2016 (#)	2017 (#)
Sample Size	19	13
Yes	10	9
No	5	4
Don't know	4	-

FR2a. Efficiency Nova Scotia paid you \$[Total incentive] for the energy efficiency level that you achieved in your new house. If you had not received the rebate from Efficiency Nova Scotia, would you have paid for the full cost to reach this energy efficiency level?

FR2b. Efficiency Nova Scotia funded a portion of the energy assessment that was performed by the energy advisor as part of the program. If Efficiency Nova Scotia had not reduced the cost of the energy assessment, would you have paid for the full cost, which is \$600?

Please answer on a scale of 0 to 10, with a 0 indicating that you "Definitely Would Not Have Paid" and a 10 indicating that you "Definitely Would Have Paid."

Would Have Paid Cost to Reach Energy Efficiency Level - Homeowners	2015		2016		2017	
	Sample Size	Mean*	Sample Size	Mean*	Sample Size	Mean*
Average rating: 10= "Definitely would have paid", 0= "Definitely would not have paid"						
Would have paid cost to reach energy efficiency level	19	8.4	18	5.7	13	5.3
*Don't know/Refused/Did not receive that rebate excluded from calculations						

FR3. Now I would like to ask you to consider what actions you would have taken if the New Home Construction program had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely,” and a 10 indicating that it is “Very Likely.”

Actions Taken in Absence of NHC - Homeowners	2016		2017	
	Sample Size	Mean*	Sample Size	Mean*
Built/bought house with exact same level of efficiency	19	8.7	12	8.8
Built/bought a standard house, designed to code, instead of high efficiency house	18	3.6	13	3.3
*Don't know/Refused excluded from calculations				

FR4. Thinking of all the energy-efficient upgrades you decided to incorporate into your build, how much would you estimate the total cost of these upgrades to be before any rebates from Efficiency Nova Scotia?

Estimated Costs of Upgrades	2015	2016	2017
Sample Size	22	8	13
Average*	\$15,540	\$18,000	\$16,545
*Don't know excluded from calculations			

FR5. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to build or buy a house with a high level of energy efficiency. Using a scale from 0 to 10 where 0 means “No influence” and 10 means “Great influence”, please rate the influence of each of the following in your decision to build or buy a house with a high level of energy efficiency.

Influence of NHC in Decision to Build or Buy a House with a High Level of Energy Efficiency - Homeowners	2016		2017	
	Sample Size	Mean*	Sample Size	Mean*
Mean (0 = “No influence”; 10 = “Great influence”)				
Expert information or advice provided by the Energy Advisor	16	5.0	13	4.9
Feedback received from the review of home plans	15	5.5	13	4.5
Program rebate	19	5.5	13	4.1
*Don't know/Refused excluded from calculations				

CI1. Before participating in the New Home Construction program in [DATE], had you at any time in the past already participated in another Efficiency Nova Scotia program?

Previous Participation in Another ENS Program - Homeowners	2016 (#)	2017 (#)
Sample Size	19	13
Yes	7	6
No	11	7
Don't know	1	-

CI2. For the following statements, please indicate whether you agree or disagree.

Impact of Previous ENS Program Participation - Homeowners	2016				2017			
	Sample Size*	Agree	Disagree	Don't know	Sample Size*	Agree	Disagree	Don't know
Because of your previous participation in an Efficiency Nova Scotia program and what you learned by participating in the program, you asked for a review of your new home plans.	7	5	2	-	6	5	1	-
Because of your previous participation in an Efficiency Nova Scotia program and what you learned by participating in the program, you took into account the cost-effectiveness of energy efficient upgrades when evaluating different options for your new home.	7	6	1	-	6	5	1	-
Your previous participation in an Efficiency Nova Scotia program was a major factor in your decision to build a house with a high level of energy efficiency.	7	4	3	-	6	3	3	-
*Base: Respondents who previously participated in another ENS program								

C13. Before participating in the New Home Construction program in [MONTH/YEAR], had you already seen Efficiency Nova Scotia promotional materials advertising the benefits of energy efficiency?

Previously Seen Energy Efficiency Promotional Materials Distributed by ENS - Homeowners	2016 (#)	2017 (#)
Sample Size	19	13
Yes	14	13
No	5	-
Don't know	-	-

C14. For the following statements, please indicate whether you agree or disagree.

Impact of Previously Seen ENS Energy Efficiency Promotional Materials - Homeowners	2016				2017			
	Sample Size*	Agree	Disagree	Don't know	Sample Size*	Agree	Disagree	Don't know
The energy efficiency promotional materials distributed by Efficiency Nova Scotia prompted you to ask for a review of your new home plans.	14	8	6	-	13	10	2	1
The energy efficiency promotional materials distributed by Efficiency Nova Scotia prompted you to take into account the cost-effectiveness of energy efficient upgrades when evaluating different options for your new home	14	10	4	-	13	10	3	-
The energy efficiency promotional materials distributed by Efficiency Nova Scotia were a major factor in your decision to build a house with a high level of energy efficiency	14	2	12	-	13	7	6	-
*Base: Respondents who previously saw ENS energy efficiency promotional materials								

B1a. On a scale of 1 to 10, where 1 is 'not at all important and 10 is 'extremely important, how important, if at all, were the following when deciding what equipment or measures would be included in your new home through the New Home Construction Program?

Importance of Upgrades - Homeowners	2016		2017	
	Sample Size*	Mean**	Sample Size*	Mean**
Reducing energy costs for your household	18	9.7	13	9.8
Reducing energy consumption, that is, increasing the energy efficiency of your household	18	9.4	13	9.5
Increasing the value of your home	18	7.3	13	7.0
Using the lowest cost options for replacing or upgrading your household features	17	5.9	13	5.0
*Base: Respondents who took part or made decisions regarding NHC energy efficient measures				
**Don't know/Don't recall and Refused excluded from calculations				

B1b. What other considerations, if any, were important in determining what equipment or measures would be included in your new home?

Other Considerations That Were Important in Determining What Equipment or Measures Would be Included in Home - Homeowners	2016* (#)	2017* (#)
Sample Size**	18	13
Recommendation from the builder or family and friends	-	2
Longevity of equipment/measures	1	2
Functionality	1	2
The environment/Energy efficiency	2	1
Comfort	1	1
The aesthetic/design of the house	3	-
Cost of equipment/measures	1	-
None	6	6
Don't know	3	-
*Multiple responses		
**Base: Respondents who took part or made decisions regarding NHC energy efficient measures		

B2a. Were there any energy efficiency equipment or upgrades that were recommended to you during the New Home Construction program review of home plans that you chose not to install in your new home?

Any Recommended Upgrades Not Installed	2017 (#)
Sample Size	13
Yes	6
No	7

B2b. How much of a barrier, if any, were each of the following in preventing you from implementing the energy efficiency equipment or measures that were recommended as part of the program? Please answer on a scale of 0 to 10, where 0 means 'not at all a barrier' and 10 means 'a major barrier'.

Barriers to implementation - Homeowners	2016		2017**	
	Sample Size*	Mean***	Sample Size*	Mean***
Lack of money****	18	5.3	6	6.2
Lack of information about energy efficiency incentives or equipment	18	2.9	6	4.8
Not convinced of the energy savings***	17	1.7	6	3.7
Lack of time****	18	1.0	6	3.3
Lack of interest	18	1.1	6	2.7
*Base: Respondents who took part or made decisions regarding NHC energy efficient measures **Base: Respondents who had upgrades recommended that they chose not to install ***Don't know and Refused excluded from calculations ****Wording change in 2017				

R1. Do you have any recommendations for improving the New Home Construction program?
PROBE: Anything else?

Homeowner Recommendations to Improve NHC	2015* (%)	2016* (#)	2017* (#)
Sample Size	22	19	13
Increase rebates	27%	-	4
Make participation simpler	9%	1	2
Offer more upgrades eligible for rebates	9%	2	2
Speed up rebates	5%	-	1
Improve communication	-	2	1
Faster certification process	5%	1	1
Make NHC more accessible – the recommended upgrades are too hard to complete money wise	-	-	1
Complete the first review of house plans faster	-	-	1
More marketing/advertising		1	-
Offer more information on the measures recommended	9%	2	-
Assessment cost is not worth it	14%	-	-
Improve quality of work of the EA	5%	-	-
Increase availability of EA to answer energy efficiency related questions	5%	-	-
Others	14%	3	-
No recommendations	27%	11	6
Don't know/Refused	5%	-	-
*Multiple responses			

D1. What type of residence do you live in?

Type of Residence	2015 (%)	2016 (#)	2017 (#)
Sample Size	22	19	13
Detached single-family home	95%	18	12
Semi-detached house	-	-	1
Mobile home or house trailer	-	1	-
Townhouse or duplex	-	-	-
Others	-	-	-
Don't know/Refused	5%	-	-

D2. How many bedrooms are in your home?

Number of Bedrooms in Home	2015 (%)	2016 (#)	2017 (#)
Sample Size	22	19	13
1	9%	-	-
2	9%	1	2
3	50%	11	9
4	23%	6	2
5+	5%	1	-
Don't know	5%	-	-

D3. Is your home occupied year round, or is it a seasonal home?

Type of Home	2015 (%)	2016 (#)	2017 (#)
Sample Size	22	19	13
All year	95%	18	12
Seasonal/vacation home	-	1	1
Don't know/Refused	5%	-	-

D4. Including yourself, how many people live in this residence on a full-time basis?

Number of Full-time residents	2015 (%)	2016 (#)	2017* (#)
Sample size	22	19	12
1	9%	2	-
2	27%	8	7
3	23%	3	2
4	18%	3	3
5	14%	2	-
6+	9%	1	-
Don't know/Refused	-	-	-
*Among those with year round residence			

D5. In which age category do you fall? Are you...

Age	2015 (%)	2016 (#)	2017 (#)
Sample Size	22	19	13
18-24	5%	-	-
25-34	23%	5	1
35-44	18%	5	2
45-54	5%	3	5
55-64	41%	3	2
65+	5%	3	3
Refused	5%	-	-

D6. What is the highest level of education you have completed?

Education	2015 (%)	2016 (#)	2017 (#)
Sample Size	22	19	13
Less than high school graduation certificate	9%	-	2
High-school grad and/or some post-secondary	5%	2	3
Trades certificate or diploma	18%	1	-
College certificate or diploma	18%	3	2
University certificate or diploma	45%	12	6
Refused	5%	1	-

D7. Which of the following income categories best describes your total annual household income before taxes in 2016?

Household Income	2015 (%)	2016 (#)	2017 (#)
Sample Size	22	19	13
Less than \$15,000	5%	-	-
\$15,000-\$24,999	-	-	-
\$25,000-\$34,999	5%	-	1
\$35,000-\$49,999	9%	-	2
\$50,000-\$69,999	9%	1	-
\$70,000-\$79,999	9%	2	-
\$80,000 or more	45%	11	7
Refused	18%	4	-
Don't know	-	1	3

D8. Gender:

Gender	2015 (%)	2016 (#)	2017 (#)
Sample Size	22	19	13
Male	64%	11	10
Female	36%	8	3

Appendix IV BUILDER SURVEY QUESTIONNAIRE

Hello may I please speak with [INSERT NAME]?

- 1 Yes [GO TO INTRODUCTION]
- 2 No [SAY "Perhaps you can help me anyway." GO TO INTRODUCTION – NON PARTICIPANT BUILDERS]

INTRODUCTION – PARTICIPANT BUILDERS (FROM SAMPLE)

Hello, my name is _____ and I am with Corporate Research Associates, and we are performing an evaluation of energy efficiency services provided by Efficiency Nova Scotia. Our records indicate that you or your company has recently participated in Efficiency Nova Scotia's New Home Construction program for new houses. We would appreciate your help in answering questions about your participation in this program and the residential new construction market in general. The information you provide will be used to help Efficiency Nova Scotia evaluate and improve the program. The survey should take about fifteen minutes. Is this a good time for you?

[IF YES, GO TO VR1]

[IF REFUSED, ASK "Can we schedule a more convenient time for you to conduct this survey?"]

[SCHEDULED, IF NECESSARY, FOR: _____]

INTRODUCTION – NON PARTICIPANT BUILDERS (FROM SAMPLE)

Hello, my name is _____ and I am with Corporate Research Associates, a Halifax-based survey research company. We are performing an evaluation of energy efficiency services provided by Efficiency Nova Scotia. We would appreciate your help in answering questions about the residential new construction market in Nova Scotia and Efficiency Nova Scotia's residential programs for new houses. The information you provide will be used to help Efficiency Nova Scotia evaluate and improve their program. The survey should take less than six minutes. Is this a good time for you?

1. Yes [GO TO VR1]
2. No/Don't know [Can we schedule a more convenient time for you to conduct this survey?]
3. Not correct person – ask to speak with someone who would know about the New Home Construction program?"]
99. Refused [THANK, TERMINATE, AND RECORD]

Verification and Recall (VR Series)

VR1. Are you in the business of building and/or selling homes?

- 1. Yes [GO TO VR2]
- 2. No [GO TO VR1a]
- 98. (Don't know) [GO TO VR1a]
- 99. (Refused) [THANK, TERMINATE, AND RECORD]

VR1a. Just to confirm, you do not build or sell residential homes in Nova Scotia?

- 1. Yes, I build or sell homes in Nova Scotia [CONTINUE]
- 2. No, I do not build or sell homes in Nova Scotia [THANK, TERMINATE, AND RECORD]
- 98. (Don't know) [THANK, TERMINATE, AND RECORD]
- 99. (Refused) [THANK, TERMINATE, AND RECORD]

VR2. Approximately how many new houses, including single units, semi-detached units and row houses, has your firm built so far in 2017 in Nova Scotia? If you built semi-detached units in 2017 in Nova Scotia, please count each as two units.

[PROBE FOR A SPECIFIC ANSWER. DO NOT ACCEPT A RANGE – IF DON'T KNOW OR UNSURE – PLEASE PROBE FOR AN ESTIMATE KEEPING IN MIND THE NUMBER CAN ONLY BE ONE NUMBER AND NOT A RANGE] [IF NUMBER IS 0 OR DK OR REFUSED, THANK, TERMINATE, AND RECORD]

- 1. [ENTER NUMBER]
- 98. (Don't know) [THANK, TERMINATE, AND RECORD]
- 99. (Refused) [THANK, TERMINATE, AND RECORD]

VR3. Among the new houses that you have built so far in 2017 in Nova Scotia, how many have been built under Efficiency Nova Scotia's New Home Construction program? [PROBE FOR A SPECIFIC ANSWER. DO NOT ACCEPT A RANGE]

- 1. [ENTER NUMBER]
- 98. (Don't know)
- 99. (Refused)

[ANSWER TO VR3 CANNOT BE HIGHER THAN ANSWER TO VR2]

[IF ANSWER TO VR3 IS 0, CONSIDER NON-PARTICIPANT BUILDER AND GO TO SECTION M, OTHERWISE CONTINUE]

[IF DON'T KNOW TO VR3, CONSIDER NON-PARTICIPANT BUILDER AND GO TO SECTION M, OTHERWISE CONTINUE]

VR4. I just want to be sure, you or someone else from your firm participated in the New Home Construction program for houses you built in 2017?

- 1. Yes
- 2. No
- 99. Refused [THANK AND TERMINATE]

NOTE FOR PROGRAMMER:

RESPONDENTS ARE PARTICIPANT BUILDERS IF “YES” TO VR4; OTHERWISE THEY ARE NON-PARTICIPANT BUILDERS.

Free-Ridership (FR Series)

[ASK THIS SECTION TO PARTICIPANT BUILDERS ONLY]

Now, I would like to examine the influence of the New Home Construction program on your decision to build houses with a high level of energy efficiency.

FR1. Without the New Home Construction program, its energy modelling service and rebate, and the energy labels it promotes, such as EnerGuide, ENERGY STAR® Canada and R2000, would you have built the same number of houses with the exact same level of energy efficiency in 2017?

- 1. Yes
- 2. No
- 98. (Don't know)
- 99. (Refused)

[IF FR1=1]

FR1a. I just want to make sure I understand - If the New Home Construction program had **NOT** been in place and had not promoted energy labels, nor offered incentives, advice, and home modelling services to build houses, you would have still built the same number of houses with the exact same level of efficiency in 2017?

- 1. Yes [GO TO QUESTION FR3]
- 2. No
- 98. (Don't know)
- 99. (Refused)

[IF VR3=NUMERIC ANSWER]

FR2a. Of the [ANSWER TO VR3] houses that you have built under the program in 2017 in Nova Scotia, how many would have reached the energy efficiency level required by the New Home Construction program if the program had NOT been in place?

[ENTER NUMBER] [CAN'T BE HIGHER THAN VR3] DO NOT ACCEPT A RANGE

- 98. (Don't know)
- 99. (Refused)

FR3. Using a scale from 0 to 10, where 0 means "Not at all important" and 10 means "Extremely important", please rate the importance of the following in terms of your decision to build houses with a high level of energy efficiency. **[READ AND ROTATE OPTIONS, CODE ONE ONLY PER OPTION]**

- a. The New Home Construction program in general
- b. The energy modelling service and advice of the New Home Construction program
- c. The incentive provided through the program
- d. The EnerGuide, ENERGY STAR and R2000 energy labels promoted by the program
- e. The energy-efficiency promotional materials distributed by Efficiency Nova Scotia

[0 to 10] Probe for an exact number

- 98. (Don't know)
- 99. (Refused)

Market Effects – Non Participants (M Series)

[ASK THIS SECTION TO NON PARTICIPANT BUILDERS ONLY]

We will now talk about the houses you have built in 2017.

M0a. What type of heating system do you most often install in the houses that you build? **[READ IN ORDER AND ACCEPT ONE RESPONSE ONLY]**

- 1. Electric baseboards or furnace
- 2. Electric furnace or boiler
- 3. Central ducted heat pump
- 4. One or more minisplit heat pumps and electric baseboards
- 5. A geothermal system
- 6. Heating stove (wood or pellet)
- 7. Other combustion equipment (for example oil or natural gas furnace)
- 97. Or something else (SPECIFY:_____)
- 98. (Don't know)
- 99. (Refused)

M0b. Of the homes you built in 2017, how many had [INSERT HEATING SYSTEM FROM M0a] installed? **[ENTER NUMBER, PROBE FOR SPECIFIC NUMBER]**

- M1. Before today, had you ever heard of the New Home Construction program from Efficiency Nova Scotia? [CHOOSE ONLY ONE ANSWER.]
1. Yes [GO TO M2]
 2. No [GO TO SECTION F]
 98. (Don't know) [GO TO SECTION F]
 99. (Refused) [GO TO SECTION F]

- M2. Has your firm ever participated in the New Home Construction program or Efficiency Nova Scotia's former program for new houses known as Performance Plus? [CHOOSE ONLY ONE ANSWER]
1. Yes
 2. No
 98. (Don't know)
 99. (Refused)

- M3. Among the [VR2] houses you told me you or your firm have built in 2017 in Nova Scotia, approximately how many would have reached the energy efficiency level required by Efficiency Nova Scotia's program for new houses?

[ENTER NUMBER] [NUMBER CAN'T BE HIGHER THAN VR2]

98. (Don't know) [GO TO SECTION F]
99. (Refused) [GO TO SECTION F]

SHOW ON SCREEN FOR INTERVIEWER TO READ IF NECESSARY: Either reaching an EnerGuide rating of 85 or higher and/or achieving ENERGY STAR certification or higher performance when modelled in Natural Resources Canada's HOT2000 software.

- M5. [DO NOT ASK IF M3 = 0] What energy efficiency upgrades were implemented in those houses to make you think that they would have reached the energy efficiency level required by Efficiency Nova Scotia's program for new houses? PROBE: Anything else? [TYPE VERBATIM]

____ Response

98. (Don't Know)
99. (Refused)

- M6. [DO NOT ASK IF 98 OR 99 IN M5 OR IF M3=0] What is the likelihood that you would have implemented those upgrades if you had never heard of or participated in any of Efficiency Nova Scotia's programs or heard of the EnerGuide rating? Please answer on a scale from 0 to 10, where 0 means "very unlikely" and 10 "very likely." [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

____ Response

98. (Don't Know)
99. (Refused)

M7. Why did you not take part in Efficiency Nova Scotia's programs for houses built in 2017 in Nova Scotia? [DO NOT READ. PROBE FOR SPECIFIC REASONS. ACCEPT MULTIPLE]

1. (I was following the homeowner's wish not to participate in the program)
2. (Did not believe the upgrades or rebates applied to those houses)
3. (I did not have a positive past experience with the program)
4. (The program is too complicated)
5. (Time commitment for participating in the program is unreasonable)
6. (Rebate reduction/Change in incentive)
96. (Other, please specify: _____)
98. (Don't know)
99. (Refused)

Market Effects – Participants (MP Series)

[ASK THIS SECTION TO PARTICIPANT BUILDERS ONLY]

[ASK THIS SECTION ONLY IF VR2-VR3 > 0]

We will now talk about the houses you have built in 2017, but without participating in the New Home Construction program.

MP0a. What type of heating system do you most often install in the houses that do not participate in the New Home Construction program? [READ IN ORDER AND ACCEPT ONE RESPONSE ONLY]

1. Electric baseboards or furnace
2. Electric furnace or boiler
3. Central ducted heat pump
4. One or more minisplit heat pumps and electric baseboards
5. A geothermal system
6. Heating stove (wood or pellet)
7. Other combustion equipment (for example oil or natural gas furnace)
97. Or something else (SPECIFY: _____)
98. (Don't know)
99. (Refused)

MP0b. Of the homes you built in 2017 that did not participate in the New Home Construction program, how many had [INSERT HEATING SYSTEM FROM MP0a] installed? [ENTER NUMBER. PROBE FOR SPECIFIC NUMBER]

MP1. You told me that you or your firm have built approximately [VR2] houses, including single units, semi-detached units and row houses, so far in 2017 in Nova Scotia. Among these houses, you told me that roughly [VR3] have been built under the New Home Construction program. It means that you or your firm has/have built [VR2-VR3] house(s) so far in 2017 in Nova Scotia without participating in the New Home Construction program. Is that correct? [CHOOSE ONLY ONE ANSWER]

1. Yes
2. No [READ INSTRUCTION BELOW]
98. (Don't know)
99. (Refused)

INSTRUCTION

READ: "Can you please tell me which answer(s) need(s) to be corrected between the number of new houses you or your firm have built so far in 2017 in Nova Scotia, and the number of houses built in Nova Scotia under the New Home Construction program? [CHANGE ANSWER TO VR2 and/or VR3 BASED ON ANSWER FROM RESPONDENT]

1. [CHANGE VR2]
2. [CHANGE VR3]

MP2. [DO NOT ASK IF VR2-VR3 = 0] Among the [VR2-VR3] house(s) you told me you or your firm have built so far in 2017 without participating in the New Home Construction program, how many would have reached the energy efficiency level required by Efficiency Nova Scotia's program for new houses? [ENTER NUMBER]

___ Response **[NUMBER CAN'T BE HIGHER THAN (VR2-VR3)]**

98. (Don't Know) [GO TO SECTION P]
99. (Refused) [GO TO SECTION P]

SHOW ON SCREEN FOR INTERVIEWER TO READ IF NECESSARY: Either reaching an EnerGuide rating of 85 or higher and/or achieving an ENERGY STAR certification or higher performance when modelled in Natural Resources Canada's HOT2000 software.

MP4. [DO NOT ASK IF MP2=0] What energy efficiency upgrades were implemented in those houses to make you think that they would have reached the energy efficiency level required by Efficiency Nova Scotia's program for new houses [TYPE VERBATIM]

- ___ Response
98. (Don't Know)
 99. (Refused)

MP5. [DO NOT ASK IF 98 OR 99 IN MP4 OR IF MP2=0] What is the likelihood that you would have implemented those upgrades if you had never participated in Efficiency Nova Scotia's programs or heard of the EnerGuide rating? Please answer on a scale from 0 to 10, where 0 means "very unlikely" and 10 "very likely." [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

____ Response

98. (Don't Know)

99. (Refused)

MP6. Why did you not take part in the New Home Construction program for those houses? [DO NOT READ. PROBE FOR SPECIFIC REASONS. ACCEPT MULTIPLE]

1. (I was following the homeowner's wish not to participate in the program)

2. (Did not believe the upgrades or rebates applied to those houses)

3. (I did not have a positive past experience with the program)

4. (The program is too complicated)

5. (Time commitment for participating in the program is unreasonable)

6. (Rebate reduction/Change in incentive)

96. (Other, please specify: _____)

98. (Don't know)

99. (Refused)

Reasons for Participating (P Series)

[ASK PARTICIPANT BUILDERS ONLY]

P1. Moving along... Usually, who makes the decision to participate in the New Home Construction program, is it you or the future home owner? [DO NOT READ. ACCEPT ONE]

1. (Me, the builder usually makes the decision)

2. (The future homeowner usually makes the decision)

3. (Both builder and future homeowner make decision)

98. (Don't know)

99. (Refused)

[ASK IF P1=1 or 3, OTHERWISE SKIP TO S1]

- P2. Now I'm going to ask you to think back to when you decided to participate in the New Home Construction program this year. What was the most important reason you were interested in participating in the program? [DO NOT READ; ACCEPT MULTIPLE RESPONSE BUT DO NOT PROBE FOR]
1. (To make a house that would save buyers/homeowners on energy costs/bills)
 2. (To find out how energy efficient the new house would be/to get house evaluated)
 3. (To get expert advice about what upgrades to install/how to make home more energy efficient)
 4. (To help buyer/homeowners save energy—not further specified whether for cost, environment)
 5. (To get rebates for upgrades that we were already planning)
 6. (To market house/make house more attractive for potential buyers)
 7. (Interested in building a better, more energy efficient home)
 8. (Interested in energy efficiency and renewable energy)
 9. (To reach/obtain the EnerGuide/ENERGY STAR/R2000 label/certification)
 96. (Other) [SPECIFY_____]
 98. (Don't know)
 99. (Refused)

Satisfaction with Program (S Series)

[ASK PARTICIPANT BUILDERS ONLY]

- S1. Using a scale from 1 to 10 where 1 is "not at all satisfied" and 10 is "completely satisfied" how would you rate your satisfaction with the New Home Construction program overall? [RECORD NUMBER, 98=Don't know, 99 Refused] DO NOT ACCEPT A RANGE
- S2. [IF S1 <8] What was the most important reason you were not more satisfied with the New Home Construction program overall? [PROBE FOR SPECIFIC REASONS. ACCEPT MULTIPLE RESPONSE.]
97. (RECORD VERBATIM: _____)
 98. (Don't know)
 99. (Refused)
- S3. Do you have any recommendations for improving the New Home Construction program? Probe: Anything else? [DO NOT READ – ACCEPT MULTIPLE RESPONSES]
10. (Increase rebates)
 11. (No recommendation)
 99. (Other) [SPECIFY_____]
 98. (Don't know)
 99. (Refused)

Firmographics (F Series)

[ASK ALL]

The final question is asked for statistical purposes only.

- F1. Approximately how many full-time equivalent workers are employed by your company/organization within Nova Scotia? [READ ONLY IF NECESSARY]
1. Fewer than 5
 2. 5 to 9
 3. 10 to 19
 4. 20 to 49
 5. 50 to 99
 6. 100 to 249
 7. 250 or More
 98. (Don't know)
 99. (Refused)

END: That is all the questions I have for you. Thank you for taking the time to respond to this survey.

Appendix V BUILDER SURVEY RESULTS

The builder survey results are presented in the following tables.

VR2. Approximately how many new houses, including single units, semi-detached units and row houses, has your firm built so far in 2017 in Nova Scotia? If you built semi-detached units in 2017 in Nova Scotia, please count each as two units.

Number of Houses Built in Year	2016	2017
Sample Size	46	59
1-2	24%	20%
3-5	35%	27%
6-10	20%	24%
11-20	11%	14%
21+	11%	15%
Average*	10.0	11.2
*Don't know/refused removed from calculations		

VR3. Among the new houses that you have built so far in 2017 in Nova Scotia, how many have been built under Efficiency Nova Scotia's New Home Construction program?

Number of Houses Built in Year as part of NHC	2016	2017
Sample Size	46	59
0	26%	32%
1-2	22%	17%
3-5	20%	14%
6-10	11%	19%
11-20	7%	10%
21+	2%	8%
Don't know	13%	-
Average*	4.1	6.4
*Don't know/refused removed from calculations		

FR1. Without the New Home Construction program, its energy modelling service and rebate, and the energy labels it promotes, such as EnerGuide, ENERGY STAR® Canada and R2000, would you have built the same number of houses with the exact same level of energy efficiency in 2017?

FR1a. I just want to make sure I understand - If the New Home Construction program had NOT been in place and had not promoted energy labels, nor offered incentives, advice, and home modelling services to build houses, you would have still built the same number of houses with the exact same level of efficiency in 2017?

Would Have Built Same Number of Houses with Same Level of Efficiency – Participant Builders	2016	2017
Sample Size	27	40
Yes	70%	60%
No	26%	40%
Don't know	4%	-

FR3. Using a scale from 0 to 10, where 0 means “Not at all important” and 10 means “Extremely important”, please rate the importance of the following in terms of your decision to build houses with a high level of energy efficiency.

Importance of Factors in Influencing Decision – Participant Builders	2015		2016**		2017	
	Sample Size	Mean*	Sample Size	Mean*	Sample Size	Mean*
Energy modeling service and advice of the NHC program	21	6.2	27	6.1	38	7.5
The New Home Construction program in general	-	-	27	6.5	40	7.3
Incentive provided through the program	20	5.4	27	6.4	40	7.1
The EnerGuide, ENERGY STAR and R2000 energy labels promoted by the program	-	-	27	7.4	39	6.9
The energy efficiency promotional materials distributed by Efficiency Nova Scotia	-	-	27	5.1	37	5.8
*Don't know/refused removed from calculations						
**Wording change in 2016						

M0a. What type of heating system do you most often install in the houses that you build?

M0b. Of the homes you built in 2017, how many had [INSERT HEATING SYSTEM FROM M0a] installed?

Heating System Typically Installed – Non-participant Builders	2016		2017	
	Installed	Installation Rate	Installed	Installation Rate
Sample Size*	19 (#)	18 (Average**)	19 (#)	19 (Average**)
Other combustion equipment (for example oil or natural gas furnace)	1	50%	1	100%
Mini-split heat pump and electric boiler	-	-	1	100%
Electric baseboards or furnace	3	100%	2	95%
One or more mini-split heat pumps and electric baseboards	5	91%	10	86%
Mini-split heat pump	-	-	1	67%
Electric furnace or boiler	-	-	1	57%
Central ducted heat pump	8	63%	3	43%
Others	1	8%	-	-
Don't know	1	-	-	-
*Base: Non-participant Builders				
**Don't know/refused removed from calculations				

M1. Before today, had you ever heard of the New Home Construction program from Efficiency Nova Scotia?

Aware of New Home Construction – Non-participant Builders	2016 (#)	2017 (#)
Sample Size*	19	19
Yes	16	16
No	2	3
Don't know	1	-
*Base: Non-participant Builders		

M2. Has your firm ever participated in the New Home Construction program or Efficiency Nova Scotia's former program for new houses known as Performance Plus?

Participation in New Home Construction or Performance Plus – Non-participant Builders	2016 (#)	2017 (#)
Sample Size*	16	16
Yes	12	16
No	3	-
Don't know	1	-
*Base: Non-participant Builders aware of NHC		

M6. What is the likelihood that you would have implemented those upgrades if you had never heard of or participated in any of Efficiency Nova Scotia's programs or heard of the EnerGuide rating? Please answer on a scale from 0 to 10, where 0 means "very unlikely" and 10 "very likely."

Likelihood of Implementation of Energy Efficiency Measures Without Awareness of ENS Programs or EnerGuide Rating – Non-participant Builders	2016	2017
Sample Size*	15	14
Average**	7.6	8.6
*Base: Non-participant Builders aware of NHC that did not build any houses that would have reached the energy efficiency level required by Efficiency Nova Scotia's program for new houses		
**Don't know/refused removed from calculations		

M7. Why did you not take part in Efficiency Nova Scotia's programs for houses built in 2017 in Nova Scotia?

Reasons for Not Participating in Efficiency Nova Scotia's Programs for Houses – Non-participant Builders**	2016	2017
Sample Size*	15 (#)	15 (#)
Rebate is not worth the effort	-	7
The program is too complicated	-	6
Rebate reduction/Change in incentive	3	3
I was following the homeowner's wish not to participate in the program	2	3
Time commitment for participating in the program is unreasonable	3	1
Takes too long to receive rebates	1	1
Did not believe the upgrades or rebates applied to those houses	-	1
Did not qualify	1	-
Not aware of program/programs have changed	1	-
I did not have a positive past experience with the program	1	-
Others	5	1
Don't know/Refused	-	-
*Base: Non-participant Builders aware of NHC **Multiple responses		

MP0a. What type of heating system do you most often install in the houses that you build?

MP0b. Of the homes you built in 2017 that did not participate in the New Home Construction program, how many had [INSERT HEATING SYSTEM FROM MP0a] installed?

Heating System Typically Installed – Participant Builders	2016		2017	
	Installed (#)	Installation Rate (Average**)	Installed (#)	Installation Rate (Average**)
Sample Size*	5	5	13	13
One or more mini-split heat pumps and electric baseboards	3	52%	8	61%
Central ducted heat pump	-	-	2	50%
Electric baseboards or furnace	1	98%	2	32%
Electric furnace or boiler	-	-	1	0%
Other combustion equipment (for example oil or natural gas furnace)	1	10%	-	-
*Base: Participants who built homes outside of program **Don't know/refused removed from calculation				

MP5. What is the likelihood that you would have implemented those measures if you had never participated in Efficiency Nova Scotia's programs or heard of the EnerGuide rating? Please answer on a scale from 0 to 10, where 0 means "very unlikely" and 10 "very likely."

Likelihood of Implementing Measures if had not Participated in ENS Programs – Participant Builders	2015**	2016**	2017**
Sample Size*	5	3	9
Mean (10= very likely, 0=very unlikely)	4.2	6.3	6.7
*Base: Participants who built homes outside of program **Don't know/refused removed from calculation			

MP6. Why did you not take part in the New Home Construction program for those houses?

Reason for Not Taking Part in Program – Participant Builders	2015**	2016**	2017**
Sample Size*	6	4	12
Rebate reduction/change in incentive	1	1	6
The homeowner applied/is responsible to apply	-	-	2
Following homeowners wish not to participate	2	-	2
The rebate is not worth the effort	-	-	1
Missed the deadline	-	-	1
Did not believe the measures or rebates applied to those houses	1	2	1
Too much paperwork	-	1	1
House did not need the program	1	-	1
I did not have a positive past experience with the program	-	-	1
Cost/customers budget	1	-	-
Others	1	1	1
Don't know	-	-	1
*Base: Participants who built homes outside of program **Multiple responses			

P1. Usually, who makes the decision to participate in the New Home Construction program, is it you or the future home owner?

Builders' Decision to Register – Participant Builders	2015	2016	2017
Sample Size	21	27	40
Me, the builder, usually make the decision	76%	85%	83%
Both builder and future homeowner make the decision	14%	11%	13%
Future homeowner usually makes the decision	5%	4%	5%
Don't know	5%	-	-

P2. Now I'm going to ask you to think back to when you decided to participate in the New Home Construction program. What was the most important reason you were interested in participating in the program?

Reasons for Participating in Program – Participant Builders	2015**	2016**	2017**
Sample Size*	19 (#)	26 (%)	38 (%)
To reach/obtain the EnerGuide/ENERGY STAR/R2000 label/certification	1	-	39%
To get rebates for upgrades that we were already planning	7	38%	26%
To make a house that would save homeowners on energy costs/bills	2	12%	26%
To market house/make house more attractive for potential buyers	4	15%	13%
Interested in building a better, more energy efficient home	3	27%	5%
To differentiate ourselves from other builders	-	-	5%
Homeowner wanted it	-	8%	5%
To help buyer/homeowners save energy—not further specified whether for cost, environment)	-	8%	3%
To find out how energy efficient the new house would be/to get house evaluated	2	19%	3%
Interested in energy efficiency and renewable energy	2	12%	-
To get expert advice about what measures to install/how to make home more energy efficient	1	8%	-
To help the environment	-	8%	-
To meet new building code requirements	-	4%	-
Others	3	15%	11%
*Base: Participants who made the decision to participate in the New Home Construction program either on their own or with the future homeowner **Multiple responses			

S1. Using a scale from 1 to 10 where 1 is “not at all satisfied” and 10 is “completely satisfied” how would you rate your satisfaction with the New Home Construction program overall?

Satisfaction with Program Overall – Participant Builders	2016	2017
Sample Size	27	40
Mean*	7.0	7.2
*Don't know/Refused excluded from calculations		

S2. What was the most important reason you were not more satisfied with the program overall?

Key Reasons Not More Satisfied – Participant Builders	2016** (#)	2017** (%)
Sample Size*	13	22
Rebates were too small	8	55%
Not enough detail/information on program/process	-	14%
Took too long to receive rebate	-	14%
Program not consistent/keeps changing	-	9%
Too much paperwork	1	9%
The review of the plans took too long	2	9%
New guidelines make it hard to get rebate	-	5%
Poor service from service organization	-	5%
Did not like the recommendations	1	-
Others	3	9%
*Base: Participants who were not satisfied with the program (NOT SATISFIED: S1 <8)		
**Multiple responses		

S3. Do you have any recommendations for improving the New Home Construction program?
Anything else?

Builder Recommendations to Improve Program – Participant Builders*	2015	2016	2017
Sample Size	21	27	40
Increase rebates	62%	30%	33%
Offer more information on the measures recommended	5%	-	5%
Offer more measures eligible for rebates	5%	-	5%
Don't change the program so often/Keep program as is	5%	4%	5%
Speed up rebates	-	-	5%
Improve communication/More notice of program changes	-	4%	5%
Faster process/process takes too long/Faster certification process	5%	4%	5%
More marketing/advertising	5%	4%	5%
Another way of receiving the incentive	-	-	3%
Make process simpler/consolidate rebate programs/clarify reports	5%	4%	3%
Complete the first review of house plans faster	-	11%	3%
Increase availability of Energy Advisor to answer energy efficiency-related questions	-	7%	-
Offer financing/help with cost	-	7%	-
Lower the EnerGuide rating needed for rebate/incentive	-	4%	-
Include other forms of energy	14%	-	-
Lengthen the time frame to register	5%	-	-
Others	10%	15%	15%
No recommendations	19%	37%	35%
*Multiple Responses			

F1. Approximately how many full-time equivalent workers are employed by your company/organization within Nova Scotia?

Full-Time Employees	2015			2016			2017		
	Overall (%)	Participating Builders (%)	Non-Participating Builders (#)	Overall (%)	Participating Builders (%)	Non-Participating Builders (#)	Overall (%)	Participating Builders (%)	Non-Participating Builders (#)
Sample Size	31	21	10	46	18	28	59	40	19
Fewer than 5	32%	29%	4	50%	7	57%	39%	33%	10
5 to 9	39%	43%	3	20%	3	21%	25%	28%	4
10 to 19	19%	14%	3	22%	6	14%	24%	28%	3
20 to 49	-	-	-	2%	1	-	5%	5%	1
50 to 99	3%	5%	-	-	-	-	2%	3%	-
100 to 249	3%	5%	-	2%	1	-	3%	5%	-
250 or more	3%	5%	-	2%	-	4%	-	-	-
Don't know	-	-	-	2%	-	4%	2%	-	1

Appendix VI

PASSIVE HOUSE PILOT PARTICIPANT INTERVIEW GUIDE

Hello may I please speak with [INSERT NAME]?

- 1 Yes [GO TO INTRODUCTION]
- 2 No [SAY "Perhaps you can help me anyway." GO TO INTRODUCTION]

INTRODUCTION

Hello, my name is _____ and I am with Corporate Research Associates, a Halifax-based survey research company. We are performing an evaluation of energy efficiency services provided by Efficiency Nova Scotia. Our records indicate that you recently participated in Efficiency Nova Scotia's Passive House pilot. We would appreciate your help in answering questions about your participation in this program. The information you provide will be used to help Efficiency Nova Scotia evaluate and improve the program. Is this a good time for you? The interview will take about 5-10 minutes.

Verification and Recall (V Series)

- V1. We understand you participated in the Passive House pilot for the house you built at [ADDRESS FROM FILE]. Is that correct?
1. Yes [CONTINUE]
 2. No, does not recall participating [PROMPT: "Are you sure? This program provides rebates for reaching the Passive House level of energy efficiency for your new house."]
[IF PERSIST AS NO, THANK, TERMINATE AND RECORD]
 98. Don't know/Refused [PROBE: "Is there someone else who would know about having participated in the Passive House pilot?"] [IF YES, ASK TO SPEAK TO THE APROPRIATE PERSON AND RESTART AT INTRODUCTION. IF PERSISTS AS NO, THANK, TERMINATE AND RECORD.]

[IF REFUSED, ASK "Can we schedule a more convenient time for you to conduct this survey?"]

[SCHEDULED, IF NECESSARY, FOR: _____]

- V2. Are you in the business of building and/or selling homes?
1. Yes
 2. No
 98. (Don't know)
 99. (Refused)

- V3. [ASK IF V2= 2, 98, 99] Did you take part in the decisions regarding the energy-efficient features to be included in your home energy model to reach the Passive House level of efficiency?
1. Yes
 2. No/The Consultant or the Builder made the decision
 98. (Don't know)
 99. (Refused)
- V4. Before you first heard about the Passive House pilot from Efficiency Nova Scotia, did you know about the Passive House level of efficiency and certification?
1. Yes
 2. No
 98. (Don't know)
 99. (Refused)

Free-ridership (FR Series)

- FR1. Before participating in the Passive House Pilot, had you already planned to include to your home design all the energy-efficient features that were identified in your home energy model?
1. Yes
 2. No
 98. (Don't know)
 99. (Refused)

[IF FR1=YES]

- FR1a. I just want to make sure I understand - **Before** you decided to participate in the Passive House pilot, your home design already included all the energy-efficient features that were identified in your home energy model?
1. Yes
 2. No
 98. (Don't know)
 99. (Refused)

[ASK FR2a IF, IN SAMPLE, TOTAL INCENTIVE>0]

FR2a. Efficiency Nova Scotia paid you \$10,000 for reaching the Passive House level of energy efficiency in your new house. If you had not received the rebate from Efficiency Nova Scotia, would you have paid for the full cost to reach this level of energy efficiency? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely Would Not Have Paid” and a 10 indicating that you “Definitely Would Have Paid.” [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response

96. (Did not receive that rebate)

98. (Don’t Know)

99. (Refused)

Now I would like to ask you to consider what actions you would have taken if the Passive House pilot had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely,” and a 10 indicating that it is “Very Likely.”

[DO NOT ACCEPT A RANGE – ASK FR3 SEQUENCE IN ORDER/DO NOT RANDOMIZE]

FR3a. If the Passive House pilot had not been offered, what is the likelihood that you would have built or bought a Passive House?

___ Response

___98 Don’t Know

___99 Refused

FR3b. If the Passive House pilot had not been offered, what is the likelihood that you would have built or bought a house with a level of energy efficiency higher than code, but lower than the Passive House requirements?

___ Response

___98 Don’t Know

___99 Refused

FR3c. If the Passive House pilot had not been offered, what is the likelihood that you would have built or bought a standard house, designed to code, instead of a Passive House?

___ Response

___98 Don’t Know

___99 Refused

FR4. Thinking of all the energy-efficient features you decided to incorporate into your build, how much would you estimate the total cost of these upgrades to be before any rebates from Efficiency Nova Scotia? [RECORD TOTAL COST IN DOLLARS.]

___ Response

___98 Don’t Know

___99 Refused

FR5. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to build or buy a Passive House. Using a scale from 0 to 10 where 0 means "No influence" and 10 means "Great influence", please rate the influence of each of the following in your decision to build or buy a Passive House. DO NOT ACCEPT A RANGE

Factor	Responses
a. The rebate offered by Efficiency Nova Scotia	___ Response ___98 Don't Know ___99 Refused
b. Expert information or advice provided by the Passive House-certified consultant you worked with	___ Response ___98 Don't Know ___99 Refused
c. The review of your home energy model by Efficiency Nova Scotia	___ Response ___98 Don't Know ___99 Refused
d. Promotional materials distributed by Efficiency Nova Scotia	___ Response ___98 Don't Know ___99 Refused
e. A previous participation in an Efficiency Nova Scotia Program	___ Response ___98 Don't Know ___99 Refused

Certification (C Series)

C1. Have you started the process to get the Passive House certification?

1. Yes
2. No
98. (Don't know)
99. (Refused)

C2. [ASK IF C1=2] Are you considering it?

1. Yes
2. No
3. Unsure/Thinking about it
98. (Don't know)
99. (Refused)

C3. [ASK IF C2=2] What is the main reason you decided not to get the certification?

- ___ Record Response
98. (Don't Know)
 99. (Refused)

C4. [ASK IF C2=3] What is keeping you from making a decision about getting the certification?

___ Record Response

98. (Don't Know)

99. (Refused)

END: That is all the questions I have for you. Thank you for taking the time to respond to this interview.

Appendix VII PASSIVE HOUSE PILOT INTERVIEW RESULTS

The results of the Passive House pilot participant interviews are presented in the following tables.

V1. We understand you participated in the Passive House pilot for the house you built at [INSERT ADDRESS]. Is that correct?

Participant Recalls Participation	2017 (#)
Sample Size	4
Yes	4
No	-
Don't know	-

V2. Are you in the business of building and/or selling homes?

Participant in the Business of Building or Selling Homes	2017 (#)
Sample Size	4
Yes	1
No	3
Don't know	-

V3. Did you take part in the decisions regarding the energy-efficient features to be included in your home energy model to reach the Passive House level of efficiency?

Participant Involved in Decisions about the Implemented Features	2017 (#)
Sample Size	3
Yes	3
No	-
Don't know	-

- V4. Before you heard about the Passive House pilot from Efficiency Nova Scotia, did you know about the Passive House level of efficiency and certification?

Prior Knowledge of Passive House Level of Efficiency and Certification	2017 (#)
Sample Size	4
Yes	3
No	1
Don't know	-

- FR1. Before participating in the Passive House pilot, had you already planned to include to your home design all the energy-efficient features that were identified in your home energy model?

- FR1a. I just want to make sure I understand - Before you decided to participate in the Passive House pilot, your home design already included all the energy-efficient features that were identified in your home energy model?

Already Made Decision to Build House with Energy Efficiency Measures Identified by Passive House	2017 (#)
Sample Size	4
Yes	3
No	-
Don't know	1

- FR2a. Efficiency Nova Scotia paid you \$10,000 for reaching the Passive House level of energy efficiency in your new house. If you had not received the rebate from Efficiency Nova Scotia, would you have paid for the full cost to reach this energy efficiency level? Please answer on a scale of 0 to 10, with a 0 indicating that you "Definitely Would Not Have Paid" and a 10 indicating that you "Definitely Would Have Paid."

Would Have Paid Cost to Reach Energy Efficiency Level	2017	
	Sample Size	Mean
Average rating: 10= "Definitely would have paid", 0= "Definitely would not have paid"		
Would have paid cost to reach energy efficiency level	4	8.2

FR3a-c. Now I would like to ask you to consider what actions you would have taken if the Passive House pilot had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely,” and a 10 indicating that it is “Very Likely.”

Actions Taken in Absence of Passive House Pilot	2017	
	Sample Size	Mean*
Built/bought a Passive House	4	9.0
Built/bought a house with a level of energy efficiency higher than code, but lower than the Passive House requirements	4	9.0
Built/bought a standard house, designed to code, instead of a Passive House	3*	2.0
*Don't know excluded from calculations		

FR4. Thinking of all the energy-efficient upgrades you decided to incorporate into your build, how much would you estimate the total cost of these upgrades to be before any rebates from Efficiency Nova Scotia?

Estimated Costs of Upgrades	2017
Sample Size	3*
Average*	\$21,667
*Don't know excluded from calculations	

FR5. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to build or buy a Passive House. Using a scale from 0 to 10 where 0 means “No influence” and 10 means “Great influence”, please rate the influence of each of the following in your decision to build or buy a Passive House.

Influence of Pilot in Decision to Build or Buy a Passive House	2017	
	Sample Size	Mean*
Mean (0 = “No influence”; 10 = “Great influence”)		
The rebate offered by Efficiency Nova Scotia	4	3.7
Expert information or advice provided by the Passive House-certified consultant you worked with	4	8.2
The review of your home energy model by Efficiency Nova Scotia	4	6.0
Promotional materials distributed by Efficiency Nova Scotia	4	3.2
A previous participation in an Efficiency Nova Scotia program	4	4.7
*Don't know excluded from calculations		

C1. Have you started the process to get the Passive House certification?

Started Passive House Certification Process	2017 (#)
Sample Size	4
Yes	2
No	2
Don't know	-

C2. Are you considering it?

Considering Passive House Certification Process	2017 (#)
Sample Size	2
Yes	-
No	2
Don't know	-

C3. What is the main reason you decided not to get the certification?

Reasons for Not Getting Passive House Certification	2017 (#)
Sample Size	2
There is no reason to get it. Our goal was to save money and be energy efficient, not get certified.	2

Appendix VIII

ALGORITHM FOR FREE-RIDERSHIP CALCULATION

The figures below present the algorithms for calculating the free-ridership level for both NHC and the Passive House pilot. The NHC participant and builder survey questionnaires included questions designed to assess the planning, quantity, efficiency, period, cost and influence of the program. Each group of questions was transposed into a level of program attribution, which was used to calculate the free-ridership level associated with each participant or builder. A similar approach was used for the Passive House pilot, with the main difference being that the information was collected through interviews instead of surveys due to the low number of participants.

NHC - Builders

FR1. Without the NHC program, its energy modelling service and rebate, and the energy labels it promotes, such as EnerGuide, ENERGY STAR and R2000, would you have built the same number of houses with the exact same level of energy efficiency?	IF Yes: Use FR1a IF No OR DK OR REF: FR1 = 0%
FR1a. I just want to make sure I understand – If the NHC program had NOT been in place and had not promoted energy labels, nor offered incentives, advice, and home modelling services to build houses, you would have still built the same number of houses with the exact same level of efficiency?	IF Yes: FR1 = 100% AND GO TO FR3 IF No OR DK OR REF: FR1 = 0%
FR2a. Of the [#] houses that you have built under the program in 2017 in Nova Scotia, how many would have reached the energy efficiency level required by the NHC program if the program had NOT been in place?	FR2 = FR2a / [#] of houses
PA1 Score:	IF FR1 = 0%: FR2/2 OTHERWISE: FR1
FR3. Level of influence of five program factors (Scale 0 to10)	FR3 = MAX(a; b; c; d; e)
PA2 Score:	(10 – FR3) x 10%
Inconsistency Test #1	IF FR1=100% AND FR3 ≥ 7: PA1 = EMPTY
Revised Free-Ridership	MEAN VALUE OF: (PA1; PA2)

NHC - Participants

FR2ab. If you had not received the rebate from ENS or if ENS had not reduced the cost of the energy assessment, would you have paid for the full cost? (Scale 0 to 10)	FR2ab = Answer x 10% IF DK OR REF: FR2ab = EMPTY
FR3a. If the program had <u>not been</u> offered, what is the likelihood that you would have built or bought a house with the exact same level of efficiency? (Scale 0 to 10)	FR3a = Answer x 10% IF DK OR REF: FR3a = EMPTY
FR3b. If the program had <u>not been</u> offered, what is the likelihood that you would have built or bought a standard house, designed to code, instead of a house with a high level of efficiency? (Scale 0 to 10)	FR3b = (10 – Answer) x 10% IF DK OR REF: FR3b = EMPTY
PA1 Score:	MEAN VALUE OF: (FR2ab; FR3a; FR3b)
FR1. Before participating in the NHC program, had you already planned to include in your home design all the energy efficient features that were identified in the review of your home plans?	IF Yes: Use FR1a IF No OR DK OR REF: FR1 = 0%
FR1a. [IF FR1=1] I just want to make sure I understand - Before you decided to participate in the NHC program, your home design already included all the energy efficient features that were identified in the review of your home plans?	IF Yes: FR1 = 100% IF No OR DK OR REF : FR1 = 0%
PA2 Score:	FR1
FR5. Level of influence of three program factors (Scale 0 to 10)	FR5 = MAX(a; b; c)
PA3 Score:	(10 – FR5) x 10%
Inconsistency Test #1	IF FR1a = 100% AND FR2ab < 70% PA2 = EMPTY
Free-Ridership	MEAN VALUE OF: (PA1; PA2; PA3)
CI2/4a. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] was a major factor in your decision to implement energy efficiency upgrades in your home. CI2/4b. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted you to ask for an energy assessment of your home. CI2/4c. [Your previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted you to take into account the savings on your energy bill when evaluating different upgrades for your home. (Agree or Disagree)	CI = IF(CI2a OR CI4a = Agree; 1) + IF(CI2b OR CI4b = Agree; 1) + IF(CI2c OR CI4c = Agree; 1)
Revised Free-Ridership	IF CI = 0 OR 1, Revised FR = FR IF CI = 2, Revised FR = FR*.75 IF CI = 3, Revised FR = FR*.50

Passive House

FR2. If you had not received the rebate from ENS, would you have paid the full cost to reach this level of energy efficiency? (Scale 0 to 10)	FR2 = Answer x 10% IF DK OR REF: FR2 = EMPTY
FR3a. If the Passive House pilot had <u>not been</u> offered, what is the likelihood that you would have built or bought a Passive House? (Scale 0 to 10)	FR3a = Answer x 10% IF DK OR REF: FR3a = EMPTY
FR3c. If the Passive House pilot had <u>not been</u> offered, what is the likelihood that you would have built or bought a standard house, designed to code, instead of a Passive House? (Scale 0 to 10)	FR3c = (10 – Answer) x 10% IF DK OR REF: FR3c = EMPTY
PA1 Score:	MEAN VALUE OF: (FR2; FR3a; FR3c)
FR1. Before participating in the Passive House Pilot, had you already planned to include to your home design all the energy-efficient features that were identified in your home energy model?	IF Yes: Use FR1a IF No OR DK OR REF: FR1 = 0%
FR1a. [IF FR1=1] I just want to make sure I understand - Before you decided to participate in the Passive House pilot, your home design already included all the energy-efficient features that were identified in your home energy model?	IF Yes: FR1 = 100% IF No OR DK OR REF : FR1 = 0%
PA2 Score:	FR1
FR5. Level of influence of five program factors (Scale 0 to 10)	FR5 = MAX(a; b; c; d; e)
PA3 Score:	(10 – FR5) x 10%
Inconsistency Test #1	IF ABS(FR3a – FR3b) < 50% FR3a = EMPTY
Inconsistency Test #2	IF FR1a = 100% AND FR2 < 70% PA2 = EMPTY
Free-Ridership	MEAN VALUE OF: (PA1; PA2; PA3)

Appendix IX SPILLOVER METHODOLOGY

The marketing of New Home Construction is primarily conducted through builders who receive promotion and awareness documents on various energy efficiency measures. Consequently, market effects, which constitute a form of spillover, can occur when a builder decides to implement energy efficiency measures in new construction projects without participating in the program.

Questions were asked to understand how program promotion could affect builders' design decisions and to determine if, with the program's influence, they had built energy efficient houses without participating in the program. An average attribution level was then established among the builders to establish the percentage of non-participating eligible houses built due to the influence of the program.

To calculate the number of non-participating eligible houses, the Evaluator first established the total number of non-participating houses by subtracting the number of new houses having participated in New Home Construction (from the 2017 tracking sheet) from the total number of houses built in Nova Scotia in 2017 (from Canada Mortgage and Housing Corporation data). This number was multiplied by the average percentage of new houses that are primarily electrically heated (%Elect). Then the proportion of non-participating eligible houses was estimated based on the builders' declarations. Finally, the number of non-participating eligible houses built due to the influence of the program was obtained using the attribution level. This number divided by the total number of participating houses corresponds to the market effects.

VR2. Approximately how many new houses, including single units, semi-detached units and row houses, has your firm built so far in 2017 in Nova Scotia? If you built semi-detached units in 2017 in Nova Scotia, please count each as two units.	Total number of houses: Σ VR2
VR3. Among the new houses that you have built so far in 2017 in Nova Scotia, how many have been built under ENS's NHC program?	Number of participating houses: Σ VR3
VR4. You or someone else from your firm participated in the New Home Construction program for houses you built in 2016?	Participating builder if VR4 = 1 Non-Participating builder if VR4 = 2
MP1/M1. You told me you or your firm have built approximately [VR2] houses in 2017. Among these houses, you told me that roughly [VR3] have been built under the NHC program. It means that you or your firm has/have built [VR2-VR3] house(s) without participating in the NHC program. Is that correct? / Had you ever heard of the NHC program?	IF 1. Yes: Continue IF 2. No: Read Instructions
MP2/M3. AMong the [VR2-VR3] houses you told me you or your firm have built so far in 2017 without participating in the NHC program, how many would have reached the energy efficiency level required by ENS's NHC program?	Number of non-participating houses reaching the energy efficiency level required by NHC: Σ MP2 OR Σ M3
% of non-participating houses who would have reached the energy efficiency level required by NHC	IF VR4 = 1: $\%N-P_{EE} = \Sigma MP2 / \Sigma (VR2-VR3)$ IF VR4 = 2: $\%N-P_{EE} = \Sigma M3 / (\Sigma VR2)$
MP5/M6. What is the likelihood that you would have implemented those measures if you had never heard of or participated in any of ENS's programs or heard of the EnerGuide rating? (Scale 0 to 10)	MP5/M6 = (10 - Answer) x 10%
Attribution Level	$\%Attrib = MP5 \times MP2 / \Sigma MP2$ OR $M6 \times M3 / \Sigma M3$
MP4/M5. What energy efficiency upgrades were implemented in those houses to make you think that they would have reached the energy efficiency level required by ENS's program for new houses?	Validation of measures
MP6/M7. Why did you not take part in the NHC program for those houses/ the ENS's programs for houses built in 2017 in Nova Scotia?	Validation of eligibility
Final Spillover = $\frac{(\text{Total \# of N-P Houses}) \times \%N-P_{EE} \times \%Attrib \times \%Elect}{(\text{Total \# of Participating Houses})}$	



ECONOLER

EFFICIENT PRODUCT REBATES PROGRAM

2017 DSM EVALUATION

EFFICIENCY NOVA SCOTIA

Final Report

March 15, 2018



ABBREVIATIONS

ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BER	Business Energy Rebates
BNI	Business, non-profit and institutional
CFL	Compact fluorescent lamp
CNC	Computer numerical control
CRA	Corporate Research Associates
DLC	DesignLights Consortium
DSM	Demand-side management
DSVG	Demand savings factor
EFLH	Equivalent full load heating and cooling hours
EISA	Energy Independence and Security Act
ENS	Efficiency Nova Scotia
ESVG	Energy savings factor
EUL	Effective useful life
GHG	Greenhouse gas
HID	High-intensity discharge
HOU	Hours of use
HP	Horsepower
HPS	High-pressure sodium
HVAC	Heating, ventilation and air conditioning
ISR	In-service rate
LED	Light-emitting diode
M&V	Measurement and verification
MH	Metal halide

NEEP	Northeast Energy Efficiency Partnerships
NRCan	Natural Resources Canada
NTGR	Net-to-gross ratio
PCF	Peak coincidence factor
PTHP	Packaged terminal heat pump
SBES	Small Business Energy Solutions
TRM	Technical reference manual
VFD	Variable frequency drive

DEFINITIONS

Accuracy	Reflects the proximity of measurements to the true value.
Adjustment ratio	The ratio of evaluated results to tracked results. This ratio expresses the adjustment made to tracked savings or other tracked values such as effective useful life.
Base case	To determine gross savings, a base case is established providing detailed information about the reference (e.g. pre-existing or standard) measure or equipment chosen to be compared with the efficient measure or equipment. For the reference measure or equipment, the base case may include such information as the hours of operation, wattage and the base consumption.
Bias	Systematic deviations of measurements from the true value.
Billing calibration	An activity that consists of adjusting the expected energy savings based on the relative difference between the results of the energy simulations and the actual energy consumption of the building or system.
Confidence interval	The estimated range of values which is likely to include the unknown population parameters.
Displaced wattage	The displaced wattage is defined as the difference between the wattage values of the baseline equipment or product and the efficient equipment or product.
EnerGuide rating	An EnerGuide (official brand of Natural Resources Canada) rating is a standard measure of the home's energy performance. It is a measure of the efficiency of the building only and does not take into account occupant behaviour. It shows how energy efficient the home is through modelled heat losses of the home, based on several factors including building envelope characteristics, heated volume, heating systems and air leakage.
Effective useful life	The period a measure is expected to be in service and provide both energy and peak demand savings. This value combines the equipment life and the measure persistence, which includes factors such as business turnover or early retirement.
Equipment life	The number of years installed equipment will operate before it fails.
Equivalent CO ₂	A unit of measurement indicating the amount of carbon dioxide to which various kinds of emitted greenhouse gases are equivalent in terms of warming effects. In this report, the gases' global-warming potential is estimated over a timescale of 100 years.
Equivalent effective useful life	The number of years by which the first-year savings estimate is multiplied to obtain lifetime energy savings. This value takes into account variations in annual energy savings throughout the effective useful life due to increased baselines.

Evaluated savings	Gross and net savings calculated by the Evaluator using the parameters (unitary savings values, installation rates, interactive effects, net-to-gross ratio, etc.) validated or measured during the evaluation process. Unless otherwise specified, the evaluated savings are the first-year savings.
Evaluation plan	The evaluation plan summarizes the program description, objectives, base cases, documentation, evaluation methodology, budget and schedule.
First-year savings	The first full year of energy savings generated by an energy efficiency measure.
Free-ridership	Percentage of gross savings attributable to participants who would have implemented the same or similar energy efficiency measures, with no change in timing, in the absence of the program.
Gross energy savings	Energy savings generated by energy efficiency measures, before applying the net-to-gross ratio.
Induced consumption	Energy consumption of appliances that would have been unplugged and not replaced by participants in the absence of the program.
Interactive effects	Effects on the energy consumption of other systems in the building (such as heating and cooling) due to the installation of an energy efficiency measure.
Internal spillover	Savings attributable to participants who continue to implement the energy efficiency measure introduced by a program after participating in it once, without participating in the program a second time.
In-service rate	The proportion of incentivized products that are installed and operating. This rate is usually applied to programs through which rebates are offered in-store and products are likely to be stored for a certain period before being installed, such as LED bulbs.
Lifetime energy savings	The energy savings that occur over the lifetime of an energy efficiency measure. Lifetime energy savings account for a measure's effective useful life and any increase in the baseline efficiency level (which reduces attributable annual savings) over its lifetime.
Line loss factor	The multiplier to convert savings at the customer meter to savings at the utility generator. It accounts for the electrical losses of the transmission and distribution system.
Margin of error	The amount of random sampling error.
Market effects	The impact of the program on the market (such as increased product availability, practices, and prices) that extends beyond changing the program participants' behaviour. This includes spillover among non-participants.
Net energy savings	Energy savings that can be reliably attributed to a program. This includes effects, such as free-ridership and spillover, that negatively or positively affect the energy savings attributable to a program.
Net-to-gross ratio	The ratio of net energy savings to gross energy savings.

Non-sampling error	Errors arising during the course of all survey activities other than sampling. Non-sampling errors tend to lead to bias in measurements and are very difficult to quantify.
Peak coincidence factor	The percentage of measure demand savings that coincide in time with the annual peak demand of the entire electricity system.
Peak demand savings	The demand savings that coincide in time with the expected annual peak demand period of the entire electricity system.
Precision	The extent to which repeated measurements agree with one another.
Random sampling error	The error in measurement due to the fact that measurements are taken from a subset of the population and not the entire population.
Sample size	The number of observations or replicates included in a statistical sample.
Secondary market impacts	Energy consumption of appliances that would have been transferred to the secondary market if said appliances had not been retired.
Tracked savings	Gross and net savings calculated by ENS in the tracking system, based on various parameters such as number of participants, unitary savings values, installation rates, interactive effects, and the net-to-gross ratio.
Unitary savings	Energy or peak demand savings established on a unitary basis. This unit can either be a product (e.g., an 8 W LED lamp), a capacity (e.g., one-ton capacity of an air-source heat pump) or a participant (e.g., one participant taking part in a behaviour-based program).

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EXECUTIVE SUMMARY

This report presents the demand-side management (DSM) results for the 2017 evaluation of the Efficient Product Rebates program comprised of the Business Energy Rebates (BER) program component. BER delivers rebates either through a mail-in or instant rebate service. The 2017 evaluation was based on an interview with the program manager, a telephone survey of 70 Mail-in participants and 60 Instant Rebates participants, 82 project reviews and on-site visits of Mail-in participants, and interviews with eight Instant Rebates distributors.

Table 1 presents the participation levels as well as gross and net savings for the BER Mail-in and Instant Rebates services.

Table 1: Overall Participation and Savings for BER

	Participation Level	Gross Savings	NTGR	Net Savings
Mail-in Rebates				
Energy Savings	288 projects	18.346 GWh	0.86	15.778 GWh
Lifetime Energy Savings		280.930 GWh	0.86	241.600 GWh
Peak Demand Savings		2.863 MW	0.86	2.462 MW
Instant Rebates				
Energy Savings	315,867 products sold	42.119 GWh	0.73	30.805 GWh
Lifetime Energy Savings		408.624 GWh	0.75	305.535 GWh
Peak Demand Savings		6.432 MW	0.75	4.823 MW
TOTAL				
Energy Savings		60.465 GWh	0.77	46.583 GWh
Lifetime Energy Savings ¹		689.554 GWh	0.79	547.135 GWh
Peak Demand Savings		9.295 MW	0.78	7.286 MW

Business Energy Rebates

BER provides financial incentives in the form of prescriptive rebates or financing to Business, Non-profit and Institutional (BNI) participants to encourage reducing electricity consumption and demand. BER offers mail-in rebates and instant rebates through electrical distributors across the province of Nova Scotia.

¹ Throughout this report, energy savings always refer to first-year energy savings rather than lifetime energy savings, unless specified otherwise.

The measures eligible under BER are divided into 13 categories:

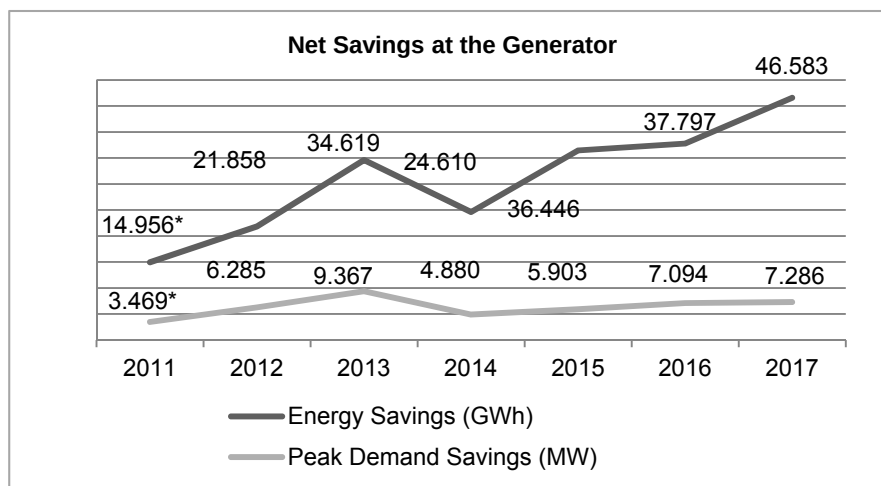
- › Agriculture
- › Lighting
- › Refrigeration
- › Laundry
- › Kitchen
- › Compressed Air
- › Heating
- › IT & Datacenters
- › Variable Frequency Drives
- › Water Heating
- › Solar Thermal
- › Pumping
- › Pool Equipment

BER Performance

BER aimed to achieve 37.2 GWh in net electricity savings and 5.9 MW in net peak demand savings at the generator for 2017. The Evaluator determined that BER achieved 46.583 GWh in net energy savings and 7.286 MW in net peak demand savings at the generator. These savings represent 30,423 tonnes of CO₂ eq in avoided greenhouse gas (GHG) emissions. The net lifetime energy savings are 547.135 GWh based on a weighted average effective useful life (EUL) value of 11.7 years.

Figure 1 below provides an overview of BER evolution in net energy and peak demand savings from 2011 to 2017. In 2017, BER achieved the highest savings levels in its history. This result is due in part to the high participation in Instant Rebates which achieved 30.805 GWh in 2017 compared to 24.299 GWh in 2016, along with an increase in average unitary savings of rebated products.

Figure 1: Overview of BER Net Savings at the Generator, 2011-2017



*2011 results include the sum of the savings for Mail-in Rebates from BER and Instant Rebates from Smart Lighting Choices.

BER Key Findings

BER Mail-in

In 2017, a total of 288 Mail-in projects were implemented by 213 unique participants. The level of satisfaction with BER Mail-in remains high for 2017, with participants rating it on average 9.0 on a 10-point scale where 1 is “not at all satisfied” and 10 is “completely satisfied”. Participants were asked about specific aspects of BER Mail-in, namely interactions and communications with contractors, distributors and consultants, as well as rebate amounts, the application forms, paperwork, and the time required to receive the rebate. BER Mail-in succeeded in maintaining high satisfaction scores with all these service aspects for a second year in a row, indicating sustained improvement in Mail-in satisfaction since 2015.

The results of the site visits and project reviews revealed that only small adjustments were required to tracked energy savings. As was the case in previous years, adjustments to peak demand savings were slightly higher because of changes made to peak coincidence factors (PCFs). Net savings were estimated using a net-to-gross ratio (NTGR) which represents the proportion of gross savings that can be reliably attributed to the service. Using free-ridership and internal spillover effects measured as part of participant surveys and interviews, the NTGR value was established at 0.86 as presented in Table 2.

Table 2: Net-to-gross Ratio for BER Mail-in

	2017 Mail-in Rebates
Free-ridership Level	14%
Spillover Level	0%
NTGR	0.86

BER Instant Rebates

For BER Instant Rebates, a total of 315,867 rebated products were sold by distributors in 2017 (compared to 294,942 products in 2016 and 215,121 products in 2015), constituting a 7 percent increase from 2016. As part of the evaluation, eight distributors involved in BER Instant Rebates were interviewed. Overall satisfaction with the service was rated an average score of 6.5 on a 10-point scale, which is consistent with the 2016 result of 6.4. Four distributors provided an overall positive opinion (ratings of 8 or higher), one distributor offered a moderate opinion (rating of 7) and three distributors were critical of BER Instant Rebates (ratings of 5 or lower).

Dissatisfaction primarily stemmed from the perception that the rebates for commercial sales are provided to contractors rather than end users, thus reducing BER effectiveness as a tool to raise awareness on energy-efficient lighting technology among end users. Furthermore, the administrative work such as rebate processing, tracking and reporting, although deemed manageable by most distributors, continues to be a source of frustration given the time required to conduct these activities without compensation. On a positive note, opinions on support and communications provided by Efficiency Nova Scotia (ENS) are high, with an average satisfaction level of 8.3 on a 10-point scale (compared to 7.9 for 2016). Seven distributors shared a favourable opinion regarding the provision of support and communications (ratings 8 or higher), while one distributor rated a 6. Distributors appreciated the advance notification of rebate changes provided by ENS in 2017, as well as the accessibility and openness of discussions with staff.

Distributors believed that BER Instant Rebates had lesser influence in 2017 on consumer purchase behaviours due to increased familiarity with light-emitting diode (LED) technology and declining prices. However, distributors recognized the positive influence ENS has had on factors contributing to the increase in LED technology adoption. Also, BER Instant Rebates had great influence on the type of lamps and fixture models offered in-store. Most distributors restricted their offerings to rebated products, and, as such, the service influenced the proportion of DesignLights Consortium (DLC) or ENERGY STAR® certified LED lamps and fixtures carried by distributors.

Thanks to the availability of participants' contact information, the Evaluator conducted a survey with Instant Rebates participants for the first time in 2017. Noteworthy is that three quarters of participants (75%) had participated in other ENS program components or services before BER Instant Rebates. Two thirds of participants (67%) claimed that eligible products were recommended by their distributor. Most participants (92%) were aware of the rebate when purchasing products.

The Evaluator used a new approach to measure the free-ridership level of BER Instant Rebates in 2017, using both the participant survey and distributor interviews. As presented in Table 3 below, the Evaluator calculated free-ridership levels for four LED product categories. Free-ridership levels for LED products vary between 32 and 38 percent. A NTGR of 1.00 was applied to the other product categories, resulting in an overall NTGR of 0.73 for BER Instant Rebates.

Table 3: Net-to-Gross Ratio for BER Instant Rebates

	LED Linear Fixtures	LED Downlight Fixtures	LED Linear Lamps	LED General-use and Decorative Lamps	Other Products	Average Value
Free-ridership Level	32%	36%	38%	38%	--	27%
NTGR	0.68	0.64	0.62	0.62	1.00	0.73

To establish the gross savings of Instant Rebates for 2017, the Evaluator reviewed the tracked savings to ensure that the recommended savings values from the 2016 evaluation were applied correctly. Net savings were then calculated by applying the NTGRs mentioned above to the gross evaluation savings.

BER Energy Savings

Table 4 below compares the 2017 tracked and evaluated savings for BER Mail-in and Instant Rebates combined.

Table 4: Overall Comparison of Tracked and Evaluated Savings at the Generator for BER

	Initial Gross Savings	Adjusted Gross Savings	NTGR*	Net Savings
Energy Savings				
ENS Tracked Savings	64.637 GWh	64.637 GWh	0.78	50.670 GWh
Evaluation Results	64.637 GWh	60.465 GWh	0.77	46.583 GWh
Peak Demand Savings				
ENS Tracked Savings	13.833 MW	13.833 MW	0.80	11.000 MW
Evaluation Results	13.833 MW	9.295 MW	0.78	7.286 MW
*Different NTGRs were established for Mail-in and Instant Rebates. The average NTGR values presented in this table correspond to the ratio of net savings to gross savings for both services.				

Overall, the evaluated net energy savings are 8 percent lower than the tracked values as a result of both Mail-in and Instant Rebates being adjusted downward (3% and 11% respectively).

For Mail-in, due to efforts made by ENS to apply the savings calculations recommended by the Evaluator in the 2016 evaluation, only minor adjustments were made to gross savings. This is highlighted by the downward adjustment between tracked and revised savings being only 3 percent. For Instant Rebates, the downward adjustment was mostly due to the lower NTGR established for 2017 and a greater proportion of products being affected by free-ridership levels, from 66 percent in 2016 to 75 percent in 2017. Furthermore, some downward adjustments were made to gross savings, which affected some of the most popular products in BER Instant Rebates, namely LED linear lamps and LED downlight fixtures.

Net peak demand savings are 34 percent lower than their corresponding tracked values. For Mail-in, the downward adjustment to net peak demand savings was 16 percent, which is the result of one large adjustment to an heating, ventilation and air conditioning (HVAC) project. As for Instant Rebates, the downward adjustment to peak demand savings was 40 percent, mainly as a consequence of the PCF being reduced by 14 percentage points this year for indoor lighting products.

BER Market Evolution Findings

As part of the 2017 evaluation, the Evaluator conducted a market analysis of the LED product market in the BNI sector in Nova Scotia. The Evaluator analyzed several market indicators over a period of up to seven years, particularly the market share of LEDs among other lighting products, the number of BER rebated units, the average retail prices of various LED products, the number of participating retailers in the service, as well as the evolution of codes and standards. In addition, past evaluation results were examined to identify free-ridership trends.

The market share of LED technology has grown drastically for the commercial and industrial sectors in Atlantic Canada, increasing from 0 percent in 2010 to 54 percent in 2016. Furthermore, prices have declined significantly, especially for LED linear lamps, LED reflector lamps, and LED linear fixtures. In addition, the majority of distributors in Nova Scotia carry LED products, indicating that this technology is widely available to BNI customers across the service. Finally, upcoming changes in Canadian regulations are expected to increase the efficiency requirements of general-service lamps (to compact fluorescent lamp [CFL] levels). Currently, no substitute more efficient than LEDs is available.

With this information, the Evaluator came to the conclusion that LEDs continue to be in a growth phase, but are approaching maturity as the BNI sector increasingly adopts these products.

BER Recommendations

Overall, the Evaluator concludes that BER generated significant savings. The participation level and savings remained stable for BER Mail-in, and the number of rebated products sold and associated savings increased for BER Instant Rebates. In addition to the general recommendations formulated for all ENS program components in the 2017 DSM Programs Evaluation Executive Summary, the Evaluator makes the following recommendations specifically aimed at optimizing BER. These are also presented in Appendix I.

- 2017-BER-R1. Continue to monitor the market evolution of LED lamps and adapt the BER offer when needed.** The 2017 evaluation served to confirm solid market evolution. The high number of LEDs sold during the 2017 year, their declining retail prices, as well as the increased market share and free-ridership levels for these products indicate that market barriers are decreasing. Moreover, the market analysis confirmed that while LED products are still in a growth phase, they are approaching maturity as the BNI sector increasingly adopts these technologies. The Evaluator therefore recommends that ENS continue to monitor the evolution of the LED market by examining market indicators such as those discussed in Section 7 to identify when some product categories should be removed from the service due to a high level of market transformation.
- 2017-BER-R2. Identify opportunities to diversify the portfolio of projects completed through BER Mail-In.** As demonstrated in the 2017 evaluation, lighting projects account for over 60 percent of gross savings in BER Mail-in. Since Instant Rebates is designed to offer almost exclusively lighting products, Mail-in is the best option to diversify the BER portfolio which generates the most savings of all ENS program components. With LED lighting products becoming increasingly popular and transforming the lighting market, ENS is at risk of seeing its savings decline for this service. The Evaluator expects to see continued increases in both free-ridership and baselines as the technology is more widely adopted. Therefore, the Evaluator recommends that ENS identify BNI sectors that are currently underrepresented in the Mail-in service and that could potentially generate significant savings.
- 2017-BER-R3. Continue and improve the tracking of BER Instant Rebates participants.** The 2017 evaluation was the first time that the Evaluator had access to a list of Instant Rebates participants and could therefore conduct a survey of participants. However, the participant list did not include all participants and information was not collected systematically. The Evaluator recommends that ENS continue tracking individuals and businesses participating in the service. ENS should document the data-collection process and, if possible, record the proportion of tracked participants among all participants as well as the savings attributable to each participant. This would allow the Evaluator to refine the quality of the impact analysis, notably with better estimations of annual hours of use (HOU) as well as free-ridership and spillover levels.

INTRODUCTION

Efficiency Nova Scotia (ENS) is a franchise held by EfficiencyOne² and is responsible for helping Nova Scotians improve the energy efficiency of their homes and workplaces. ENS designs, markets and delivers energy efficiency and conservation programs for various segments of the population. ENS receives funding for its activities from Nova Scotia Power and the Province of Nova Scotia. The funds received from Nova Scotia Power cover the costs of activities designed to help reduce electricity consumption, whereas funds from the Province of Nova Scotia are primarily used for activities designed to help reduce the use of other fuels by households with lower incomes.

Econoler was commissioned to evaluate ENS's 2017 demand-side management (DSM) program portfolio comprised of six electricity efficiency programs and assess the impact of energy efficiency codes and standards introduced in Nova Scotia. To carry out this assignment, Econoler collaborated with Research Into Action, Equilibrium Engineering and Corporate Research Associates (CRA).

Econoler served as team leader in the 2017 evaluation and was involved in every aspect of the evaluation. Specifically, Econoler was in charge of coordinating and supervising all activities, conducting final reviews of all data collection instruments, performing impact evaluation calculations, as well as preparing and reviewing the evaluation reports. Research Into Action carried out the process evaluations, while Equilibrium Engineering conducted the on-site visits and contributed to some impact evaluation analyses. CRA conducted the interviews and surveys with participants and partners, as well as analyzed and reported on the data collected from these activities. Throughout this report, this team is referred to as the Evaluator.

For each program, the Evaluator prepared a DSM evaluation report presenting the general findings, electrical first-year and lifetime energy savings, peak demand savings and avoided greenhouse gas (GHG) emissions.

Table 5 below lists the various programs assessed as part of the 2017 evaluation and indicates their respective components and the types of evaluations conducted. In this table, "C" means a complete evaluation, and "R" indicates that reduced evaluation activities were performed, as compared to 2016. Section 1 of the DSM Programs Evaluation Executive Summary presents the scope of work in further detail, along with the rationale for the types of evaluations performed for each program component. The impact evaluation scope was reduced for Instant Rebates; this is described in the methodology section herein.

² On January 1, 2015, ENS became a franchise owned by the Province of Nova Scotia and was licensed to the new not-for-profit organization EfficiencyOne.

Table 5: Types of Evaluations Conducted for Each Program Component

Program	Program Component	2016			2017		
		Process	Market	Impact	Process	Market	Impact
Residential Efficient Product Rebates Program	Appliance Retirement		C	C			R
	Instant Savings		C	C		R	R
Existing Residential Program	Home Energy Assessment		C	C		C	C
	Green Heat		C	C	C	C	C
	Efficient Product Installation		C	C		C	C
New Residential Program	New Home Construction		C	C		C	C
Efficient Product Rebates Program	Business Energy Rebates		C	C		C	R
Custom Incentives Program	Custom		C	C	C*	C	R
	Energy Management Information Systems	C	C	C		C	C
	Strategic Energy Management**	C	C	C			
Direct Installation Program	Small Business Energy Solutions	C	C	C		C	C
*The process evaluation specifically targets the Retrofit service of the Custom program component. ** Due to the start date of the latest Strategic Energy Management (SEM) cohort, SEM did not have any participants who achieved savings in 2017; therefore, no evaluation was conducted for 2017.							

This evaluation report is for the Efficient Product Rebates program, which is comprised of one component: Business Energy Rebates (BER). BER offers two services: Mail-in Rebates and Instant Rebates. The program component description, evaluation methodology and main evaluation findings are presented in the following sections.

1 BER OVERVIEW

This section describes BER, follows up on 2016 evaluation recommendations and presents participation history.

1.1 Description

BER provides financial incentives in the form of prescriptive rebates or financing to Business, Non-profit and Institutional (BNI) participants to foster reductions in electricity consumption and demand. All businesses, non-profits, and institutions in Nova Scotia are eligible.

The term prescriptive rebate refers to a particular rebate value that is calculated prior to a participant submitting a proposal. If a given product or technology demonstrates energy savings potential, then the product or technology and corresponding rebate value is applied universally to any eligible participant.

In 2017, BER was expanded to include a new measure category, namely pool equipment. The measures currently offered are divided into 13 categories:

› Agriculture	› IT & Datacenters
› Lighting	› Variable Frequency Drives
› Refrigeration	› Water Heating
› Laundry	› Solar Thermal
› Kitchen	› Pumping
› Compressed Air	› Pool equipment
› Heating	

Any product designed by any manufacturer can be offered through BER provided that the product meets the specified criteria for that measure category. Specific criteria include minimum efficiency/efficacy values, as well as industry standards such as ENERGY STAR® performance levels or those established by the DesignLights Consortium (DLC) and the National Electrical Manufacturers Association.

Rebates offered through BER are delivered either through a mail-in or instant rebate service. Instant Rebates aims to reach a greater volume of participants and offer participants easier access to BER. Conversely, Mail-in Rebates allows for better project-level control and lower risk since more participant details are provided to ENS. The appropriate rebate delivery service is selected by ENS for each technology.

BER Instant Rebates is delivered through a network of participating distributors within the province of Nova Scotia. These distributors play a key role in not only promoting Instant Rebate measures to end users, but also providing customer service to end users in the form of product expertise and assistance in completing mail-in applications.

As per the BER promotion activities introduced in 2016, BER was advertised through presentations to relevant industry associations, marketing materials for specific verticals or placed in distributor branches, trade show appearances, articles in trade association newsletters, and province-wide mail-outs to businesses.

BER aimed to achieve 37.2 GWh in net electricity savings and 5.9 MW in net peak demand savings at the generator for 2017.

1.2 Follow-up on 2016 Evaluation Report Recommendations

The BER component was evaluated in 2016 and improvement recommendations were made by the Evaluator. Table 6 below provides a brief summary of the implementation status of each recommendation presented in the Executive Summary section of the 2016 Evaluation Report.

Table 6: Implementation Status of Recommendations in the 2016 Executive Summary

2016 Recommendations	Status
2016 BER-R1. Continue improving the BER Mail-in internal review procedure for savings calculations	Implemented
2016 BER-R2. Implement complete measurement and verification (M&V) procedures for Mail-in projects generating large energy savings	Implemented
2016 BER-R3. Conduct deeper market analysis to adapt the BER Instant Rebates offer when needed	Implemented
2016 BER-R4. Update the values used in the BER Mail-in and Instant Rebates calculations to match the 2016 evaluation results	Implemented

All the 2016 BER recommendations have been implemented. The methodology for calculating interactive effects (recommendation 2016 BER-R4) was revised in the ENS CIRx Screening Tool,³ as were the values used for heat pump full load hours. Additionally, new procedures for baseline wattages in new construction projects and in Instant Rebates have been established.

Also, ENS has improved the BER Mail-in internal review as per recommendation 2016 BER-R1. As a result, fewer adjustments were required on measures when revising gross savings, as detailed in Subsection 4.1. Participant forms were upgraded in late 2017 to collect additional hours of use (HOU) information from participants as of 2018; this additional information is expected to improve the accuracy of tracked savings. To act upon recommendation 2016 BER-R2, a M&V protocol was developed in 2017 and will be applied to Mail-in projects generating large energy savings in 2018.

³ Internal tool which references and defines the standard equations to be used for the gross savings calculations for each measure category.

To address recommendation 2016 BER-R3, ENS mandated the Evaluator to conduct additional market analyses. These analyses focus on light-emitting diode (LED) lighting and are presented in a new section of this report entitled BER Market Evolution.

1.3 Participation History

BER Mail-in

In 2017, a total of 288 BER Mail-in projects were implemented by 213 unique participants.⁴ Figure 2 below illustrates how participation in BER Mail-in has evolved since its inception in 2011. While the participation level remained steady between 2016 and 2017, a decrease was observed from the levels achieved in the 2013 to 2015 period. However, the gross savings achieved were 86.131 MWh per participant in 2017, a 13 percent increase from 2016.

Figure 2: Summary of Participation in BER Mail-in for 2011-2017

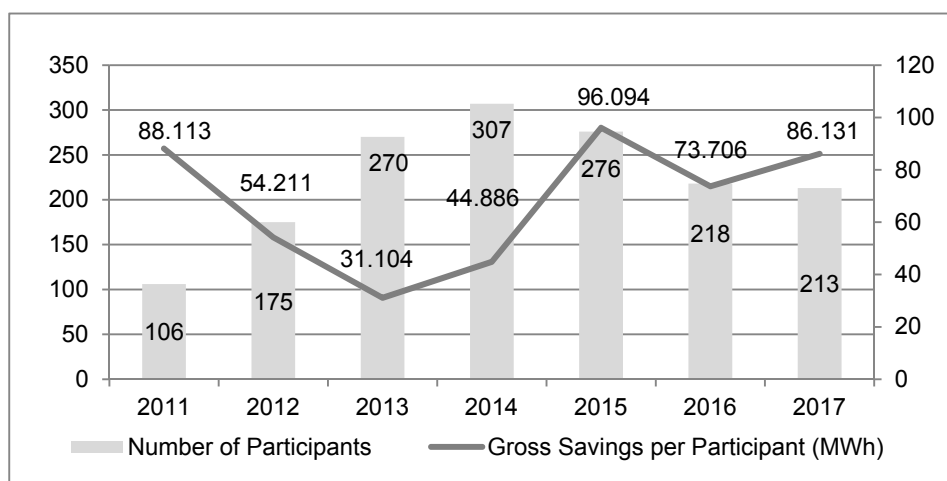
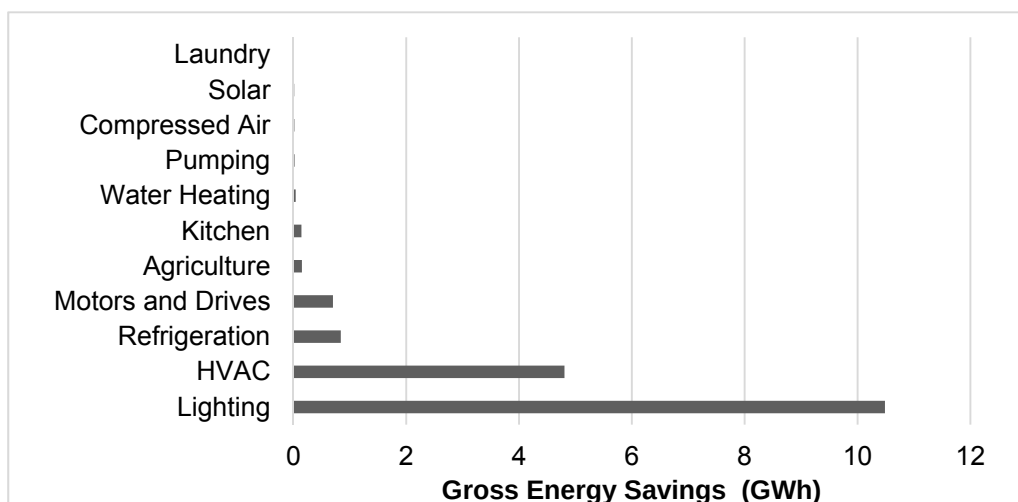


Figure 3 below illustrates the distribution of gross savings among the product types for BER Mail-in. With 62 percent of gross savings being generated by lighting product types and 27 percent of gross savings by heating, ventilation and air conditioning (HVAC) product types, these two categories account for most of the Mail-in savings. This trend is consistent with past evaluations wherein lighting accounted for 58 percent of savings in 2016 and 78 percent in 2015.

⁴ The number of unique participants in BER Mail-in corresponds to the number of businesses that participated in the program component.

Figure 3: Distribution of BER Mail-in Gross Energy Savings by Product Type


BER Instant Rebates

Since participant-related information is not tracked systematically for BER Instant Rebates, the number of participants is unknown. Available information does, however, indicate the number of rebated products sold by distributors. Figure 4 below indicates that 315,867 products were rebated through BER Instant Rebates in 2017, a 7 percent increase from 2016.

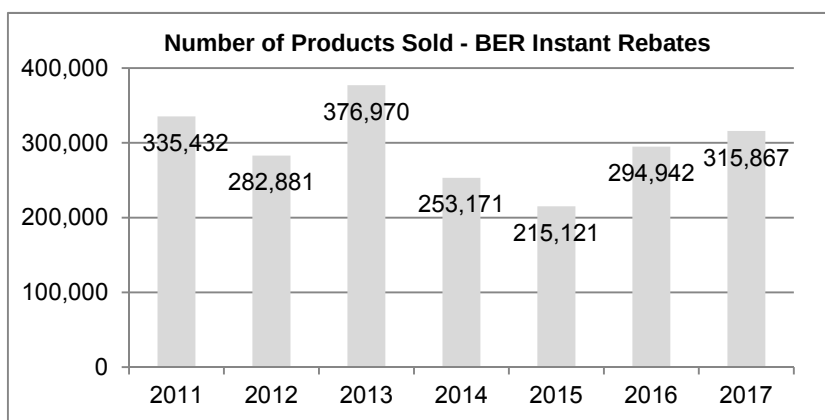
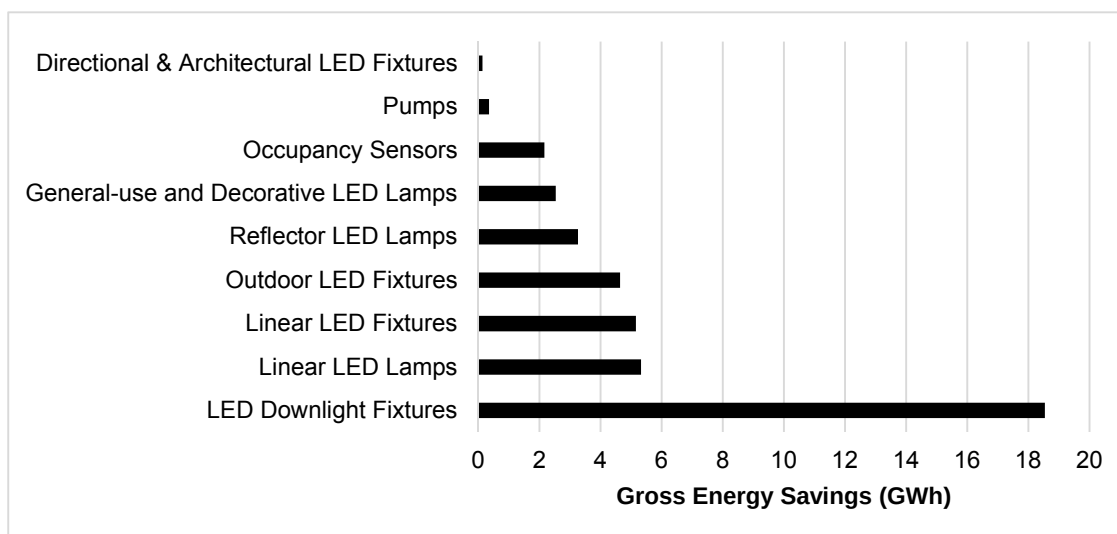
Figure 4: BER Instant Rebates Products Sold, 2011-2017


Figure 5 below provides an overview of the distribution of gross savings in BER Instant Rebates among the different pumps and lighting products. In 2017, LED downlight lamps generated the largest share of gross savings (44%), followed by LED linear lamps (13%) and LED linear fixtures (12%).

Figure 5: Distribution of BER Instant Rebates Gross Savings by Product Type


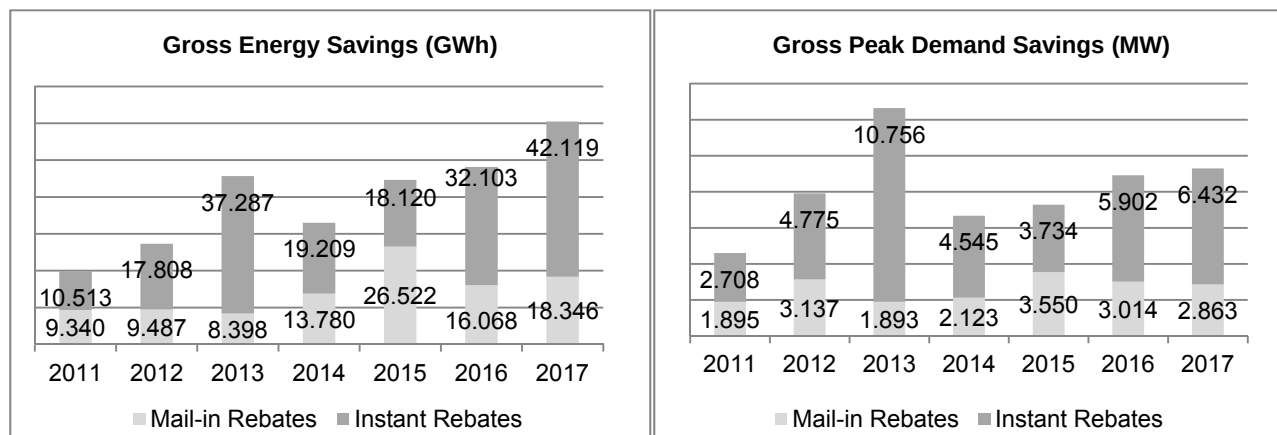
BER Overall

As presented in Figure 6 below, BER generated a total of 60.465 GWh in gross energy savings at the generator, which is the highest result since inception. BER Mail-in accounted for 30 percent of the savings, while BER Instant Rebates accounted for the remaining 70 percent.

The increase in overall savings is mostly due to BER Instant Rebates whose savings have grown by 31 percent since 2016. This is due to the unprecedented popularity of LED lamps and fixtures, but also the increase in the average unitary savings of rebated products, from 108 kWh in 2016 to 133 kWh in 2017. In other words, participants chose, on average, products that generated more savings than in 2016. Furthermore, lighting measures were also key in generating gross savings in BER Mail-in since they accounted for 61 percent of 2017 savings.

In 2017, gross peak demand savings totalled 9.295 MW for both BER Mail-in and BER Instant Rebates, up from 8.917 MW in 2016 and representing a four percent increase. The increase in peak demand savings did not match the increase in energy savings, mostly due to the decrease in the peak coincidence factor (PCF) in Instant Rebates.

Figure 6: Summary of Gross Savings for BER 2011-2017⁵

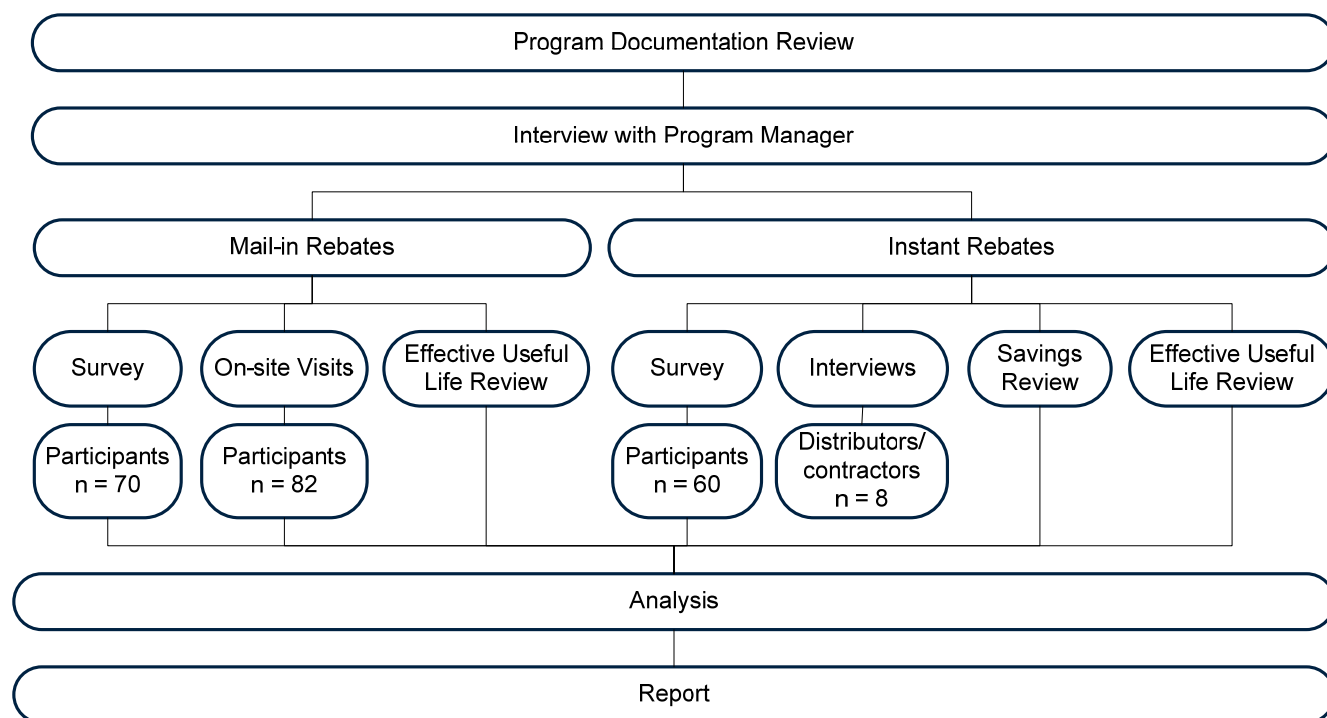


⁵ 2011 results include the sum of savings for Mail-in Rebate from BER and Instant Rebates from Smart Lighting Choices.

2 BER EVALUATION METHODOLOGY

This section presents the methodology used and the activities carried out for the BER 2017 evaluation. As illustrated in Figure 7, various data-collection activities were used throughout the evaluation.

Figure 7: Methodological Model



The Evaluator first reviewed the BER documentation and then met the program manager in August 2017 to verify the implementation status of the previous evaluation recommendations and learn about recent BER changes. Based on the information obtained from this meeting, a list of questions and topics to be included in the data-collection instruments was prepared.

Once the program manager meeting and the BER documentation review were completed, specific evaluation activities were undertaken, as described in the following subsections.

For evaluation activities that yield quantitative results based on a sample, the Evaluator aimed to achieve a maximum margin of error of 10 percent at a confidence level of 90 percent. This means that if measurements were conducted many times with different samples, the data would be within 10 percentage points above or below the percentage reported 90 percent of the time. Thus, the margin of error indicates the relative level of precision⁶ of the measurement, while its associated confidence level indicates the probability of a measure falling within this margin of error.⁷

As part of this evaluation, the Evaluator calculated the margin of error for survey samples, free-ridership levels and savings adjustment ratios. The margins of error are presented alongside the results in the relevant sections. Examples of calculations used to establish margins of error can be found in Appendix II of the 2017 DSM Programs Evaluation Executive Summary.

2.1 Mail-in Rebates

Participant Survey

In October and November 2017, CRA conducted a telephone survey with a total of 70 BER Mail-in participants using computer-assisted telephone interviewing technology. The average length of the survey was 15 minutes. The questionnaire and complete survey results are presented in Appendix II and Appendix III respectively. All appendices are presented in the Efficient Product Rebates Program – Appendices.

The survey was meant to generate feedback on the following aspects of BER Mail-in:

- › Reasons of participation
- › Free-ridership
- › Cross-influence
- › Satisfaction with the service
- › Barriers
- › Recommendations for improvements
- › Firmographics

The total number of unique BER Mail-in participants was 213 for the entire 2017 year. Drawing a random sample of 70 from a population of 213 yields a margin of error of 8.1 percent at a 90 percent confidence level.

⁶ Precision refers to how reproducible a set of measurements is. However, it does not take into account how close the measured values are to the true values since this refers to accuracy.

⁷ As part of this evaluation, the confidence level and the margin of error only take random sampling errors into account; they do not reflect non-sampling errors or biases such as data entry errors, inaccurate responses from respondents or the inability to contact certain people.

On-site Visits

In the fall of 2017, 80 on-site visits were conducted at the facilities of participants who received a rebate through BER Mail-in. These visits were conducted by Equilibrium Engineering. The purpose of the on-site visits was to validate whether the measures implemented were consistent with the information contained in the tracking sheet. Additionally, the HOU's, various operating conditions and, whenever possible, old and new equipment characteristics (power consumption in watts or horsepower [HP], efficiency, etc.) were validated. These elements were used to revise gross savings, either by adjusting savings on individual projects or by applying an adjustment factor to all the projects of a given category when the sample size was large enough. Finally, as part of the on-site visits, the Evaluator interviewed participants to assess and quantify possible spillover. The on-site visit sampling and protocol are presented in Appendix IV.

Effective Useful Life Review

As part of the 2017 evaluation, to examine the effective useful life (EUL) values used by ENS to calculate lifetime energy savings, the Evaluator conducted a thorough literature review by consulting technical reference manuals (TRMs), evaluation reports and relevant studies.

2.2 Instant Rebates

Participant Survey

In November 2017, CRA conducted a telephone survey with a total of 60 BER Instant Rebates participants using computer-assisted telephone interviewing technology. The average length of the survey was nine minutes. The questionnaire and complete survey results are presented in Appendix V and Appendix VI respectively.

The survey was meant to generate feedback on the following aspects of BER Instant Rebates:

- › Reasons for participation
- › Free-ridership
- › Cross-influence
- › Decision criteria

A total of 60 interviews were completed based on a partial participant list provided by ENS, which included 161 names. Because it is not possible to obtain a complete list of BER Instant Rebate participants due to the nature of this service, the margin of error is calculated using a conservative assumption that the service population is infinite. Drawing a random sample of 60 from an infinite population yields a margin of error of 10.6 percent at a 90 percent confidence level.

Interviews with Distributors

In November 2017, CRA conducted eight interviews with participating distributors for BER Instant Rebates. These interviews were mainly used to establish free-ridership levels by estimating how the market would have reacted without the existence of the service. As part of these interviews, the distributors were also asked about their satisfaction with the service. The guide used for the distributor interviews is presented in Appendix VII.

Savings Review

Since unitary savings values for each measure were reviewed in depth for the 2016 evaluation, the savings review for the 2017 evaluation was limited to validating whether claimed savings were consistent with the recommended values from the 2016 evaluation.

Effective Useful Life Review

As part of the 2017 evaluation, to examine the EUL values used by ENS to calculate lifetime energy savings, the Evaluator conducted a thorough literature review by consulting TRMs, evaluation reports and relevant studies.

Comparison with 2016 Evaluation Scope

The market evaluation scope for Instant Rebates is defined as “reduced” in 2017 because the Evaluator did not conduct a literature review to update the savings values assumptions used in the 2016 evaluation, since said assumptions were considered still valid. The rationale behind this is based on an analysis of 2017 evaluation objectives, key results of the previous evaluations and recent changes made to each program. Further explanations can be found Section 1 of the DSM Programs Evaluation Executive Summary.

3 BER MARKET EVALUATION

This section presents the findings of the 2017 BER market evaluation from the perspectives of participants and partners.

3.1 Participant Perspective

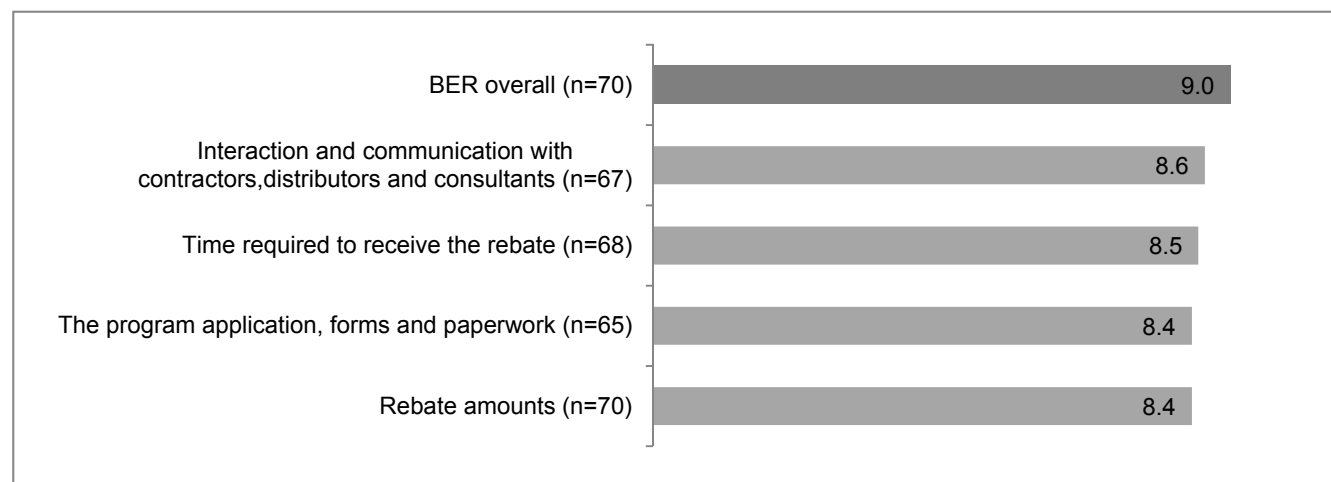
3.1.1 Mail-in Rebates

A survey of 70 Mail-in participants was conducted as part of the BER evaluation. The main reason for participating in BER Mail-in was to save on energy costs or bills (53%). Updating equipment (19%) or purchasing high-quality energy efficiency products (9%) were also mentioned as reasons for participation. Noteworthy is that nearly one half of participants (47%) had participated in other ENS program components or services before Mail-in.

Again in 2017, participants are highly satisfied with BER Mail-in, with an average rating of 9.0 on a 10-point scale where 1 indicates “not at all satisfied” and 10 indicates “completely satisfied”. The few participants who were less satisfied with the service mostly mentioned the paperwork was burdensome (2 mentions) and the lengthy process (2 mentions).

As outlined in Figure 8, there is also a high level of satisfaction with various aspects of BER Mail-in, including interactions and communication with contractors, distributors and consultants (8.6), the time required to receive the rebate (8.5), the application forms and paperwork, as well as the rebate amounts (8.4). BER Mail-in succeeded in maintaining high satisfaction scores in all service aspects for a second year in a row, indicating sustained improvement with Mail-in satisfaction since 2015.

Figure 8: Participant Satisfaction with BER Mail-in (10-point scale)



Nearly one participant in ten (9%) had issues with measures installed through BER Mail-in, which mainly related to equipment malfunctions. In all cases, the problems were resolved and participants were satisfied.

While one half of participants were unable to offer any suggestions to improve the service, a small number mentioned that forms should be more user-friendly (11%), rebate amounts should be increased (10%), the service should be better promoted (9%), and more information should be provided or information sessions offered (7%).

3.1.2 Instant Rebates

A survey of 60 Instant Rebates participants was conducted as part of the BER evaluation. Noteworthy is that three quarters of participants (75%) had participated in other ENS program components or services before BER Instant Rebates.

The main reasons for participating in BER Instant Rebates were to save on energy costs or bills (43%) or to improve energy efficiency (32%). Seven in ten participants (70%) used a payback period threshold when deciding whether to implement energy efficient lighting. The average maximum payback period acceptable to move forward with energy efficient lighting upgrades is 2.6 years, although a majority of participants (66%) set the maximum payback period at two years or less.

Two thirds of participants were recommended products by their distributor (67%). Most participants were aware of the rebate when purchasing their products (92%), and of these, 95 percent were aware the rebate was offered by ENS as part of BER.

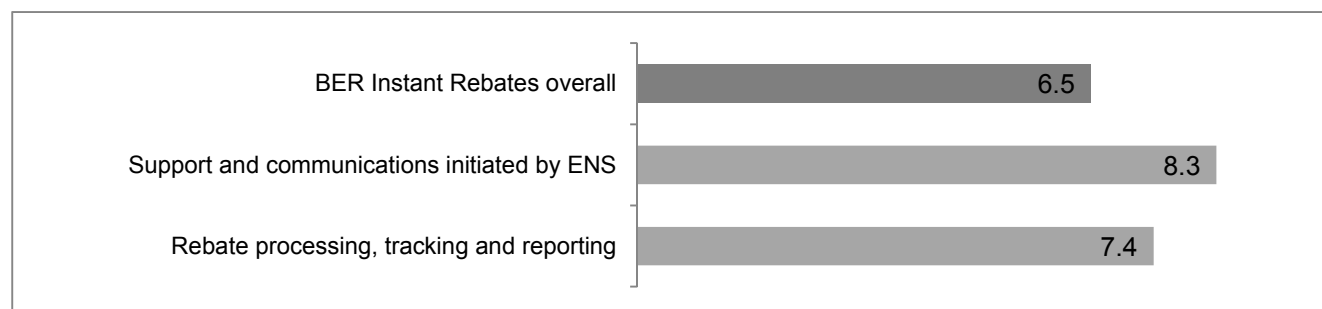
3.2 Partner Perspective

As part of the BER evaluation, eight distributors involved in BER Instant Rebates were interviewed. Distributors were asked about their satisfaction with the service and its influence on the market.

Satisfaction with BER Instant Rebates

Figure 9 presents an overview of distributor satisfaction ratings with BER Instant Rebates, support and communications, as well as rebate processing, tracking and reporting.

Figure 9: Distributor Satisfaction with BER Instant Rebates (10-point scale)



As shown in Figure 9, overall satisfaction with BER Instant Rebates received an average score of 6.5 on a 10-point scale where 1 means “not at all satisfied” and 10 means “very satisfied.” This level of satisfaction is consistent with 2016 results (average of 6.4). Four distributors provided an overall positive opinion (ratings of 8 or higher), while three distributors expressed concerns (ratings of 5 or lower) and one distributor offered a moderate opinion (rating of 7).

Dissatisfaction primarily stemmed from the perception that the rebates for commercial sales are provided to contractors rather than end users, thus reducing BER effectiveness as a tool to raise awareness on energy-efficient lighting technology among end users. Furthermore, the administrative cost of delivering BER Instant Rebates continues to be a source of frustration. One distributor also criticized the manner in which rebates are calculated and suggested that the rebate level be aligned with the level of energy savings by product. In other words, products with higher energy savings should have higher rebates. Another distributor mentioned that increased familiarity with LED technology and more widespread LED market adoption have rendered BER Instant Rebates less influential in consumer choices.

Opinions with respect to rebate processing, tracking and reporting are positive, with a satisfaction rating now averaging 7.4 on a 10-point scale (compared to 7.0 in 2016). Four distributors offered a positive rating (8 or higher), while one distributor rated a 7 and two distributors were more critical (rating a 5). Though the process of identifying models eligible for rebate was considered time-consuming, most distributors believed that their understanding of the process, combined with years of experience with BER Instant Rebates, rendered these administrative functions manageable. Dissatisfaction was explained by the time required to conduct these activities without compensation. One distributor also expressed concern with the possibility of financial loss if the rebates change after a previously quoted order is placed by consumers. In such situations, the distributor mentioned that they would have to honour the quoted rebate and bear the financial loss without being compensated. It should be noted that ENS recommends, in the participating distributor agreement, that distributors mention the incentives separately and that they are subject to change at the discretion of ENS.

Opinions on the BER Instant Rebates support and communications provided by ENS are high, with an average satisfaction level of 8.3 on a 10-point scale (compared to 7.9 for 2016). Seven distributors shared a favourable opinion regarding the provision of support and communications (ratings 8 or higher), while one distributor rated a 6. Distributors appreciated the advance notification of rebate changes provided by ENS in 2017, as well as the accessibility and openness to discussions with staff. The distributor less satisfied with ENS support and communications experienced delays in ENS responding to queries and found a lack of clear direction regarding the eligibility of certain products.

Instant Rebates Influence

Most distributors continue to believe that BER Instant Rebates influenced their decisions as to the number of LED lamps and fixture models they carry. For the most part, distributors offer rebated models to remain price competitive and meet consumer expectations. Three distributors who do not believe the service influenced decisions on the number of models they carry either had an exclusive deal with certain manufacturers or mostly place orders based on engineering specifications. In terms of the type of LED lamps and fixture models available, most distributors restricted offerings to rebated products, and thus offer a limited variety of models. As such, most perceived that BER Instant Rebates is highly influential in those decisions.

BER Instant Rebates is perceived as having minimal influence on staff knowledge of LED lamps and fixtures. Many distributors believe that manufacturers are the main source of information and training for their employees. Two distributors stated that ENS has a significant impact in motivating staff to stay knowledgeable about the technology to better serve consumers. These two distributors also mentioned that ENS does not directly train store staff about LED lamps and fixtures.

Distributors believed that BER Instant Rebates has a moderate influence on consumer purchase behaviours in three of the four product categories discussed during interviews, namely linear LED fixtures, LED downlight fixtures, and LED linear lamps. In most instances, it was believed that the price reduction resulting from the rebates enhanced the appeal of LED technology, although to a lesser extent than in the past. As for the fourth product category, the general-use/decorative LED lamps, the low price point, broad consumer appeal, and wide availability of the product category led most distributors to believe that BER Instant Rebates has minimal influence on consumers choosing this technology over incandescent bulbs or compact fluorescent lamps (CFLs).

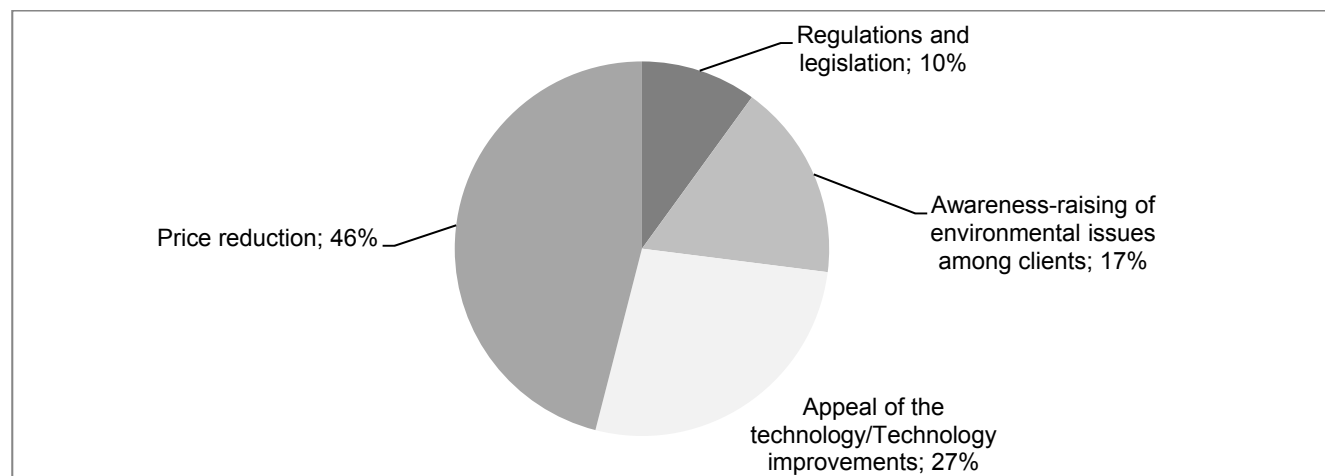
While distributors believed that BER Instant Rebates had moderate to minimal influence on consumer purchase behaviours, the service had greater influence on the type of lamps and fixture models offered in-store. Indeed, in terms of the proportion of DLC or ENERGY STAR certified LED lamps and fixtures carried by distributors, the perceived influence of BER Instant Savings was high with respect to linear LED fixtures and LED downlight fixtures, while it was moderate for LED linear lamps and general-use/decorative LED lamps.

Factors Contributing to LED Penetration

Distributors were asked to rate the relative influence of four predetermined factors to the increase in market share of LED lamps and fixtures since 2011 by distributing 100 percent influence among the four factors. The lower price of LED lamps and fixtures was viewed as the factor that most contributed to increased market share (46%), followed by the appeal of the technology and technology improvements (27%). Awareness-raising of environmental issues among participants was considered to have a moderate influence (17%), while regulations and legislation were seen as the least influential factor (10%). Two distributors believed that technology adoption was most greatly influenced by increased product availability and the variety of choices available to consumers.

Figure 10 provides an overview of the average influence rating of all four factors.

**Figure 10: Perceived Influence on Increased Market Share of LED Lamps and Fixtures
(with Ratings Across Factors Totalling 100%)**



Distributors were asked to rate the extent to which ENS programs and activities influenced these factors⁸ using a scale ranging from 0 to 100 percent. Distributors rated ENS influence at 58 percent for reducing LED technology price, primarily due to the financial incentives provided, and 56 percent for raising awareness of environmental issues among participants. Finally, distributors rated ENS influence at 24 percent for the appeal of the technology and technology improvements. Distributors therefore recognized the positive influence of ENS on the factors contributing to the increase of LED technology adoption.

⁸ The regulations and legislation factor is not included here because it does not reflect the influence of ENS on the market.

4 IMPACT EVALUATION FOR BER MAIL-IN REBATES

The objective of the 2017 BER Mail-in impact evaluation is to determine the gross and net electrical energy and peak demand savings.

4.1 Gross Savings

Gross savings refer to changes in energy consumption resulting from actions taken by participants, regardless of their reasons for participating.⁹ For each BER Mail-in Rebates project, ENS tracks the annual gross savings using the equations defined in the most up-to-date CIRx Screening Tool and the equipment parameters specific to each project.

In 2017, the BER Mail-in tracking sheet contained a total of 288 projects implemented by 213 participants across 11 different measure categories. The Evaluator reviewed the ENS gross savings based on the equations found in the CIRx Screening Tool and the information collected from 82 on-site visits. Similar to last year, the PCF was tracked and revised for each measure. In this report, a measure is defined as one specific type of installation such as an air-source heat pump, an HVAC occupancy sensor, or one LED fixture type. The tracking report usually presents each measure on a separate line with a single project containing one or more unique measures.

To present revised savings, the Evaluator established an adjustment ratio for each category. This corresponds to the factor by which tracked savings are multiplied to obtain revised savings.

4.1.1 Heating, Ventilation and Air Conditioning Measures

Twenty-eight (28) HVAC projects comprising 45 different measures were evaluated in the 2017 sample.

Equivalent full load heating and cooling hours (EFLH) were revised as part of the 2016 evaluation based on values published in the State of Minnesota TRM,¹⁰ which provides EFLH for different building occupancies based on energy models. These values were implemented by ENS, however transcription errors were present in the table provided in the 2016 Efficient Product Rebates Evaluation Report for the multi-family and convenience store building categories.

⁹ Definition adapted from National Renewable Energy Laboratory, *The Uniform Methods Project Chapter 23: Estimating Net Savings: Common Practices*, September 2014, p. 3

¹⁰ Minnesota Department of Commerce – Division of Energy Resources, *State of Minnesota Technical Reference Manual for Energy Conservation Improvement Programs – Version 2*, Effective January 1, 2017.

As part of 2017 evaluation, the EFLHs were adjusted in the tracked savings to match the values listed in Table 7. Multi-family EFLHs were adjusted for 18 HVAC projects in 2017 and no adjustments were required for the convenience store category. The changes were made to the final tracking sheet and applied to both the tracked and evaluated cases to ensure that the 2017 adjustment ratio was not negatively impacted.

Table 7: Tracked and Adjusted Full Load Heating and Cooling Hours

	FLH (heating) Values (hrs/year)	FLH (cooling) Values (hrs/year)
Convenience store		
Tracked	2,750	647
Adjusted	1,887	647
Multi-family		
Tracked	2,208	213
Adjusted	2,280	228

The most common adjustment made to the HVAC category was revising the heating capacity value at -15 °C to estimate peak demand savings. In the tracking sheet, three measures were identified as not having a heating capacity at -15°C, while a review of the specification sheets confirmed they could indeed operate at that temperature. This adjustment resulted in increased peak demand savings. In two other cases, the Evaluator revised the tracked heat pump specifications to match the Northeast Energy Efficiency Partnerships (NEEP) list of products that meet the new Cold Climate Air-Source Heat Pump Specification requirements. These specifications have been developed by NEEP to better identify air-source heat pumps that perform well at low temperatures since low-temperature performance is not typically included in standard metrics such as HSPF.

One significant adjustment was made by the Evaluator to the peak demand savings formula for a project containing 66 water source heat pumps. The adjustment was made to correct for a missing factor required to convert imperial to metric units and to correct the reported HC_{min} value. The combination of these two adjustments resulted in an adjustment ratio of 0.329 for peak demand savings. As the heating efficiency factor for water-source heat pumps is normally expressed as a COP, ENS should consider updating the notes in the CIRx Screening Tool to prevent future errors. Specifically, the Evaluator suggests using either imperial units with the additional conversion factor of 3.412, or using metric capacity values combined with the COP.

Overall, adjustments were limited and evaluated savings globally matched the tracked values. All HVAC measures were included in the energy savings adjustment ratio calculation. However, for peak demand savings, the size of the abovementioned adjustment and the fact that this single project represented 79 percent of the tracked savings for the HVAC category, a one-time adjustment was applied for this project. The resulting adjustment ratios were calculated at 0.985 for energy savings and 0.447 for peak demand savings.

4.1.2 Commercial Lighting Measures

Thirty-four lighting projects were evaluated in 2017, comprising 75 different commercial lighting measures.

The common causes of savings adjustments were updates to the annual HOU, the baseline wattage values and the PCF. In a handful of cases, minor adjustments were made to the total lamp/fixture counts, but overall tracked quantities represented what the Evaluator found on-site.

Overall, the accuracy of the tracked annual HOU saw a significant improvement over 2017 with only 36 percent of the validated lighting measures requiring an adjustment of more than 5 percent (14 projects were adjusted upward and 13 projects were adjusted downward), which is a large decrease over the 80 percent that required adjustments in 2016. The Evaluator significantly reduced the HOU value of one project because the database indicated that lamps were on 12 hours per day, but timers were in fact used to reduce lighting hours. This adjustment led to a nearly 50 percent reduction in energy savings for this project. Other adjustments occurred in storage warehouses and garage facilities where HOU are typically low and are sometimes over reported by participants.

Baseline wattages used in the tracking sheet were revised approximately 32 percent of the time. There were two common reasons for baseline wattage modifications. The first was that the tracked baseline wattages sometimes did not account for ballast consumption. The Evaluator corrected the input fixture wattage for high-intensity discharge or fluorescent fixtures based on the Duke Energy Fixture Wattage Table.¹¹ This resulted in a positive adjustment to energy savings. The second was that tracked baseline fixture wattages did not represent the actual light sources installed on-site or were different from the baseline wattage values referred to in the Duke Energy Fixture Wattage Table.

The overall adjustment ratios for commercial lighting measures were calculated using all measures reviewed in the 2017 sample and did not require the removal of any major outliers from the sample. The overall adjustment ratio applied to the tracked energy savings and peak demand savings was 0.927 and 0.955 respectively.

¹¹ Duke Energy Progress, *Energy Efficiency for Business - Fixture Wattage Table*, https://www.progress-energy.com/assets/www/docs/business/DEP_WattTable-072513.pdf, (Last accessed on February 3, 2017).

4.1.3 Commercial Refrigeration Measures

Five site visits covering four projects from three participants were conducted to evaluate the commercial refrigeration category. One of the two sampled projects which belonged to the same participant was a multi-site project, so two visits were conducted at different locations for this project, to ensure consistent results across installations. These two site visits confirmed the tracking sheet contained accurate information on the installed measures with the exception of one data entry error. Thus, it was not required to visit more retail locations and savings were then based on a review of the documented calculations. One of the measures consisted in installing refrigeration economizers. The Evaluator increased energy savings because it was found that the load connected to the economizer was three times higher. Also, the HOU was doubled for another measure, which led to a 15 percent increase in the energy savings of this project.

For one other project, refrigerated strip curtains were installed on a commercial walk-in cooler. ENS referenced the Pennsylvania Public Utility Commission TRM¹² for a calculation methodology for this measure since it does not appear in the CIRx Screening Tool. The Evaluator accepted the calculation due to the reputable source and recommends adding this methodology to the CIRx Screening Tool for future use.

All four above-mentioned projects required minor adjustments to some variables such as interactive effects factors or quantities, but overall adjustments were limited in scale. Given the small number of projects reviewed, the Evaluator did not extrapolate the adjustments made to all commercial refrigeration projects, but instead applied one-time adjustments for both energy and peak demand savings. For this category, energy savings were increased by 39,328 kWh and peak demand savings were reduced by 2.068 kW, resulting in equivalent adjustment ratios of 1.000 for energy savings and 0.989 for peak demand savings.

4.1.4 Motor and Variable Frequency Drive Measures

Six projects were evaluated for the motor and variable frequency drive (VFD) category, comprising 15 of the 16 measures implemented in 2017. Adjustments were required for 13 measures which affected each project.

¹² Pennsylvania Public Utility Commission, *State of Pennsylvania Technical Reference Manual – June 2016*, Effective January 1, 2017.

One large revision was made by adjusting the energy savings factors (ESVG) and peak demand savings factors (DSVG) to match the actual equipment function for three measures. Two measures were tracked as return fans driven by 40 HP and 30 HP motors, however, the site visit served to determine that they are exhaust fans for mechanical rooms. As the ESGV and DSVG are per-HP factors, the revised savings factors had a large impact and resulted in an additional 134,000 kWh in savings for one of the revised projects which accounted for more than a quarter of all the revised energy savings of the 15 projects sampled. Similarly, one measure was tracked as an exhaust fan but was changed to a return fan based on the site visit, which resulted in a 50 percent downward adjustment in energy savings. The 2016 Evaluation report specifically addressed the issue of confusing exhaust and return fans and recommended that ENS further validate applications for these measures to reduce the number of large adjustments.

The motor and drive category required large revisions to energy savings which were similar in magnitude, although not consistent as some were positive and others negative. The Evaluator again recommends further reviewing applications for return and exhaust measures and identifying if projects achieve savings from VFDs through controls or schedule changes. Additionally, applying short-term metering to larger projects is suggested given that one 2017 project resulted in much larger tracked savings than was calculated through the CIRx Screening Tool.

An overall adjustment ratio of 0.995 was calculated for energy savings using all reviewed measures. For peak demand savings, the variation in adjustments made was too wide to obtain a reasonable margin of error, despite including 15 of the 16 measures in the sample. Therefore, the peak demand savings were increased by 18.755 kW without applying the adjustment ratio to measures not included in the sample. This resulted in an overall adjustment ratio of 1.856.

4.1.5 Compressed Air

One compressed air project was reviewed in 2017 and required adjustments to the HOU and PCF. The site visit revealed that a computer numerical control (CNC) machine was programmed to run unattended overnight and during weekends when the business is normally closed. The operating time of the compressor (which provides compressed air to the CNC machine) was revised upward from 50 to 120 hours per week, resulting in a positive adjustment to energy savings which almost doubled. The PCF was consequently revised to 1 due to the extended schedule discovered by the Evaluator during the site visit.

This was the only compressed air project in 2017. As a result of the adjustments made to the project, total tracked energy savings were multiplied by a factor of 2.439. Tracked peak demand savings were multiplied by a factor of 1.019.

4.1.6 Agricultural Measures

One agriculture project was visited for the 2017 Evaluation, a new dairy barn comprising over 98 percent of the tracked energy and peak demand savings in the agriculture measure category.

Two adjustments were made that affected both the tracked energy and peak demand savings for the project.

The first adjustment consisted of reducing the quantity of cows listed because the participant declared the maximum capacity of the barn and not the current average number of cows milked per day. This led to a 30 percent decrease in energy savings.

The second adjustment was to the PCF used for each measure. Two of the measures can be controlled by manual switches. Since this is the first year operating the barn, the participant could not declare if the measures would be active during the peak demand period. Therefore, the default agriculture CF value of 0.84 listed the CIRx Screening Tool was used. The remaining three measures all applied to the milking process. Under the current milking schedule, these measures do not operate during peak hours. The PCF for these three measures was consequently adjusted.

The adjustments made to the savings of this project were not extrapolated to other agriculture projects, although the fact that this project made up 98 percent of the category's total savings resulted in the adjustments having a sizeable impact on overall category savings. The revisions resulted in overall category adjustment ratios of 0.894 for tracked energy savings and 0.456 for tracked peak demand savings.

4.1.7 Commercial Kitchen Measures

Six commercial kitchen projects were reviewed for a total of 16 measures which all required adjustments. The hours of operation identified on-site caused the most adjustments, either affecting equipment annual HOU's or the PCF. The Evaluator recommends that, in the future, ENS provide copies of the Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment to the Evaluator, which are used for many commercial kitchen measures to ensure that all of the input model variables can be confirmed.

Four other types of adjustments were made to measures in the category sample. First, one measure was not installed, resulting in revised savings of zero. Second, the site visit for a dishwasher measure required that the racks washed per day be revised from 10 to 40, positively affecting the energy savings. Third, the quantities for two measures were revised to reflect site visit findings. Fourth, an adjustment was required to resolve a typographical error because the energy savings calculated from the Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment was not correctly inserted into the peak demand savings formula. This resulted in a tracked savings value of 0.194 kW and a revised value of 1.073 kW, which yields an adjustment ratio greater than 5 for this measure. To reduce the margin of error, the measure was removed from the overall adjustment calculation and included in the final results as a one-time adjustment.

All measures were used to calculate the energy savings adjustment ratio, and one measure was removed from the peak demand savings ratio due to the abovementioned typographical error. The adjustment ratio was calculated at 0.989 for energy savings. For peak demand savings, an adjustment ratio of 0.711 was extrapolated to all measures except one; when taking into account the one-time adjustment to that measure, the overall adjustment ratio was 0.

4.1.8 Commercial Laundry Measures

No commercial laundry applications were received as part of 2017 BER.

4.1.9 Commercial Pumping Measures

One commercial pumping project was reviewed in 2017 and no adjustments were necessary.

4.1.10 Commercial Solar Measures

One commercial solar project was reviewed in 2017, and no adjustments were necessary.

4.1.11 Commercial Water Heating

One commercial water heating project was submitted in 2017, but it was not included in the project review sample.

4.1.12 Summary of Adjustments to Gross Savings

Table 8 below lists the adjustment ratios used for each measure category, as presented in Subsections 4.1.1 to 4.1.11. The table also presents the corresponding margin of error at a confidence level of 90 percent for measure categories for which adjustment ratios were extrapolated.

Table 8: Adjustment Ratios per BER Mail-in Measure Category

Measure Category	Number of Measures		Energy Savings		Margin of Error	Peak Demand Savings		Margin of Error
	Total	Sample	Overall Adjustment Ratio	Extrapolated Adjustment Ratio		Overall Adjustment Ratio	Extrapolated Adjustment Ratio	
HVAC	110	45	0.985	0.985	1.28%	0.447	0.381	6.77%
Commercial Lighting	503	75	0.927	0.927	6.41%	0.955	0.955	9.61%
Commercial Refrigeration	76	10	1.000	-	-	0.989	-	-
Motors and Variable Frequency Drives	16	15	0.995	0.995	7.02%	1.856	-	-
Compressed Air	1	1	2.439	-	-	1.019	-	-
Agriculture	6	5	0.894	-	-	0.456	-	-
Commercial Kitchen	22	16	0.989	0.989	7.67%	0.711	0.709	10.56%
Commercial Laundry	1	0	1.000	-	-	1.000	-	-
Commercial Pumping	8	4	1.000	-	-	1.000	-	-
Commercial Solar	1	1	1.000	-	-	1.000	-	-
Water Heating	1	0	1.000	-	-	1.000	-	-

4.1.13 Interactive Effects

Whenever a measure installed as part of BER Mail-in is affected by interactive effects, this is taken into account by the gross savings standard equation presented in the CIRx Screening Tool. In 2016, the Evaluator improved the methodology used by ENS to calculate interactive effects and applied it to the commercial program and service components (namely BER, Small Business Energy Solutions [SBES] and Custom Retrofit). The resulting interactive effect factors obtained for energy and peak demand savings have been integrated into the CIRx Screening Tool and applied to all 2017 lighting projects.

4.1.14 Effective Useful Life

As part of the 2017 evaluation, the Evaluator reviewed the EUL values used by ENS in the calculations of energy savings that are expected to persist over time. The EUL values of all the measures eligible for the service were reviewed based on the findings of a literature review. When establishing the EUL of a given measure, the Evaluator considered the most common values found in TRMs, evaluation reports or relevant studies.

For BER, ENS tracked a single EUL value for each measure category. The Evaluator attributed a revised EUL for each measure; measure-specific EUL values were then applied to all measures found in the 2017 tracking sheet.

Table 9 below lists the tracked and revised EUL values by measure category for the sake of comparison. The revised equivalent EULs represent the average EUL in each measure category, weighted with revised gross savings of each measure. These averages were not used in calculations.

Table 9: Summary of Effective Useful Life Values by Measure Category

Measure	ENS Tracked EUL	Revised Equivalent EUL
Agriculture	13	14.9
Compressed Air	10	15.0
HVAC	15	16.1
Kitchen	13	13.2
Laundry	11	11.0
Lighting	12	15.1
Motors and VFDs	13	15.0
Pumps	20	15.0
Refrigeration	14	14.0
Solar	15	20.0
Water heating	10	10.0

Overall, the revised equivalent EULs are similar to those tracked by ENS. The most important increases in EULs are for compressed air (5 years), solar products (5 years), and lighting products (3 years), while the only decrease in EULs was for pumps (5 years).

For lighting products, which represent over 60 percent of service energy savings, the increase in EUL is mostly due to an upward revision of product lifetimes. The Evaluator reviewed the specification sheets of the most popular product types of each lighting measure and found high rated life values. In many cases these values were higher than what is required by the Design Light Consortium. Furthermore, even if some lighting measures are expected to experience increased baselines during their lifetimes, which reduces their equivalent EULs, most lighting products rebated in BER Mail-in are not affected by a change in baseline. As for HVAC product types, which account for 28 percent of service energy savings, no revision was made to the tracked EUL. For the other product types, the changes in EUL had only marginal effects on lifetime savings.

Overall, the tracked weighted average EUL was 13 years while the revised EUL is 15.3 years, thus increasing lifetime savings for the service. Additional details on how EULs were established are provided in Appendix VIII.

4.1.15 Revised Gross Savings

The savings achieved by every BER Mail-in measure category are presented in Table 10 below. Both the energy and peak demand savings were revised by incorporating the adjustments discussed in the previous sections.

The savings at the generator were calculated using a line loss factor of 1.066, which accounts for electricity losses occurring between the meter and the generator. This value is a weighted average of the line loss factors, which NSP provided for each rate code, and the corresponding energy savings listed in the final tracking report.

The total gross energy savings for BER Mail-in are 18.346 GWh at the generator, which represents 280.930 GWh in lifetime energy savings based on a weighted average EUL value of 15.3 years. The total gross peak demand savings were estimated at 2.863 MW at the generator.

Table 10: Revised Gross Energy and Peak Demand Savings for BER Mail-in

Measure Category	HVAC	Lighting	Refrigeration	Motors and VFDs	Compressed Air	Agricultural
Energy Savings						
Tracked Gross Energy Savings (GWh)	4.878	11.309	0.838	0.704	0.007	0.168
Adjustment Ratio on Energy Savings	0.985	0.927	1.000	0.995	2.439	0.894
Gross Energy Savings – at the Meter (GWh)	4.804	10.487	0.838	0.700	0.016	0.150
Line Loss Factor	1.066	1.066	1.066	1.066	1.066	1.066
Gross Energy Savings – at the Generator (GWh)	5.121	11.179	0.894	0.747	0.017	0.160
Effective Useful Life (years)	16.1	15.1	14.0	15.0	15.0	14.9
Gross Lifetime Energy Savings – at the Generator (GWh)	82.525	169.032	12.518	11.199	0.254	2.390
Peak Demand Savings						
Tracked Gross Peak Demand Savings (MW)	0.888	2.095	0.190	0.022	0.002	0.047
Adjustment Ratio on Peak Demand Savings	0.447	0.955	0.989	1.856	1.019	0.456
Gross Peak Demand Savings – at the Meter (MW)	0.397	2.002	0.188	0.041	0.002	0.021
Line Loss Factor	1.066	1.066	1.066	1.066	1.066	1.066
Gross Peak Demand Savings – at the Generator (MW)	0.423	2.134	0.200	0.043	0.002	0.023

Revised Gross Energy and Peak Demand Savings for BER Mail-in (Continued)

Category of Measure	Kitchen	Water Heating	Pumping	Laundry	Solar	Total for All Categories
Energy Savings						
Tracked Gross Energy Savings (GWh)	0.143	0.038	0.019	0.005	0.013	18.121
Adjustment Ratio on Energy Savings	0.989	1.000	1.000	1.000	1.000	-
Gross Energy Savings – at the Meter (GWh)	0.141	0.038	0.019	0.005	0.013	17.211
Line Loss Factor	1.066	1.066	1.066	1.066	1.066	-
Gross Energy Savings – at the Generator (GWh)	0.151	0.040	0.020	0.005	0.014	18.346
Effective Useful Life (years)	13.2	10.0	15.0	11.0	20.0	-
Gross Lifetime Energy Savings – at the Generator (GWh)	1.984	0.401	0.296	0.060	0.271	280.930
Peak Demand Savings						
Tracked Gross Peak Demand Savings (MW)	0.030	0.009	0.004	0.001	0.000	3.288
Adjustment Ratio on Peak Demand Savings	0.711	1.000	1.000	1.000	0.000	-
Gross Peak Demand Savings – at the Meter (MW)	0.022	0.009	0.004	0.001	0.000	2.686
Line Loss Factor	1.066	1.066	1.066	1.066	1.066	-
Gross Peak Demand Savings – at the Generator (MW)	0.023	0.010	0.004	0.001	0.000	2.863

4.2 Net-to-gross Ratio

The net-to-gross ratio (NTGR) serves to determine net savings, i.e. the savings that can be reliably attributed to a service. More precisely, the NTGR is established by giving due consideration to the effects, such as free-ridership and spillover, that positively or negatively affect the energy savings generated by a service. Only one such effect is considered for BER Mail-in, namely free-ridership.

4.2.1 Free-ridership

In the case of BER Mail-in, free-ridership occurs when participants would have still implemented the energy efficiency upgrades and measures in the absence of the service. The assessment of the free-ridership level is based on a self-report approach that involves asking participants a set of questions during a telephone survey.

These questions were designed to assess the likelihood for participants to have deployed energy efficient technologies in the absence of the service. The questions consider all the applicable variables related to the decision-making process, including planning, efficiency, cost, timing and quantity. Additional questions were used to determine the extent to which participant decisions to have products installed had been influenced by previous participation in an ENS energy efficiency program component or ENS efforts to raise awareness about energy efficiency. When participant answers indicated that they had been significantly influenced by one of these two factors, the free-ridership level was adjusted downward.

For 2017, a question on lighting products was added to the questionnaire to better capture the impact of BER on the decision to purchase premium lighting products. This question related to participant awareness of the DLC and ENERGY STAR certifications met by the eligible lighting products.

The feedback collected from the participant survey was converted into an overall free-ridership level using the algorithm presented in Appendix IX.

The overall free-ridership level obtained is a weighted average free-ridership level based on the revised energy savings for each project. No adjustments to the weight of each measure category were applied for two reasons: (1) the number of sampled participants for categories other than lighting and HVAC was too small to obtain a statistically significant result; and (2) the distribution of savings of the surveyed sample was approximately equivalent to that of the entire population, which eliminated the need for a weighted average based on measure categories. An overall free-ridership level of 14 percent was obtained, with a margin of error of 2.4 percent.

Statistically significant individual results were obtained for the two most important measure categories (lighting and HVAC) and are presented here for reference. The free-ridership level for participants who installed lighting measures was 8 percent while free-ridership was 19 percent for participants who installed HVAC measures. For lighting, this value was lower in 2017 at 8 percent compared to 2016 (16%), which can partially be explained by the additional question to determine participant knowledge of certifications for lighting products. The free-ridership level for HVAC measures increased by 5 percentage points compared to the 2016 level of 14 percent. The Evaluator noticed that a few participants had higher than usual free-ridership levels (above 40%), including some who had installed measures that generated a lot of savings and who therefore had a larger impact on the weighted average. This increase might be an indication that heat pumps are becoming more popular since this measure constitutes a majority of the savings in this category.

4.2.2 Internal Spillover

For BER Mail-in, internal spillover occurs when participants implement eligible energy efficiency measures due to previous participation in the service, but without having had any kind of additional support.

The Evaluator conducted on-site visits to directly question participants about any potential spillover effects. The algorithm used to determine the level of internal spillover is presented in Appendix X.

The Evaluator used on-site visits to directly question participants about any potential spillover effects and found that the spillover level for 2017 was nil.

4.2.3 NTGR Calculation

The NTGR is calculated using the following equation:

$$NTGR = (1 - \% \text{ free-ridership} + \% \text{ spillover})$$

Based on the free-ridership and spillover levels established for BER Mail-in, the NTGR value is estimated at 0.86.

4.3 Net Savings

Net savings are defined as the changes in energy use attributable specifically to BER Mail-in. Net savings were estimated by applying the NTGR above to the revised gross savings, as shown in the following equation:

$$\text{Net Savings} = \text{Revised Gross Savings} \times NTGR$$

The total net energy savings are 15.778 GWh at the generator, while the total net peak demand savings are 2.462 MW at the generator. By applying 0.6531 kg CO₂ eq/kWh, which is Nova Scotia's specific factor¹³ for GHG emissions generated by electricity production, it is estimated that the net energy savings have resulted in 10,305 tonnes of avoided CO₂ eq. Based on the weighted average EUL of 15.3 years, the net lifetime energy savings were established at 241.600 GWh.

Detailed results are presented in Table 11.

¹³ At the time of writing, 2017 data was not available. The Nova Scotia-specific factor was obtained from Nova Scotia Power's 2016 total system emissions data (7,079,268 CO₂ eq tonnes) and total electricity generation (10,839 GWh) from the following two sources:

Nova Scotia Power, *Total System Emissions*, <http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx>, (Last accessed December 17, 2017).

Emera Inc., *Management's Discussion & Analysis as at February 10, 2017*, <http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693>, (Last accessed December 17, 2017).

Table 11: Revised Net Energy and Peak Demand Savings for BER Mail-in

Category of Measure	HVAC	Lighting	Refrigeration	Motors and VFDs	Compressed Air	Agricultural
Energy Savings						
Revised Gross Energy Savings – at the Meter (GWh)	4.804	10.487	0.838	0.700	0.016	0.150
NTGR	0.86	0.86	0.86	0.86	0.86	0.86
Net Energy Savings – at the Meter (GWh)	4.131	9.019	0.721	0.602	0.014	0.129
Line Loss Factor	1.066	1.066	1.066	1.066	1.066	1.066
Net Energy Savings – at the Generator (GWh)	4.404	9.614	0.769	0.642	0.015	0.138
Effective Useful Life (years)	16.1	15.1	14.0	15.0	15.0	14.9
Net Lifetime Energy Savings – at the Generator (GWh)	70.972	145.368	10.766	9.631	0.218	2.055
Peak Demand Savings						
Revised Gross Peak Demand Savings – at the Meter (MW)	0.397	2.002	0.188	0.041	0.002	0.021
NTGR	0.86	0.86	0.86	0.86	0.86	0.86
Net Peak Demand Savings – at the Meter (MW)	0.341	1.722	0.161	0.035	0.002	0.018
Line Loss Factor	1.066	1.066	1.066	1.066	1.066	1.066
Net Peak Demand Savings – at the Generator (MW)	0.364	1.835	0.172	0.037	0.002	0.020

Revised Net Energy and Peak Demand Savings for BER Mail-in (Continued)

Category of Measure	Kitchen	Water Heating	Pumping	Laundry	Solar	Total for All Categories
Energy Savings						
Revised Gross Energy Savings – at the Meter (GWh)	0.141	0.038	0.019	0.005	0.013	17.211
NTGR	0.86	0.86	0.86	0.86	0.86	-
Net Energy Savings – at the Meter (GWh)	0.122	0.032	0.016	0.004	0.011	14.802
Line Loss Factor	1.066	1.066	1.066	1.066	1.066	-
Net Energy Savings – at the Generator (GWh)	0.130	0.034	0.017	0.005	0.012	15.778
Effective Useful Life (years)	13.2	10.0	15.0	11.0	20.0	-
Net Lifetime Energy Savings – at the Generator (GWh)	1.706	0.345	0.254	0.052	0.233	241.600
Peak Demand Savings						
Revised Gross Peak Demand Savings – at the Meter (MW)	0.022	0.009	0.004	0.001	0.000	2.686
NTGR	0.86	0.86	0.86	0.86	0.86	-
Net Peak Demand Savings – at the Meter (MW)	0.019	0.008	0.003	0.001	0.000	2.310
Line Loss Factor	1.066	1.066	1.066	1.066	1.066	-
Net Peak Demand Savings – at the Generator (MW)	0.020	0.009	0.004	0.001	0.000	2.462

Table 12 compares the energy and peak demand savings established through this BER Mail-in evaluation to those calculated in the 2017 tracking system.

Table 12: Comparison of Tracked and Evaluated Savings at the Generator – BER Mail-in

	Initial Gross Savings	Adjusted Gross Savings	NTGR	Net Savings
Energy Savings				
ENS Tracked Savings	19.316 GWh	19.316 GWh	0.84	16.225 GWh
Evaluation Results	19.316 GWh	18.346 GWh	0.86	15.778 GWh
Peak Demand Savings				
ENS Tracked Savings	3.505 MW	3.505 MW	0.84	2.944 MW
Evaluation Results	3.505 MW	2.863 MW	0.86	2.462 MW

The gross evaluated energy savings are 5 percent lower than the tracked values. While the Evaluator applied a very small adjustment to the energy savings of most measure categories, lighting savings were reduced by 7.3 percent. Since this measure category accounted for over 62 percent of the gross savings, this explains most of the difference between the tracked and evaluated gross savings. The slight increase in the NTGR partially compensated for the decrease of gross savings, resulting in the evaluated net energy savings being only 3 percent lower than their tracked value.

The evaluated net peak demand savings are 16 percent below their tracked value. This is due to the downward adjustment of 18 percent applied to gross savings, which is the result of one large adjustment to an HVAC project.

5 IMPACT EVALUATION FOR BER INSTANT REBATES

The objective of the 2017 BER Instant Rebates impact evaluation is to determine gross and net electrical energy and peak demand savings.

5.1 Gross Savings

Gross savings refer to changes in energy consumption resulting from actions taken by participants regardless of their reasons for participating.¹⁴ Since eligible products are tracked at the point of sale, ENS estimates savings based on a set of assumptions specific to each product type rather than using the real operating conditions and old equipment of projects. Energy and peak demand savings are calculated for each transaction; the equation used includes the baseline wattage, the actual wattage of the efficient product, a ballast factor when applicable, interactive effects factors, a PCF, and an in-service rate (ISR).

In 2017, the Evaluator did not conduct a full literature review to update the savings values that were recommended in the 2016 evaluation. Instead, the content of ENS's database was reviewed to ensure that the Evaluator's 2016 recommended savings values were applied correctly.

The following subsections present the 2016 evaluated savings values for each product type offered under BER Instant Rebates (referred to as "Recommended Savings"), followed by the adjustments made to the 2017 tracked savings to ensure values match 2016 evaluation results.

The changes applied to ISRs, PCF and interactive effects are presented separately in Subsections 5.1.10 to 5.1.12.

5.1.1 Linear LED Fixtures

Recommended Savings

The linear LED fixtures category contains four subcategories representing the most common types of lighting technology. Table 13 below presents the 2016 evaluation recommended values to calculate the energy and peak demand savings of this category.

¹⁴ Definition adapted from National Renewable Energy Laboratory, *The Uniform Methods Project, Chapter 23: Estimating Net Savings: Common Practices*, September 2014, p. 3

Table 13: Recommended Values for Linear LED Fixtures

Subcategory	Lumen Output (lm)	Baseline Wattage (W)	Hours of Use
1 x 4 Luminaires	1,500 – 3,500	61.00	4,410
	≥ 3,500	83.25	
2 x 2 Luminaires & Retrofit Kits	1,500 – 4,500	61.00	4,410
	≥ 4,500	84.00	
2 x 4 Luminaires & Retrofit Kits	3,000 – 6,500	88.00	4,410
	≥ 6,500	128.50	
Linear Ambient & Low Bay Luminaires	< 2,500	29.50	4,410
	2,500 – 5,000	58.00	
	5,000 – 10,000	112.00	
	≥ 10,000	200.00	

The efficient wattage is not included in this table since the actual wattage of each product is used, which is the case for all products in BER Instant Rebates.

Revised Savings

Baseline and Efficient Wattage

The Evaluator reviewed each category and confirmed that the appropriate baseline wattage had been applied in the tracked savings, as per Table 13 above. The Evaluator reviewed the specification sheets for the five most frequently purchased LED fixtures in this category and found no errors in tracked wattage beyond 2 percent. Thus, no adjustments were made to the efficient wattage values.

Hours of Use

In 2017, the value of 4,410 hours per year was adopted for all lighting products (except outdoor fixtures and occupancy sensors). This value was correctly applied to close to 100 percent of data entries for linear LED fixtures, with 4,065 hours being tracked in the remaining cases. The HOU were revised to the 2017 value for 15 entries in the tracking report, which affected 318 linear LED fixtures.

Overall Adjustment

These corrections resulted in an overall adjustment ratio of 1.000 for energy savings and 0.999 for peak demand savings.

5.1.2 Linear LED Lamps

Recommended Savings

The linear LED lamps category includes LED replacement lamps for both two-foot and four-foot fluorescent lamps. Table 14 below lists the variables recommended in the 2016 evaluation report for the savings calculations in this category.

Table 14: Recommended Values for Linear LED Lamps

Subcategory	Baseline Wattage (W)	HOU
4-foot Replacement Lamps	32	4,410
2-foot Replacement Lamps	17	4,410

Revised Savings

Baseline and Efficient Wattage

The Evaluator confirmed that the appropriate baseline wattage was applied for all products in this category. The Evaluator reviewed the specification sheets for the five most frequently purchased LED lamps in this category and found one product tracked as both 18 W and 20.5 W, while the DLC listing was 20.5 W. Upon further review, all linear LED lamps belonging to this product category had similar discrepancies, as shown in Table 15 below. It appears that the lowest wattage value is the bare lamp wattage, while the highest wattage is the true system wattage. The Evaluator revised the efficient wattage for these products to the DLC listing wattage, which affected a total of 481 data entries in the tracking sheet and 21,776 linear LED lamps.

Table 15: Linear LED Lamp Tracked Wattages

Product	Tracked Efficient Wattage (W)	DLC Wattage (W)
LED18ET8	18, 20.5	20.5
LED15ET8	15, 18	18
LED12ET8	12, 15	15

Hours of Use

In 2017 the value of 4,410 hours per year was adopted for all lighting products except outdoor fixtures and occupancy sensors. This value was correctly applied to over 95 percent of the linear LED fixture products. The value of 4,065 hours per year was tracked for the remaining cases. The hours of use were revised to the 2017 value for 59 data entries in the tracking report, which affected 2,293 products.

Overall Adjustment

These corrections resulted in an overall adjustment ratio of 0.979 for energy savings and 0.978 for peak demand savings.

5.1.3 General-use and Decorative LED Lamps

Recommended Savings

General-use and decorative LED lamps include omnidirectional A-type and globe lamps, as well as chandelier and candle type lamps. The recommended baseline wattage for LED general-use and decorative lamps are consistent with the current federal energy efficiency regulations¹⁵ (which allow incandescent technology for decorative lamps, but require using the efficiency level of incandescent halogen lamps for omnidirectional lamps). Baseline wattage and hours of use values are outlined in Table 16.

Table 16: Recommended Values for General-use and Decorative LED Lamps

Subcategory	Lumens (lm)	Baseline Wattage (W)	Hours of Use
LED Decorative (chandelier)	220	25	4,410
	314	40	4,410
	506	60	4,410
LED Omnidirectional (A-lamp and globe)	< 750	29	4,410
	≥ 750 and < 1,050	43	4,410
	≥ 1,050 and < 1,490	53	4,410
	≥ 1,490	72	4,410

Revised Savings

Baseline and Efficient Wattage

The Evaluator reviewed each subcategory to determine if the appropriate baseline wattage was applied in the tracked savings. The baseline wattage for the decorative LED subcategory is defined by a 25 W, 40 W and 60 W equivalent incandescent lamp with single lumen values (as opposed to a range) for each wattage. For products for which lumen output was not exactly 220, 314 or 506 lumens, the closest lumens value was chosen to set the baseline. For example, the baseline of a product with a 300 lumen output was established at 60 W. This method resulted in two positive changes in the tracked baseline wattage from 40 W to 60 W. The baseline wattage values were correctly applied for all omnidirectional type lamps.

¹⁵ Natural Resources Canada. General Service Lamps and Modified Spectrum Incandescent Lamps
<http://www.nrcan.gc.ca/energy/regulations-codes-standards/products/6869>. (Last accessed February 28, 2018).

The Evaluator reviewed the specification sheets for the five most frequently purchased products in this category and found no errors in tracked wattage. Thus, no adjustments were made to the efficient wattage values.

Hours of Use

The hours of use were correctly applied in almost all cases, with only two revisions required to the 2017 value.

Overall Adjustment

These corrections resulted in an overall adjustment ratio of 1.000 for energy savings and 1.000 for peak demand savings.

5.1.4 Reflector LED Lamps

Recommended Savings

Reflector LED lamps include lamp types such as BR and PAR lamps. The baseline technology used by ENS for each of the four category sizes are halogen lamps. Table 17 lists the baseline wattage values and hours of use recommended for this product category.

Table 17: Recommended Values for Reflector LED Lamps

Subcategory	Baseline Wattage (W)	Hours of Use
Small LED Reflector Lamp - PAR, MR, MRX 16	20	4,410
Small LED Reflector Lamp - PAR, R 20	50	4,410
Large LED Reflector Lamp - PAR, BR, R 30/30L	50	4,410
Large LED Reflector Lamp - PAR, BR, R 38/40	65	4,410

Revised Savings

Baseline and Efficient Wattage

The Evaluator confirmed that the appropriate baseline wattage was applied in all cases.

The Evaluator reviewed the specification sheets for the five most frequently purchased products in this category and found discrepancies in both the tracked efficient wattage and the baseline wattage values, which affected 97 data entries and 1,174 products.

Hours of Use

The hours of use were correctly applied in all cases and did not require adjustment.

Overall Adjustment

The correction made to the baseline and efficient wattage values for one product resulted in an overall adjustment ratio of 1.043 for energy savings and 1.043 for peak demand savings.

5.1.5 LED Downlight Fixtures

Recommended Savings

LED downlight fixtures category includes recessed, ceiling-mounted, surface-mounted, and wall sconce fixtures, as well as solid-state and wall sconce retrofit kits. The recommended wattage values and annual hours of use for LED downlight fixtures are presented in Table 18 below. LED recessed fixture savings are based on a halogen lamp baseline with corresponding baseline wattages of 45 W, 90 W and 250 W, depending on their lumen outputs. All other subcategories use incandescent halogen lamps as the baseline technology because these fixtures house general-use lamps to which the federal energy efficiency regulations apply.

Table 18: Recommended Values for LED Downlight Fixtures

Subcategory	Lumens	Baseline Wattage (W)	Annual Hours of Use
LED Recessed	≥ 400 and $< 1,000$	45	4,410
	$\geq 1,000$ and $< 3,000$	90	4,410
	$\geq 3,000$	250	4,410
LED Ceiling Mount, LED Surface Mount, LED Solid State Retrofit, LED Inseparable Solid State Luminaire, LED Wall Sconces, LED Wall Sconce Retrofit	< 750	29	4,410
	≥ 750 and $< 1,050$	43	4,410
	$\geq 1,050$ and $< 1,490$	53	4,410
	$\geq 1,490$	72	4,410

Revised Savings

Baseline and Efficient Wattage

The Evaluator reviewed the baseline wattage values as per Table 18 above. The baseline wattage required corrections for 411 data entries, totalling 2,448 products sold. Baseline revisions were required because the lumen ranges indicated in Table 18 above were not consistently applied.

The Evaluator reviewed the specification sheets for the five most frequently purchased LED fixtures in this category and found no errors in tracked wattage above 5 percent. Thus, no adjustments were made to the efficient wattage values.

Hours of Use

The 2017 HOU value of 4,410 hours per year was correctly applied to over 99 percent of the products sold in the LED downlight category, with the previous HOU value of 4,065 being tracked in the remaining cases. The hours of use were revised to the 2017 value for these products.

Overall Adjustment

These corrections resulted in an overall adjustment ratio of 0.998 for energy savings and 1.008 for peak demand savings.

5.1.6 Outdoor LED Fixtures

Recommended Savings

The outdoor LED fixtures category contains the outdoor full-cutoff wall-mounted area luminaires, as well as the architectural flood and spot luminaires subcategories with the majority of fixtures belonging to the latter. Both subcategories are divided into groups by lumen output to assign the correct baseline wattage, and the baseline technology used for each subcategory is different. A weighted average of 50 percent metal halide (MH) and 50 percent high-pressure sodium (HPS) fixture system wattages was used by ENS to determine the baseline wattage values for the outdoor full-cutoff wall-mounted area luminaires presented in Table 19.

Table 19: Recommended Wattages per Lumen Output for Outdoor Full-cutoff Wall-mounted Area Luminaires

Lumen Range (lumens)	MH Baseline Fixture Wattage (W)	HPS Baseline Fixture Wattage (W)	Weighted Average Baseline Wattage (W)	Annual Hours of Use
≥ 300 and < 2,000	43	46	44.5	4,380
≥ 2,000 and < 5,000	95	95	95.0	4,380
≥ 5,000 and < 15,000	295	250	272.5	4,380

The architectural flood and spot luminaires subcategory is divided into six ranges according to the baseline lamp technology. The typical lumen output of these fixtures is grouped into ranges to be able to select the appropriate efficient LED fixture depending on required light output. A summary of the recommended values is provided in Table 20 below. The baseline technologies were derived from the Duke Energy fixture wattage table.¹⁶ The annual HOU for this category are 4,380 based on the common assumption of 12 hours of use per day since these luminaires are used for outdoor lighting.

¹⁶ Duke Energy, *Fixture Wattage Table*, <http://www.ahutton.com/LED/Progress%20wattages.pdf>, (Last accessed January 10, 2018).

Table 20: Recommended Values for Architectural Flood and Spot Luminaires

Lumen Range of Efficient Luminaires	Baseline Fixture	Baseline Wattage (W)	Annual Hours of Use
≥ 250 and < 1,000	Halogen	37	4,380
≥ 1,000 and < 5,000	MH (70 W)	95	4,380
≥ 5,000 and < 15,000	MH (250 W)	295	4,380
≥ 15,000 and < 30,000	MH (250 W x 2)	590	4,380
≥ 30,000 and < 50,000	MH (1,000 W)	1,080	4,380
≥ 50,000	MH (1,500 W)	1,610	4,380

Revised Savings

Baseline and Efficient Wattage

The Evaluator found no errors in the baseline wattage values applied in the tracked savings.

The Evaluator reviewed the specification sheets for the five most frequently purchased LED fixtures in this category and found no errors in tracked wattage above 5 percent. Thus, no adjustments were made to the efficient wattage values.

Hours of Use

The value of 4,380 hours per year was correctly applied to all products sold in the outdoor LED fixture category. Thus, no adjustments were required.

Overall Adjustment

No adjustments were required for the energy and peak demand savings calculations for this product category. Therefore, the adjustment ratios were 1.000 for both energy savings and peak demand savings.

5.1.7 Directional and Architectural LED Fixtures

Recommended Savings

The directional and architectural LED fixtures category contains track or mono-point directional luminaires. The baseline technology is halogen lamps generating 17 lumens per watt. The recommended variables for this category are listed in Table 21.

Table 21: Recommended Values for Directional and Architectural LED Fixtures

Category	Lumens	Baseline Wattage (W)	Annual Hours of Use
Track or Mono-point Directional Luminaires	≥ 250	60.4	4,410

Revised Savings

Baseline and Efficient Wattage

The Evaluator reviewed the category to determine if the appropriate baseline wattage was applied in the tracked savings. No baseline wattage revisions were required since all fixtures tracked over 250 lumens.

The Evaluator reviewed the specification sheets for the five most frequently purchased LED fixtures in this category and found no errors in tracked wattage.

Hours of Use

The correct value of 4,410 hours per year was applied to all entries with one exception which was revised to the appropriate value.

Overall Adjustment

The overall adjustment ratio was 1.037 for energy savings and 1.000 for peak demand savings.

5.1.8 Occupancy Sensors

Recommended Savings

Occupancy sensors are tracked as five different categories to distinguish the types of technologies. The recommended energy savings and peak demand savings are unitary values derived from the savings equations used in the 2015 Efficiency Vermont TRM,¹⁷ which are summarized in Table 22.

Table 22: Recommended Values for Occupancy Sensors

Type	Energy Savings (kWh/year)	Tracked SVG Value	Tracked Pconn Value (W)
Ceiling Remote-mounted	467	24%	517
Wall Remote-mounted	467	24%	517
Fixture Mounted	162	24%	180
Wall Switch	275	24%	305
Exterior	134	41%	76

¹⁷ Efficiency Vermont, *Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions*, March 2015.

These unitary savings values are derived from the algorithm used in the BER CIRx Screening Tool. The equation is as follows:

$$ES = P_{conn} \times SVG \times OTF \times ISR \times HRS/1000$$

Where:

- › *Pconn* is the connected wattage controlled by the occupancy sensor (varies by lighting control type)
- › *SVG* is the percentage of annual lighting energy savings (varies by lighting control type)
- › *OTF* is the operational testing factor (constant value = 1)
- › *ISR* is the in-service rate (assumed to be 100%)
- › *HRS* is the annual hours of operation (3,799 hours as per the metering study from which the percentages of annual lighting energy savings are derived)
- › 1,000 is the conversion factor from W to kW

It should however be noted that the variables presented above, when used in the energy savings equation, do not exactly yield the energy savings values listed in Table 22. The Evaluator could not find the source of this discrepancy but fixed it in their calculation of the revised savings.

Revised Savings

The Evaluator applied the parameters described above to obtain the revised values presented in Table 23.

Table 23: Revised Values for Occupancy Sensors

Type	Energy Savings (kWh/year)	Tracked SVG Value	Tracked Pconn Value (W)
Ceiling Remote-mounted	471	24%	517
Wall Remote-mounted	471	24%	517
Fixture Mounted	164	24%	180
Wall Switch	278	24%	305
Exterior	118	41%	76

This change had a small impact on the overall savings and the adjustment ratios are 1.000 for both energy and peak demand savings.

5.1.9 Pumps

Recommended Savings

Pumps are divided into three categories based on the input wattage range of installed pumps as shown in Table 24. Each input wattage corresponds to a unitary savings value for energy and peak demand savings.

Table 24: Recommended Savings for Pumps

Type	Max Input Power (W)	Estimated DS (kW)	Estimated ES (kWh)
Variable Speed ECM Circulator Pump	< 150	0.088	422
	≥ 150 and < 500	0.165	795
	≥ 500 and < 2,500	0.532	2,558

Revised Savings

The Evaluator verified the input wattages of the two most popular pumps sold in BER Instant Rebates for 2017, which comprised 157 of the 199 pumps sold. Input wattages were tracked correctly for these models. Thus, no changes were made to the products and the adjustment ratios are 1.000 for both energy and peak demand savings.

5.1.10 In-service Rate

To establish the ISR, the Evaluator conducted a literature review in 2016 of other jurisdictions with an upstream commercial program similar to BER Instant Rebates because research indicates that a percentage of purchased products might be stored for later use. Based on a study conducted by DNV-GL for the Massachusetts Energy Efficiency Program Administrators,¹⁸ an ISR of 85 percent was applied, which corresponds to the proportion of in-service fluorescent and LED lighting technology three years after their purchase through an instant rebate program. The Evaluator used an 85-percent third-year ISR for lamps only, since within a three-year period there is little chance that spare lamps will be used to replace other efficient lamps given that the EUL of LEDs is nearly 10 years. The Evaluator maintained the ISR of 100 percent for fixtures, occupancy sensors and pumps because their higher price point discourages stocking in large quantities.

Again in 2017, the Evaluator applied this methodology to all product categories, the results of which largely corresponded to values that had been tracked by ENS.

¹⁸ DNV-GL, *Massachusetts Commercial and Industrial Upstream Lighting Program: "In Storage" Lamps Follow-up Study*, March 2015.

5.1.11 Peak Demand Savings

Since no on-site visits were conducted for BER Instant Rebates, no PCF specific to the lighting products sold through the service could be established. Hence, the PCF of 64.6 percent, obtained from the average results from BER Mail-in and SBES on-site visits for indoor lighting products, was applied to BER Instant Rebates, which is in line with the approach used for HOU's and interactive effects (as explained in the following subsection). For outdoor products (which would typically be turned on between 5 and 7 p.m. throughout December, January and February) and products that are on 24 hours per day (LED refrigerated strip lighting), a PCF of 100 percent was applied.

As for circulator pumps, since they are typically used as part of residential and commercial hydronic heating-system applications, it is assumed that they work continuously during the coldest days of winter. Thus, a PCF of 100 percent is applied to this product category.

5.1.12 Interactive Effects

Whenever a measure installed as part of BER Instant Rebates is affected by interactive effects, this is taken into account by the gross savings unitary equation presented in the tracking sheet.

Since 2016, a standardized approach based on a methodology published in the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Journal¹⁹ has been used to calculate the interactive effects for lighting projects on a per building-type basis.

¹⁹ Rundquist, Robert A. et al., "Calculating Lighting and HVAC Interactions," *ASHRAE Journal*, November 1993, pp. 28 to 37.

The interactive effects for BER Instant Rebates are based on the building types and associated heating and cooling systems verified during the SBES and BER Mail-in lighting project on-site visits conducted as part of the 2016 evaluation. In 2016, for SBES the average peak demand savings interactive effects factor was -14.7 percent and the average energy savings interactive effects factor was -8.2 percent, while for BER Mail-in the peak demand savings interactive effects factor was -3.2 percent and the average energy savings interactive effects factor was 0.3 percent. When averaged, these values resulted in overall interactive effects factors of -8.9 percent and -4.0 percent respectively for peak demand savings and energy savings. The Evaluator elected to continue using these values in 2017 since it was not possible to update some of the numbers used the calculations for SBES due to missing information in the tracking sheet. Additionally, the proportion of BER Mail-in measures that are not Instant Rebate eligible products has increased and is now at 61 percent. Those products are essentially outdoor and high bay lighting and the Evaluator believes that the characteristics of the participating facilities where they are installed might be too different from those where Instant Rebate products are installed to draw useful conclusions.

Additionally, the Evaluator applied a factor of 57 percent to interactive effects to take into account the limited contribution of recessed fixtures; this factor was consistently applied to BER lighting product categories that included recessed fixtures. This factor impacted the interactive effects factors for LED linear fixtures, LED linear lamps and LED downlight fixtures. For each of these categories, the percentage of savings generated by recessed fixtures and lamps was estimated from the database and a recessed factor of 57 percent was applied to the interactive effect factor for this proportion of savings only.

5.1.13 Effective Useful Life

As part of the 2017 evaluation, the Evaluator reviewed the EUL values used by ENS. These values are used to calculate energy savings over the lifetime of products. ENS tracked an average EUL value of 14 years for lighting products and 15 years for pumps.

For BER Instant Rebates, the EUL values of all the measures eligible for the service were reviewed based on the findings of the literature review. When establishing the EUL for a given measure, the Evaluator considered the most common values found in TRMs, evaluation reports or relevant studies.

For lighting measures, the Evaluator also consulted the specification sheets of the most popular products rebated through the service to establish the rated life of the product. The EUL was then determined by dividing the rated life (in hours) by the annual HOU. The EUL was adjusted to account for increases in baselines through the EUL of the measure. This equivalent EUL therefore corresponds to the number of years by which the first-year savings estimate is multiplied to obtain lifetime energy savings. For BER Instant Rebates, this adjustment only modified the EUL value of LED downlight fixtures. The revised equivalent EUL values by subcategory are presented in Table 25.

Table 25: Revised Equivalent Effective Useful Life Values by Measure Category

Evaluation Category	Subcategory	Rated Life (hours)	Annual HOU	Tracked EUL (years)	Revised EUL (years)	Equivalent EUL (years)
Linear LED Fixtures	1 x 4 Luminaires	50,000	4,410	14	11.3	11.3
	2 x 2 Luminaires and Retrofit Kits					
	2 x 4 Luminaires and Retrofit Kits					
	Linear Ambient and Low Bay Luminaires					
Linear LED Lamps	4-foot Replacement Lamps	50,000	4,410	14	11.3	11.3
	2-foot Replacement Lamps					
General-use and Decorative LED Lamps	LED Decorative (chandelier)	25,000	4,410	13.6	5.7	5.7
	LED Omnidirectional (A-lamp and globe)					
Reflector LED Lamps	Small LED Reflector Lamp - PAR, MR, MRX 16	25,000	4,410	13.6	5.7	5.7
	Small LED Reflector Lamp - PAR, R 20					
	Large LED Reflector Lamp - PAR, BR, R 30/30L					
	Large LED Reflector Lamp - PAR, BR, R 38/40					
LED Downlight Fixtures	LED Recessed	50,000	4,410	14.2	11.3	8.3
	LED Ceiling Mount, LED Surface Mount, LED Solid State Retrofit, LED Inseparable Solid State Luminaire, LED Wall Sconces, LED Wall Sconce Retrofit	50,000	4,410	14.2	11.3	8.4
Outdoor LED Fixtures	Outdoor Full-cutoff Wall-mounted Area Luminaires	50,000	4,380	15 or 18	11.4	11.4
	Architectural Flood and Spot Luminaires	75,000	4,380	18	17.1	17.1
Directional and Architectural LED Fixtures	Track or Mono-point Directional Luminaires	50,000	4,410	14	11.3	11.3
Occupancy Sensors	Ceiling Remote-mounted	-	-	10	10	10
	Wall Remote-mounted					
	Fixture Mounted					
	Wall Switch					
	Exterior					
Pumps	Variable Speed ECM Circulatory Pump	-	-	15	15	15

The following provides additional details on the methodology for establishing equivalent EUL values for LED lamps and other products offered in BER Instant Rebates.

LED Lamps

For all LED lamps, ENS tracked an EUL value of 10 years. The Evaluator established a revised EUL for each subcategory with the rated lifetime of the product and the annual HOU. The Evaluator consulted the specification sheets of the most popular products of each evaluation category to establish their rated lifetime.

The Evaluator then examined the possibility of seeing an increased baseline over the lifetime of general-use, decorative and reflector lamps, as well as LED downlight fixtures (which replace fixtures including general-use lamps). This analysis was based on current and projected Canadian regulations for general service lamps.

For general-service lamps, the current baseline used in BER Instant Rebates is incandescent halogen lamps or halogens lamps. In the United States, the Energy Independence and Security Act (EISA) will raise the minimum efficiency of general service lamps to the efficiency of a CFL lamp in 2020.²⁰ Natural Resources Canada (NRCAN) has included an update of the general service lamp minimum energy performance requirement in Amendment 16 to Canada's Energy Efficiency Regulations which is planned for pre-consultation in 2019²¹ (and should therefore be applied within a few years after).

The NRCAN update will most likely align Canadian regulation with EISA 2020. Although this regulation effectively bans the import and fabrication of so-called efficient incandescent light bulbs, it is expected that these will still be available from electrical distributors until their stocks are depleted for up to two years after the legislation is implemented. With this information, the Evaluator reached the conclusion that the baseline change will occur in 2024. This regulation will affect the baselines of general-use, decorative and reflector lamps, as well as downlight fixtures, for all of which a minimum efficiency of 45 lumens/watt is expected.

Since general-use, decorative and reflector lamps have EULs of less than six years, their equivalent EUL is not affected by the change in baseline expected to occur in 2024. However, the equivalent EUL of downlight fixtures, for which the basecase is fixtures including A-type and reflector lamps, is impacted since its EUL is 11.3 years. For this category, the Evaluator established equivalent EULs for LED recessed fixtures and other LED downlight fixtures separately.

²⁰ US EPA, *Summary of the Energy Independence and Security Act. Public Law 110-140 (2007)*, www.epa.gov/laws-regulations/summary-energy-independence-and-security-act. (Last accessed February 28, 2018)

²¹ Natural Resources Canada, *Forward Regulatory Plan 2017-19*, <http://www.nrcan.gc.ca/energy/regulations-codes-standards/18318>. (Last accessed February 28, 2018).

For LED recessed fixtures, basecase fixtures mostly use reflector lamps, so the baseline is halogen lamps. As mentioned previously, the Canadian regulations are expected to impact the market in 2024, which will increase the baseline to a CFL equivalent. The equivalent EUL calculation for LED recessed fixtures is based on 9 W lamps being the most common efficient product purchased in this subcategory in 2017 BER Instant Rebates. With the information presented in Table 26, the following equation was used to establish the equivalent EUL to be applied to first-year savings to determine lifetime energy savings.

$$\text{Equivalent EUL} = \frac{\Delta W_{\text{Halogen}} \times 7 \text{ years} + \Delta W_{\text{CFL}} \times 4.3 \text{ years}}{\Delta W_{\text{Halogen}}}$$

Table 26: Baseline Evolution During the Effective Useful Life of LED Reflector Lamps

Replaced Lamp (W)	Typical Efficient Lamp (W)	Halogen Baseline 7 years (2017-2023)		CFL Equivalent Baseline American Legislation ²² 4.3 years (2024-2028)	
		Baseline (W)	Displaced Wattage (W)	Baseline (W)	Displaced Wattage (W)
45	9	45	36	20	11

The same methodology was used for the remaining LED downlight fixtures, which use A-type lamps, using the information presented in Table 27 and the following equation. Again, the equivalent EUL calculation is based on 9 W lamps being the most common product purchased for among A-types in 2017 BER Instant Rebates.

$$\text{Equivalent EUL} = \frac{\Delta W_{\text{Halogen Incandescent}} \times 7 \text{ years} + \Delta W_{\text{CFL}} \times 4.3 \text{ years}}{\Delta W_{\text{Halogen Incandescent}}}$$

Table 27: Baseline Evolution During the Effective Useful Life of LED A-type Lamps

Replaced Lamp (W)	Typical Efficient Lamp (W)	Halogen Incandescent Baseline 7 years (2017-2023)		CFL Equivalent Baseline American Legislation ²³ 4.3 years (2024-2028)	
		Baseline (W)	Displaced Wattage (W)	Baseline (W)	Displaced Wattage (W)
43	9	45	34	20	11

For products other than general-service lamps, there is no indication that regulations will change over the lifetime of these products. Furthermore, in the case of linear ambient luminaires, linear replacement lamps, and MH lamps, the baseline products are already considered efficient, which further suggests that regulations will not be changed in the near future.

²² As imposed by U.S. federal legislation. Incandescent Equivalent 2nd Tier EISA 2007.

²³ As imposed by U.S. federal legislation. Incandescent Equivalent 2nd Tier EISA 2007.

Other Products

Other than LED lamps, BER Instant Rebates offers rebates for occupancy sensors and pumps.

ENS tracked an EUL value of 10 years for occupancy sensors. The Evaluator found that the most common values used in other jurisdictions for occupancy sensors is either eight or 10 years, based on the 2007 GDS report²⁴ and on Database for Energy Efficiency Resources 2008²⁵ respectively. Therefore, the Evaluator agrees with ENS that the use of 10 years is appropriate.

As for pumps, ENS tracked a value of 15 years. The Evaluator agrees with this value because it is also used in the literature for high efficiency circulatory pumps.²⁶

5.1.14 Revised Gross Savings

The energy and peak demand savings associated with BER Instant Rebates were calculated using the unitary savings values, ISRs, and interactive effects factors revised as part of this evaluation. The savings at the generator were also calculated using a line loss factor of 1.066 between the meter and the generator. This value corresponds to the weighted average line loss factor calculation applied to BER Mail-in participants.

The total savings established for each product type are presented in Table 28 below. For BER Instant Rebates, gross energy savings amounted to 42.119 GWh at the generator, which represents 408.624 GWh in lifetime energy savings based on a weighted average EUL value of 9.7 years. The total gross peak demand savings were estimated at 6.432 MW at the generator.

²⁴ GDS Associates. *Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures*, June 2007.

²⁵ Database for Energy Efficiency Resources (DEER), *DEER 2008 EUL Table*, 2008.

²⁶ PA Consulting Group. *Focus on Energy Evaluation Business Programs: Measure Life Study*, August 25, 2009.

Table 28: Revised Gross Energy and Peak Demand Savings for BER Instant Rebates

Product Category	Linear LED Fixtures	Linear LED Lamps	General-use and Decorative LED Lamps	Reflector LED Lamps	LED Downlight Fixtures	Outdoor LED Fixtures
Tracking Sheet						
Number of Units	29,103	116,785	20,017	20,920	115,513	6,641
Energy Savings						
Tracked Gross Energy Savings (GWh)	4.991	6.191	2.914	3.594	17.903	4.354
Adjustment Ratio on Energy Savings	1.000	0.979	1.000	1.043	0.998	1.000
In-service Rate	1.000	0.850	0.850	0.850	1.000	1.000
Interactive Effects Factor	0.970	0.970	0.960	0.960	0.974	1.000
Total Gross Energy Savings – at the Meter (GWh)	4.839	4.997	2.378	3.059	17.395	4.354
Line Loss Factor	1.066	1.066	1.066	1.066	1.066	1.066
Total Gross Energy Savings – at the Generator (GWh)	5.158	5.327	2.535	3.261	18.542	4.642
Effective Useful Life (years)	11.3	11.3	5.7	5.7	8.4	15.7
Gross Lifetime Energy Savings – at the Generator (GWh)	58.288	60.195	14.451	18.586	155.752	72.874
Peak Demand Savings						
Tracked Gross Non-peak Demand Savings (MW)	1.133	1.406	0.661	0.815	4.063	0.994
Adjustment Ratio on Demand Savings	0.999	0.978	1.000	1.043	1.008	1.000
In-service Rate	1.000	0.850	0.850	0.850	1.000	1.000
Peak Coincidence Factor	0.646	0.646	0.646	0.646	0.646	1.000
Interactive Effects Factor	0.933	0.933	0.911	0.911	0.942	1.000
Total Gross Peak Demand Savings – at the Meter (MW)	0.682	0.704	0.331	0.425	2.493	0.994
Line Loss Factor	1.066	1.066	1.066	1.066	1.066	1.066
Total Gross Peak Demand Savings – at the Generator (MW)	0.727	0.751	0.353	0.453	2.658	1.060

Revised Gross Energy and Peak Demand Savings for BER Instant Rebates (Continued)

Product Category	Directional & Architectural LED Fixtures	Occupancy Sensors	Pumps	Total for All Products
Tracking Sheet				
Number of Units	709	5,980	199	315,867
Energy Savings				
Tracked Gross Energy Savings (GWh)	0.123	2.116	0.331	42.517
Adjustment Ratio on Energy Savings	1.037	1.000	1.000	-
In-service Rate	1.000	1.000	1.000	-
Interactive Effects Factor	1.000	0.960	1.000	-
Total Gross Energy Savings – at the Meter (GWh)	0.128	2.031	0.331	39.512
Line Loss Factor	1.066	1.066	1.066	-
Total Gross Energy Savings – at the Generator (GWh)	0.137	2.165	0.352	42.119
Effective Useful Life (years)	11.3	10.0	15.0	-
Gross Lifetime Energy Savings – at the Generator (GWh)	1.543	21.650	5.286	408.624
Peak Demand Savings				
Tracked Gross Non-peak Demand Savings (MW)	0.029	0.520	0.069	9.689
Adjustment Ratio on Demand Savings	1.000	1.000	1.000	-
In-service Rate	1.000	1.000	1.000	-
Peak Coincidence Factor	1.000	0.646	1.000	-
Interactive Effects Factor	1.000	0.911	1.000	-
Total Gross Peak Demand Savings – at the Meter (MW)	0.029	0.306	0.069	6.034
Line Loss Factor	1.066	1.066	1.066	-
Total Gross Peak Demand Savings – at the Generator (MW)	0.031	0.326	0.073	6.432

5.2 Net-to-gross Ratio

The net-to-gross ratio (NTGR) serves to determine net savings, i.e. the savings that can be reliably attributed to a service. More precisely, the NTGR is established by considering effects, namely free-ridership and spillover, that positively or negatively affect the energy savings generated by a service. In the case of BER Instant Rebates, only one such effect is considered, namely free-ridership.

5.2.1 Free-ridership

For BER Instant Rebates, free-ridership corresponds to the proportion of savings that is due to natural market trends. Thus, the free-ridership assessment aims to estimate what the sales of energy-efficient products would have been in a market that evolves naturally, i.e. without service influence.

For the 2017 evaluation, the Evaluator used a new approach for measuring the free-ridership level. Due to the availability of a new participant contact list, the Evaluator conducted a survey with 60 end users of BER Instant Rebates to assess free-ridership. Along with the participant survey, free-ridership was measured through in-depth interviews with distributors as in previous evaluations, although a new question was added to assess the influence of the service on the distributors' inventory of DLC and ENERGY STAR certified products. This new approach allows assessing free-ridership from the perspectives of both participants and distributors. Using multiple methods, such as triangulation, results in the most defensible NTGR estimate.²⁷

The evaluation targets the following four specific products:

- › LED linear fixtures
- › LED downlight fixtures
- › LED linear lamps
- › LED general-use and decorative lamps

These product categories represent 75 percent of all the gross energy savings generated by BER Instant Rebates. They were selected because they are the best-selling categories in 2017 and/or because they are more likely to attract a significant level of free-ridership (especially in the case of LED general-use and decorative lamps).

²⁷ TecMarket Works, *The California Evaluation Framework*, June 2004.

During the interviews with distributors, the Evaluator used a set of questions to identify the influence that the service had on the market. The in-depth interviews with distributors included questions to estimate:

- › The percentage of their energy efficient products that would not have been sold in the absence of the service
- › The service influence (on a scale of 0 to 10) on participants' decisions to purchase the target energy-efficient lighting products
- › The service influence (on a scale of 0 to 10) on the distributors' decisions to carry DLC and ENERGY STAR certified products

As for the end-user survey, the Evaluator used a set of questions to identify the influence of the service on their decision to purchase LED products. The questions included in the questionnaire aimed to estimate:

- › The influence of the rebates on end users' decisions to purchase the target energy-efficient lighting products.
- › The cross-influence that previous exposure to ENS communication and programs had on participants' decisions.

The Evaluator calculated the level of free-ridership for each product category using the results of the in-depth interviews and end-user survey, as presented in Table 29. Appendix IX provides the algorithm used to convert the end-user survey results into free-ridership levels. The margins of error for the end-survey results are: 10.8 percent for LED linear fixtures; 12.8 percent of LED downlight fixtures; 10.2 percent for LED linear lamps; and finally, 10.0 percent for LED general-use and decorative lamps. No margin of error was calculated for distributor interviews since a census approach was used.

Table 29: Free-ridership for BER Instant Rebates

Product	Free-ridership Level (from distributor interviews)	Free-ridership Level (from end-user survey)	Overall 2017 Free-ridership Level
LED linear fixtures	40%	23%	32%
LED downlight fixtures	39%	33%	36%
LED linear lamps	47%	28%	38%
LED general-use and decorative lamps	54%	23%	38%

The free-ridership levels obtained for each product category vary between 32 and 38 percent, meaning that approximately two thirds of these LED products would not have been sold in the absence of the service. The free-ridership levels obtained from the end-user survey ranged from six to 21 percent points lower than the levels obtained from the distributor interviews. This is mostly explained by the cross-influence factor which takes into consideration in the free-ridership calculations the influence of previous exposure to ENS communication and programs.

The change in the approach for assessing free-ridership does not allow for direct comparison of free-ridership levels from past years. The free-ridership level of LED linear lamps was evaluated for the first time in 2017. The overall free-ridership level of 38 percent points to the rapid adoption of the product and its declining price.

The answers provided by distributors to the questionnaire indicated higher free-ridership levels than those given in 2016. Surveyed distributors explained that the price for these LED products continues to decrease and participants are more aware of the technology, thus reducing the impact of the rebate on the sales of these products. Regardless, various distributors recognized the important role played by the service in raising customer awareness and lowering the price closer to standard technologies. Furthermore, distributors attributed to the service a strong influence in their decision to carry DLC and ENERGY STAR certified products.

The answers from end users were similar to those provided by distributors in some areas. Surveyed end users claimed to have been sufficiently aware of the benefits of LED products that they would have purchased the same products in the absence of the service, indicating high levels of free-ridership. Contrarily, they recognized the large influence of the rebate on their decision and noted their past exposure to ENS communication and programs, which reduced the end-user free-ridership level.

In sum, the rapid decline of the cost of LED products as well as increased awareness about the technology indicate that free-ridership levels will likely increase in the future.

5.2.2 NTGR Calculation

The NTGR is calculated using the following equation:

$$NTGR = (1 - \% \text{ free-ridership})$$

Using the free-ridership levels established for BER Instant Rebates, the NTGR was established for each product category covered by this analysis, as presented in Table 30 below.

Table 30: NTGRs for BER Instant Rebates

Product	NTGR
LED linear fixtures	0.68
LED downlight fixtures	0.64
LED linear lamps	0.62
LED general-use and decorative lamps	0.62

For the other products sold through Instant Rebates, an NTGR of 1.00 was used. This resulted in an overall NTGR of 0.73 for energy savings and 0.78 for peak demand savings.

5.3 Net Savings

Net savings are defined as the changes in energy use that are specifically attributable to BER Instant Rebates. Net savings were estimated by applying the NTGR presented above to the revised gross savings, as exemplified in the following equation:

$$\text{Net Savings} = \text{Revised Gross Savings} \times \text{NTGR}$$

Net energy savings were first calculated separately for each product category because the NTGR differed from one product category to another. Table 31 below presents the details of these calculations.

Overall, the total net energy and peak demand savings amounted to 30.805 GWh and 4.823 MW respectively at the generator. Based on the average EUL of 9.9 years, the net lifetime energy savings were established at 305.535 GWh. Using the 2016 Nova Scotia-specific factor²⁸ of GHG generated by electricity production, 0.6531 kg CO₂ eq/kWh, it was estimated that the net energy savings resulted in 20,119 tonnes of avoided CO₂ eq.

²⁸ At the time of writing, 2017 data was not available. The Nova Scotia-specific factor was obtained from Nova Scotia Power's 2016 total system emissions data (7,079,268 CO₂ eq tonnes) and total electricity generation (10,839 GWh) from the following two sources:

Nova Scotia Power, *Total System Emissions*, <http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx>, (Last accessed December 17, 2017).

Emera Inc., *Management's Discussion & Analysis As at February 10, 2017*, http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693_, (Last accessed December 17, 2017).

Table 31: Evaluated Net Energy and Peak Demand Savings for BER Instant Rebates

Product Category	LED Linear Fixtures	LED Linear Lamps	LED General-use and Decorative Lamps	LED Reflector Lamps	LED Downlight Fixtures	LED Outdoor Fixtures
Energy Savings						
Revised Gross Energy Savings – at the Meter (GWh)	4.839	4.997	2.378	3.059	17.395	4.354
NTGR	0.68	0.62	0.62	1.00	0.64	1.00
Net Energy Savings – at the Meter (GWh)	3.291	3.098	1.475	3.059	11.133	4.354
Line Loss Factor	1.066	1.066	1.066	1.066	1.066	1.066
Net Energy Savings – at the Generator (GWh)	3.508	3.303	1.572	3.261	11.867	4.642
Effective Useful Life (years)	11.3	11.3	5.7	5.7	8.4	15.7
Net Lifetime Energy Savings – at the Generator (GWh)	39.636	37.321	8.960	18.586	99.681	72.874
Peak Demand Savings						
Revised Gross Peak Demand Savings – at the Meter (MW)	0.682	0.704	0.331	0.425	2.493	0.994
NTGR	0.68	0.62	0.62	1.00	0.64	1.00
Net Peak Demand Savings – at the Meter (MW)	0.464	0.437	0.205	0.425	1.596	0.994
Line Loss Factor	1.066	1.066	1.066	1.066	1.066	1.066
Net Peak Demand Savings – at the Generator (MW)	0.494	0.466	0.219	0.453	1.701	1.060

Evaluated Net Energy and Peak Demand Savings for BER Instant Rebates (Continued)

Product Category	LED Directional & Architectural Fixtures	Occupancy Sensors	Pumps	Total for All Products
Energy Savings				
Revised Gross Energy Savings – at the Meter (GWh)	0.128	2.031	0.331	39.512
NTGR	1.00	1.00	1.00	-
Net Energy Savings – at the Meter (GWh)	0.128	2.031	0.331	28.899
Line Loss Factor	1.066	1.066	1.066	-
Net Energy Savings – at the Generator (GWh)	0.137	2.165	0.352	30.805
Effective Useful Life (years)	11.3	10.0	15	-
Net Lifetime Energy Savings – at the Generator (GWh)	1.543	21.650	5.286	305.535
Peak Demand Savings				
Revised Gross Peak Demand Savings – at the Meter (MW)	0.029	0.306	0.069	6.034
NTGR	1.00	1.00	1.00	-
Net Peak Demand Savings – at the Meter (MW)	0.029	0.306	0.069	4.525
Line Loss Factor	1.066	1.066	1.066	-
Net Peak Demand Savings – at the Generator (MW)	0.031	0.326	0.073	4.823

Table 32 below compares the savings tracked by ENS with the 2017 evaluated savings for BER Instant Rebates.

Table 32: Comparison of Tracked and Evaluated Savings at the Generator – BER Instant Rebates

	Initial Gross Savings	Adjusted Gross Savings	NTGR	Net Savings
Energy Savings				
ENS Tracked Savings	45.321 GWh	45.321 GWh	0.76	34.444 GWh
Evaluation Results	45.321 GWh	42.119 GWh	0.73	30.805 GWh
Peak Demand Savings				
ENS Tracked Savings	10.328 MW	10.328 MW	0.78	8.056 MW
Evaluation Results	10.328 MW	6.432 MW	0.75	4.823 MW

Evaluated gross energy savings were 7 percent below tracked savings due to downward adjustments made to unitary savings in some of the BER Instant Rebates most popular product categories, namely LED linear lamps and LED downlight fixtures. Evaluated net energy savings were found to be 11 percent below the value tracked by ENS, which is explained by a decrease in the NTGR which was 0.76 in 2016. High levels of free-ridership were measured in 2017, and the proportion of gross savings covered by the products for which free-ridership was measured was 75 percent, which is higher than in 2016, when this proportion was 66 percent. Net evaluated peak demand savings were 40 percent below tracked savings. This is due mostly to the change in the PCF from 78 percent in 2016 to 65 percent in 2017.

6 OVERALL BER RESULTS

Table 33: Comparison of Overall Tracked and Evaluated Savings at the Generator for BER

	Initial Gross Savings	Adjusted Gross Savings	NTGR*	Net Savings
Energy Savings				
ENS Tracked Savings	64.637 GWh	64.637 GWh	0.78	50.670 GWh
Evaluation Results	64.637 GWh	60.465 GWh	0.77	46.583 GWh
Peak Demand Savings				
ENS Tracked Savings	13.833 MW	13.833 MW	0.80	11.000 MW
Evaluation Results	13.833 MW	9.295 MW	0.78	7.286 MW
*Different NTGRs were established for Mail-in and Instant Rebates. The average NTGR values presented in this table correspond to the ratios of net savings to gross savings for both services.				

Table 34 summarizes the participation level as well as gross and net savings for BER Mail-in and Instant Rebates.

Table 34: Overall Participation and Savings for BER

	Participation Level	Gross Savings	NTGR	Net Savings
Mail-in Rebates				
Energy Savings	288 projects	18.346 GWh	0.86	15.778 GWh
Lifetime Energy Savings		280.930 GWh	0.86	241.600 GWh
Peak Demand Savings		2.863 MW	0.86	2.462 MW
Instant Rebates				
Energy Savings	315,867 products sold	42.119 GWh	0.73	30.805 GWh
Lifetime Energy Savings		408.624 GWh	0.75	305.535 GWh
Peak Demand Savings		6.432 MW	0.75	4.823 MW
TOTAL				
Energy Savings		60.465 GWh	0.77	46.583 GWh
Lifetime Energy Savings		689.554 GWh	0.79	547.135 GWh
Peak Demand Savings		9.295 MW	0.78	7.286 MW

7 BER MARKET EVOLUTION

ENS has been active in the LED market of the business, non-profit, and institutional (BNI) sector through BER since 2010. The 2016 Evaluation of BER found an increase in rebated LEDs and that market barriers to LED adoption, such as the price of LEDs in the BNI sector, have been declining. As a result of these findings, the 2016 Evaluation recommended that ENS continue monitoring key market indicators to recognize whether BER offerings should be adapted or discontinued. The following section aims to determine if changes observed in 2016 persist over time and glean insights into the current state of market evolution for LEDs in the BNI sector of Nova Scotia.

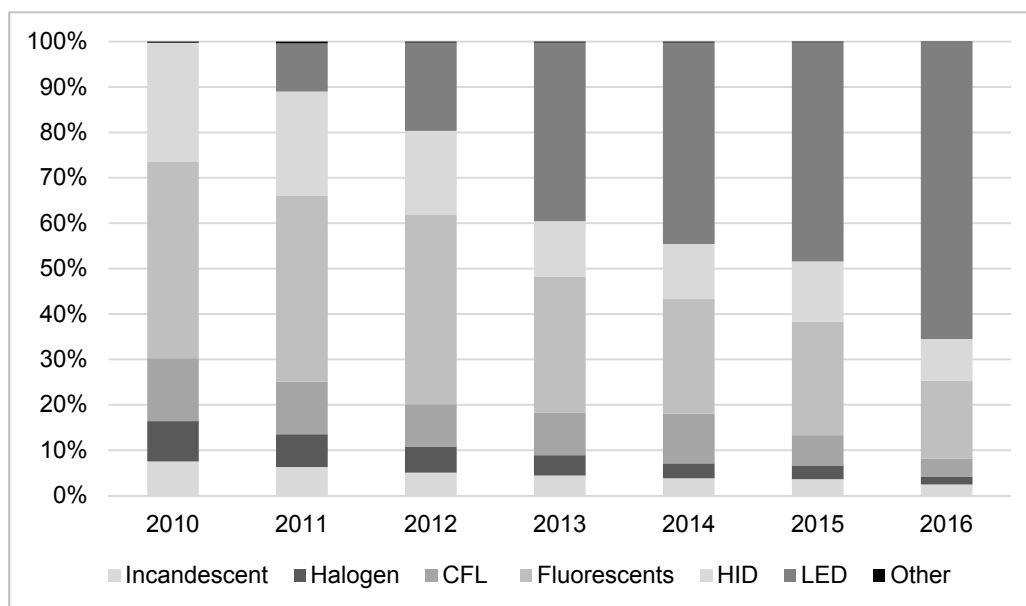
7.1 Market Indicators

The Evaluator analyzed a number of market indicators to understand the state of the LED market in the Nova Scotia BNI sector. Examined indicators included market share of lighting technologies, LED units incented by BER Instant Rebates, number of participating retailers in BER Instant Rebates, retail prices, as well as codes and standards. For this analysis, the Evaluator relied mostly on data from Instant Rebates since sales quantities and prices are documented with a level of detail that is not available for BER Mail-in lighting category measures.

7.1.1 Market Shares of Lighting Technologies

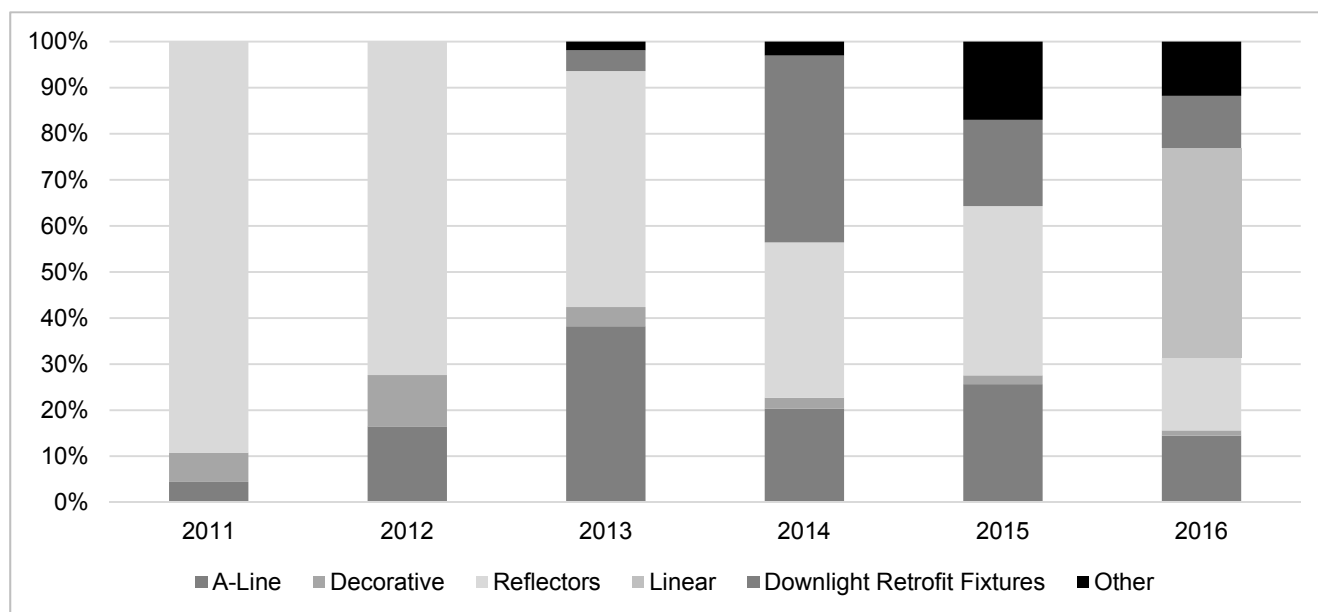
The BNI lighting market is comprised of six main technologies: incandescent, halogen, CFL, high-intensity discharge (HID), LED and fluorescents. Looking at lighting shipments in the Atlantic region between 2010 and 2016 reveals that the share of LEDs is rapidly growing in the commercial and industrial sectors.²⁹ As illustrated in Figure 11 below, LEDs have grown from having no sales in 2010 to having the highest share of sales in 2016 at 65 percent. Gains in LED market share have largely been at the expense of fluorescents which have gone from having the largest market share in 2010 at 43 percent to just 17 percent in 2016. HID lighting has also lost market share, from 26 percent in 2010 to 9 percent in 2016. Although not as significant in magnitude, CFLs, halogens, and incandescent lights have also lost market share between 2010 and 2016.

²⁹ Data was not available specifically for the BNI sector. Data was available for two groups: consumer; and commercial and industrial. The commercial and industrial sectors were selected as the most similar sectors to the BNI sector among available data.

Figure 11: Atlantic Commercial and Industrial Lighting Shipments by Technology (%)


Source: Electro-Federation Canada, Lamp Data - Consumer Channel and C&I Channel 2004–2016, March 2017.

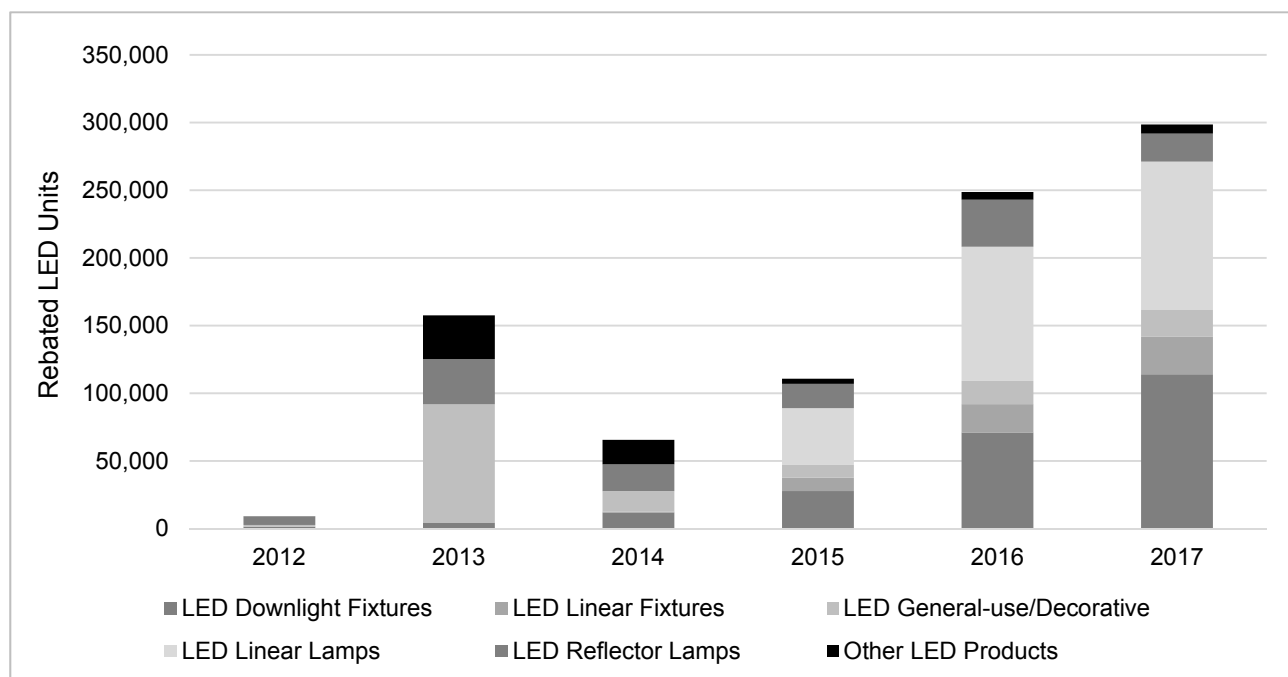
The breakdown of LED shipments in the Atlantic region by bulb type is presented in Figure 12 below. Data was unavailable for LED linear lamps until 2016. The large number of shipments of LED linear lamps in 2016, as demonstrated in Figure 12, is consistent with the trend illustrated in above, whereby the popularity of fluorescent lamps is declining while LED lamp shipments are increasing.

Figure 12: Atlantic Commercial and Industrial LED Lighting Shipments by Type (%)


Source: Electro-Federation Canada, *Lamp Data - Consumer Channel and C&I Channel 2004–2016, March 2017*.

7.1.2 BER Instant Rebates Rebated Units

The total number of LED lamps and fixtures incented by BER Instant Rebates since 2012 is presented in Figure 13 below, along with the proportion of each LED product type. The increase that occurred in 2013 is an outlier. As reported in the 2013 Evaluation Report, this increase is due to a rebate and pricing change with two distributors that led to abnormal sales. The number of LED units rebated by BER grew significantly from 2015 to 2017. Linear LED lamps were first rebated in 2014, and since then their uptake has been increasing steadily.

Figure 13: BER Instant Rebates Rebated LED Units from 2012 to 2017³⁰


7.1.3 BER Participating Distributors

BER Instant Rebates collaborates with distributors to provide rebates on lighting products to BNI participants. These distributors are typically located in commercial settings in Nova Scotia and must meet a minimum sales volume largely accounted for by commercial customers. The overall number of participating distributors reporting LED sales has slightly varied throughout the years. The minimum was 12 distributors in 2012, and the maximum was 16 in 2015. In 2017, 14 distributors reported LED sales. These distributors are present in 10 cities.

ENS estimates that the majority of distributors in the province are included in BER and carry rebated LED products because of the competitive price advantage. This indicates that LED products are currently widely available in Nova Scotia.

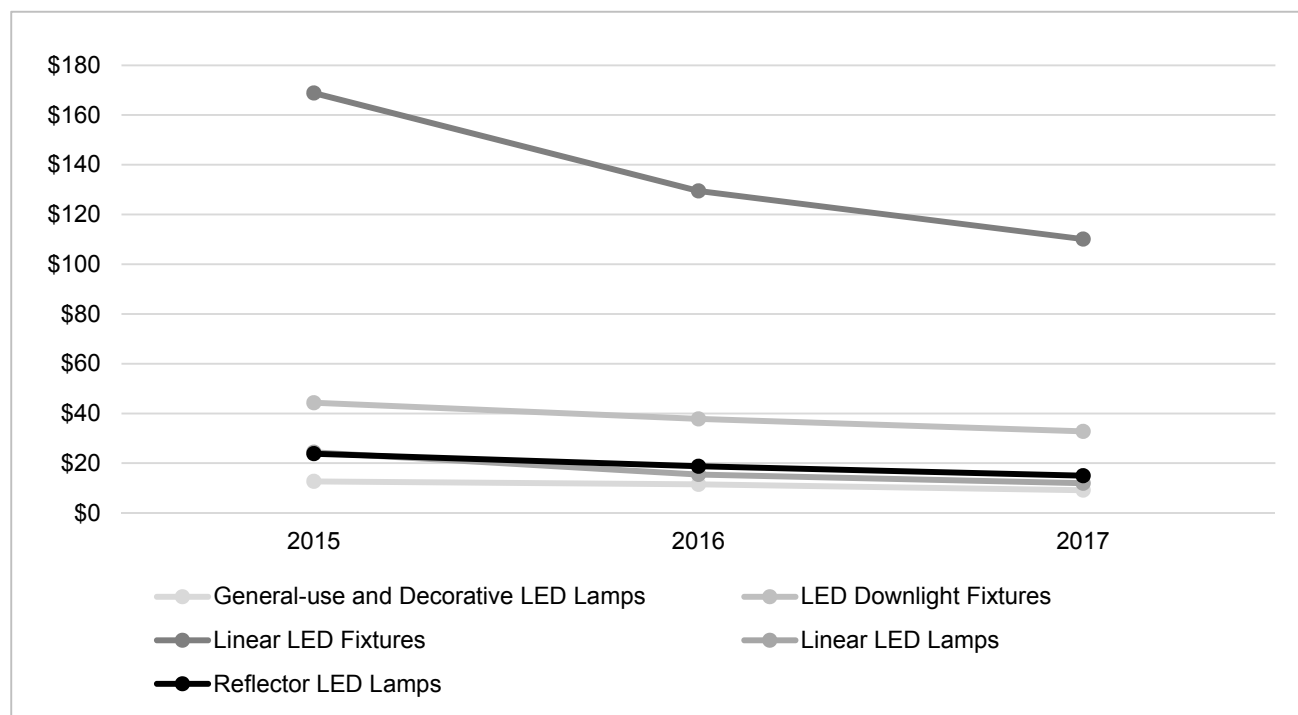
7.1.4 Retail LED Prices

As prices vary greatly among LED lighting types, the evolution of LED prices was examined for the most popular lighting categories offered in BER Instant Rebates. Figure 14 below illustrates the evolution of average unit costs for the following LED categories: downlight fixtures; linear fixtures; general-use and decorative lamps; as well as linear lamps. The data originate from BER Instant Rebates tracking reports and were unavailable before 2015.

³⁰ Data by type of LEDs should be used with caution before 2015 since product descriptions found in the 2012-2014 tracking sheets were not as detailed as they have been since 2015.

Overall, prices of all types of LED lighting have decreased over the past three years, although the most notable declines were for LED linear lamps (51%, from about \$25 to \$12), LED reflector lamps (37%, from about \$24 to \$15) and LED linear fixtures (35%, from about \$170 to \$110).

Figure 14: Average Retail Prices of Rebated LED Products from 2015 to 2017



In accordance with the decrease in retail prices for LED products, rebate amounts offered by ENS have also declined. As listed in Table 35, the average values of allocated rebates in BER Instant Rebates have decreased for all LED product categories, ranging from 21 percent (LED linear fixtures) to 47 percent (LED linear lamps).

Table 35: Average Value of Rebates in BER IR for LED Products from 2015 to 2017

Product Type	2015 (\$)	2016 (\$)	2017 (\$)
LED Linear Fixtures	37.04	34.67	29.24
LED Downlight Fixtures	13.98	13.28	9.80
LED Reflector Lamps	8.56	6.77	5.69
LED General-use and Decorative Lamps	4.76	4.55	3.04
LED Linear Lamps	8.49	5.76	4.48

7.1.5 Codes and Standards

The ultimate indicator of market transformation is the adoption of more stringent codes and standards. Currently, general-service lamps³¹ are required to meet an efficiency level that corresponds to halogen incandescent bulbs. (For instance, a standard 60 W incandescent bulb is no longer allowed and its equivalent is a 43 W halogen incandescent bulb.) This minimum energy performance standard has been enforced since early 2014 or early 2015, depending on lamp wattages. The latest amendment to the Canadian Energy Efficiency Regulations (Amendment 13 published on December 28, 2016)³² did not have any significant impact on the efficiency of lamps rebated through BER. Although the United States is expected to enforce a standard requiring that general service lamps meet the efficiency level of 45 lumens per watt (equivalent to a technology between halogen incandescent and CFLs) by 2020, Canada does not yet have proposed legislation to align with U.S. regulations. The next update to general service lamps is expected to undergo pre-consultation in the winter of 2019 as part of Amendment 16.³³ This Canadian update, which is likely to be enforced between 2021 and 2023, could have one of the two following impacts:

- › CFLs will become the base case technology for general-use lighting because they will be the least efficient technology that complies with the regulation.
- › LED lamps will become the base case technology if their price continues to decrease. LED lamps are already more popular than CFLs, and it is possible that the price difference becomes too low (or even that the price of LED lamps falls below that of CFLs) for CFLs to remain the mainstream option for general-use lighting.

In summary, the state of energy efficiency lighting regulation does not indicate that LED lamps and fixtures will become the least efficient alternative in the near future, but it is possible that this will happen within five to ten years.

³¹ The Energy Efficiency Regulation covering general-service lamps covers most A-type lamps (incandescents and LEDs). Natural Resources Canada, *General Service Lamps and Modified Spectrum Incandescent Lamps Energy Efficiency Regulations*, <http://www.nrcan.gc.ca/energy/regulations-codes-standards/products/6869>, (Last accessed February 28, 2018).

³² Natural Resources Canada, *Amendment 13, December 2016*. <http://www.nrcan.gc.ca/energy/regulations-codes-standards/18419>, (Last accessed February 28, 2018).

³³ Natural Resources Canada, *Forward Regulatory Plan 2017-19*, <http://www.nrcan.gc.ca/energy/regulations-codes-standards/18318>, (Last accessed February 28, 2018).

Other lamp and fixture types are also affected by Canadian energy efficiency regulations. Amendment 13 has introduced new requirements for the efficiency of fluorescent linear lamp ballasts. However, the minimum energy performance requirements of this new regulation are still below that of the base cases used to calculate savings for a vast majority of linear lamps and fixtures under BER. It is expected that Amendment 14 (currently in the pre-consultation phase of the regulatory process) will increase the range of fluorescent lamp ballasts affected by the current regulation. It will include new minimum energy performance requirements for MH ballasts in an effort to align Canadian and American regulations. While those new regulations are an indication that the market is evolving, they do not represent significant improvements to the overall efficiency of lighting products and do not affect the most popular lighting technologies on the market. Overall, the efficiency levels of LED products rebated through BER remain far superior to the efficiency levels required by current Canadian regulations.

7.2 Evaluation Results

The Evaluator looked at the unitary savings values and free-ridership levels to gain insights into the evolution of the LED BNI market in Nova Scotia.

7.2.1 Free-ridership Levels

For BER Instant Rebates, free-ridership corresponds to the proportion of savings that is due to natural market trends. The free-ridership levels were measured through in-depth interviews with distributors using the same approach from 2012 to 2016. However, in 2017, the free-ridership approach was changed to include results from distributor interviews as well as an end-user survey. This should be considered when comparing the 2017 results with those of past evaluations. Table 36 lists the free-ridership levels calculated since 2012 and indicates higher free-ridership levels over the years. In 2017, free-ridership for all LED products ranged between 32 and 38 percent. Distributors noted in the 2017 interviews that rebates offered to participants have enhanced the appeal of LED technology, although to a lesser extent than in the past. This observation is consistent with the increasing free-ridership levels over the years.

Table 36: Free-ridership Levels for LEDs in BER Instant Rebates

Product Type	2012	2013	2014	2015	2016	2017
LED Linear Fixtures	-	-	-	25%	37%	32%
LED Downlight Fixtures ³⁴	11%	24%	35%	34%	37%	36%
LED Reflector Lamps	-	-	-	33%	34%	-
LED General-use and Decorative Lamps	-	-	-	32%	35%	38%
LED Linear Lamps	-	-	-	-	-	38%
LED Outdoor Wallpacks	-	-	29%	-	-	-

³⁴ This product category has changed over the years. Before 2015, it included LED bulbs in addition to fixtures.

For BER Mail-in, free-ridership was measured specifically for lighting measures from 2015 to 2017 and is generally much lower than for BER Instant Rebates. The main reason is that a significant proportion of Instant Rebates sales go toward new fixtures rather than retrofits. The incremental cost for an LED fixture or lamp is much less if a new standard fixture needs to be purchased, thus making the payback period more attractive for new fixtures.

7.3 Market Evolution Summary

In their recommendations on market transformation program planning, Rosenberg and Hoefgen (2009) identify a number of factors, listed in Table 37 below, to be analyzed to identify whether program support should be withdrawn or reduced in light of changes observed in the market.³⁵

Table 37: Analysis of Key Factors in Program Planning

Factor	Results
Market share of LEDs for BNI sector	LED shipments targeted at the commercial and industrial sector in Atlantic Canada have steadily increased in recent years and attained 54% in 2016.
Trends in prices and availability	LED prices have declined for the BNI sector, especially for linear LED lamps, reflector LED lamps and linear LED fixtures. The majority of distributors in Nova Scotia offers LED products, indicating that this technology is widely available to BNI customers across the province.
Likelihood of inclusion in a near-term code or standard	The efficiency levels of LED products rebated through BER remain far superior to the efficiency levels required by current Canadian regulations. Canada will update the general service lamp minimum energy performance requirement in Amendment 16, which is planned for pre-consultation in 2019 and is likely to be enforced between 2021 and 2023. Amendment 14, which is currently under pre-consultation, will include new minimum energy performance requirements for MH ballasts.
Market readiness of more efficient substitute technology	No substitute more efficient than LEDs has come to the forefront.

Assessing the above factors demonstrates that barriers to LEDs continue to decline in the BNI sector, as observed by increases in LED lighting market share, availability, and price reductions. Increasing adoption of LEDs has also translated into higher free-ridership levels over the years, as revealed by this evaluation.

Figure 15 below provides an indication of the stage of LED lamp adoption in the Nova Scotia BNI sector. The technology diffusion curve illustrates how successive groups of customers adopt the new technology (as shown by the innovation adoption curve, in black)³⁶ and how the market share (as shown by the S-curve, in grey) eventually reaches saturation levels.

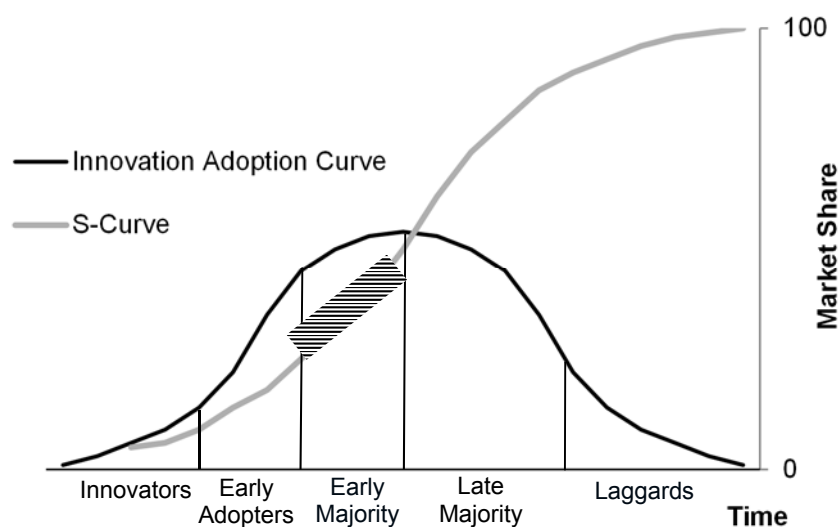
³⁵ Rosenberg and Hoefgen, *Market Effects and Market Transformation: Their Role in Energy Efficiency Program Design and Evaluation*, Prepared for California Institute of Energy and the Environment, 2009.

³⁶ Everett M. Rogers, *Diffusion of Innovations – Fifth Edition*, August 16, 2003.

Considering the factors described above, the Evaluator concludes that LEDs remain in a growth phase but are beginning to approach maturity as the BNI sector increasingly adopts LEDs, as indicated by the hatched area of the grey market share curve.

Growth is expected to continue since more efficient technology is not currently available and no Canadian energy efficiency regulations will impact LED lamps and fixtures in the near future.

Figure 15: Market Evolution for Commercial LED Lighting



CONCLUSION

The 2017 evaluation revealed that BER largely surpassed planned energy and peak demand savings which were 37.2 GWh and 5.9 MW respectively. The Evaluator determined that BER achieved 46.583 GWh in net energy savings and 7.286 MW in net peak demand savings at the generator, representing 30,423 tonnes of CO₂ eq in avoided GHG emissions annually. The total net lifetime energy savings amount to 547.135 GWh.

The Instant Rebates service was the greatest contributor to program component total net energy and peak demand savings in 2017, with net energy savings of 30.805 GWh and net peak demand savings of 4.823 MW. Instant Rebates increased its share of BER savings in 2017 because some products such as downlight fixtures, which generate large unitary savings, are more popular than ever. Similar to past years, distributors taking part in Instant Rebates expressed mixed views as to their satisfaction with the service. Those who expressed dissatisfaction primarily mentioned the administrative burden and cost of managing Instant Rebates and the perception that the rebates do not benefit the consumer, although they did recognize that they carry more energy efficient products due to the influence of the service.

The Mail-in service achieved 15.778 GWh in net energy savings and 2.462 MW in net peak demand savings at the generator. While a slight decrease in the participation level of Mail-in was observed in 2017, the gross savings per participant were at the third highest level since 2011. Participants expressed high satisfaction with Mail-in.

Since BER transitioned in 2015 toward LED products as the exclusive lighting technology eligible under the program component, the share of savings generated by these products has been increasing. Lighting measures constitute over 86 percent of BER net savings. They also represent almost all of the savings under Instant Rebates and are the largest measure category for Mail-in (61% of net savings). While the rebate still helps increase sales of LED products, its impact on LED sales is now less than in previous years. The Evaluator noted in the 2016 evaluation that market barriers had been reduced and confirmed that it is the case in the 2017 evaluation. The Evaluator noted the increase in the number of LEDs sold in recent years and their declining retail price. Furthermore, distributors believed that Instant Rebates had lesser influence in 2017 on consumer purchase behaviours due to increased general familiarity with LED technology and declining prices. As a result, the Evaluator recommends that ENS continue to monitor the evolution of the LED market by examining market indicators to identify when some product categories should be removed from the service due to a high level of market transformation. The Evaluator also suggests looking for opportunities to diversify the portfolio of projects completed through Mail-in to increase the proportion of non-lighting projects.

LIST OF APPENDICES

The following are presented in the Efficient Products Rebates Program – Appendices.

BER

Appendix I - BER: 2017 Recommendations

Appendix II - BER: Mail-in Participant Survey Questionnaire

Appendix III - BER: Mail-in Participant Survey Results

Appendix IV - BER: Mail-in On-site Visit Sampling Methodology and Protocol

Appendix V - BER: Instant Rebates Participant Survey Questionnaire

Appendix VI - BER: Instant Rebates Participant Survey Results

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Appendix VIII - BER: Mail-in Effective Useful Life

Appendix IX - BER: Algorithm for Free-ridership Calculation

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EFFICIENT PRODUCT REBATES

2017 DSM EVALUATION

EFFICIENCY NOVA SCOTIA

Appendix Report

March 15, 2018

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Appendix I

BER: 2017 RECOMMENDATIONS

This appendix summarizes all the recommendations made by the Evaluator as part of the 2017 evaluation. There were no incomplete 2016 recommendations at the time of evaluation.

Sections	Recommendations
Executive Summary	1. Continue to monitor the market evolution of LED lamps and adapt the BER offer when needed. The 2017 evaluation served to confirm solid market evolution. The high number of LEDs sold during the 2017 year, their declining retail prices, as well as the increased market share and free-ridership levels for these products indicate that market barriers are decreasing. Moreover, the market analysis confirmed that while LED products are still in a growth phase, they are approaching maturity as the BNI sector increasingly adopts these technologies. The Evaluator therefore recommends that ENS continue to monitor the evolution of the LED market by examining market indicators such as those discussed in Section Erreur ! Source du renvoi introuvable. to identify when some product categories should be removed from the service due to a high level of market transformation.
	2. Identify opportunities to diversify the portfolio of projects completed through BER Mail-In. As demonstrated in the 2017 evaluation, lighting projects account for over 60 percent of gross savings in BER Mail-in. Since Instant Rebates is designed to offer almost exclusively lighting products, Mail-in is the best option to diversify the BER portfolio which generates the most savings of all ENS program components. With LED lighting products becoming increasingly popular and transforming the lighting market, ENS is at risk of seeing its savings decline for this service. The Evaluator expects to see continued increases in both free-ridership and baselines as the technology is more widely adopted. Therefore, the Evaluator recommends that ENS identify BNI sectors that are currently underrepresented in the Mail-in service and that could potentially generate significant savings.
	3. Continue and improve the tracking of BER Instant Rebates participants. The 2017 evaluation was the first time that the Evaluator had access to a list of Instant Rebates participants and could therefore conduct a survey of participants. However, the participant list did not include all participants and information was not collected systematically. The Evaluator recommends that ENS continue tracking individuals and businesses participating in the service. ENS should document the data-collection process and, if possible, record the proportion of tracked participants among all participants as well as the savings attributable to each participant. This would allow the Evaluator to refine the quality of the impact analysis, notably with better estimations of annual hours of use (HOU) as well as free-ridership and spillover levels.

Sections	Recommendations
Impact Evaluation – 4.1.3 Commercial Refrigeration Measures	4. For one other project, refrigerated strip curtains were installed on a commercial walk-in cooler. ENS referenced the Pennsylvania Public Utility Commission TRM ¹ for a calculation methodology for this measure since it does not appear in the CIRx Screening Tool. The Evaluator accepted the calculation due to the reputable source and recommends adding this methodology to the CIRx Screening Tool for future use.
Impact Evaluation – 4.1.4 Motor and VFD Measures	5. The motor and drive category required large revisions to energy savings which were similar in magnitude, although not consistent as some were positive and others negative. The Evaluator again recommends further reviewing applications for return and exhaust measures and identifying if projects achieve savings from VFDs through controls or schedule changes.
Impact Evaluation – 4.1.7 Commercial Kitchen Measures	6. Six commercial kitchen projects were reviewed for a total of 16 measures which all required adjustments. The hours of operation identified on-site caused the most adjustments, either affecting equipment annual HOU's or the PCF. The Evaluator recommends that, in the future, ENS provide copies of the Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment to the Evaluator, which are used for many commercial kitchen measures to ensure that all of the input model variables can be confirmed.

¹ Pennsylvania Public Utility Commission, *State of Pennsylvania Technical Reference Manual – June 2016*, Effective January 1, 2017.

Appendix II

BER: MAIL-IN PARTICIPANT SURVEY QUESTIONNAIRE

Could I speak with **[INSERT NAME]**?

- 1 Yes [GO TO INTRODUCTION]
- 2 No [SAY “Perhaps you can help me anyway.” GO TO INTRODUCTION]

Introduction

Hello, my name is _____ and I am calling from Corporate Research Associates, a Halifax-based survey research company. We are performing an evaluation of energy efficiency services provided by Efficiency Nova Scotia. Our records indicate that your organization recently participated in Efficiency Nova Scotia’s Business Energy Rebates Program. We would appreciate your help in answering questions related to your participation in this program. The information you provide will be used to help Efficiency Nova Scotia evaluate and improve the program. Is this a good time for you?

(**IF NEEDED:** You may have recently been contacted by Corporate Research Associates or by an Efficiency Nova Scotia representative about your experience with the program. This survey is different as it focuses on other aspects of your participation in the program.)

(**IF NEEDED:** The survey will take about fifteen minutes.)

Verification and Recall (V Series)

- V1. Our records indicate that your organization would have received a mail-in rebate for energy efficiency measures that were implemented at your facility located at [FACILITY ADDRESS] in [FACILITY CITY], as part of Efficiency Nova Scotia’s Business Energy Rebates Program. Is this correct?
- 1 Yes [CONTINUE]
 - 2 No [Is there someone else in your organization who would know about having participated in the Business Energy Rebates Program]?
 - Yes [ASK TO SPEAK TO THEM AND REPEAT INTRODUCTION]
 - No [THANK, TERMINATE, RECORD, AND KEEP DATA]
- V2. Are you the person in your organization who is most knowledgeable about your recent experience with the Business Energy Rebates Program?
- 1 Yes (IF YES GO TO V4)
 - 2 No

- V3. We would like to talk to the person who is the most knowledgeable about your experience with the Business Energy Rebates Program. Could you give me the name and telephone number of this person? [Probe if respondent is unsure who best to forward the call to. This individual may be an engineer, equipment contractor, or utility account manager].

Name: _____

Telephone #: _____

(Note: Thank, terminate, record and keep data. Schedule interview with best contact regarding experience with the program.)

- V4. According to our information, through its participation in the Business Energy Rebates Program, your organization submitted [INSERT NUMBER OF APPLICATIONS] application(s) in 2017. For [THIS / ONE] application you implemented [MEASURE CATEGORY] measures at your facility located at [FACILITY ADDRESS] in [FACILITY CITY], and received a rebate of [REBATE]. When answering the survey questions, please take into account this specific application for [MEASURE CATEGORY] measures.

Program Participation (P Series)

- P1. What was the SINGLE most important reason your organization chose to implement energy-efficient [MEASURE CATEGORY] measures? (DO NOT READ – accept one response)
- 1 (Take advantage of program rebates)
 - 2 (Save on energy costs / bills)
 - 3 (Reduce maintenance costs)
 - 4 (Update equipment)
 - 5 (Quality of efficiency products)
 - 6 (Protect the environment)
 - 96 (Other: Please Specify: _____)
 - 98 (Don't know) **(Go to FR Series)**
 - 99 (Refused) **(Go to FR Series)**
- P1a. [DO NOT ASK IF 98 OR 99 IN P1] What was the SECOND most important reason your organization chose to implement energy-efficient [MEASURE CATEGORY] measures? (DO NOT READ – accept one response – SAME LIST AS P1)
- 96 No other reason

Free-Ridership (FR Series)

FR1. Had your organization **already** decided to implement energy-efficient **[MEASURE CATEGORY]** measures **before** you heard about the Business Energy Rebates Program?

- 1 Yes
- 2 No
- 8 (Don't know)
- 9 (Refused)

FR1a. **IF FR1= YES, THEN ASK:** I just want to make sure I understand - Before you decided to participate in the Business Energy Rebate Program, you had already made the decision to implement energy efficient **[MEASURE CATEGORY]** measures?

- 1 Yes
- 2 No
- 8 (Don't know)
- 9 (Refused)

FR2. Efficiency Nova Scotia paid your organization \$[REBATE VALUE FROM SAMPLE BY CATEGORY] for the energy-efficient [MEASURE CATEGORY] measures. If your organization had not received the rebate from Efficiency Nova Scotia, would you have paid the full cost of the energy-efficient [MEASURE CATEGORY] measures? Please answer on a scale of 0 to 10, with a 0 indicating that you "Definitely **Would Not** Have Paid," and a 10 indicating that you "Definitely **Would Have** Paid." PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE

___ Response ___98 Don't Know ___99 Refused

FR3a_2. [ASK IF MEASURE CATEGORY=LIGHTING] Were you aware that the lighting products rebated through the Business Energy Rebates Program are premium products certified by Design Light Consortium or ENERGY STAR®?

- 1 Yes
- 2 No
- 8 (Don't know)
- 9 (Refused)

[READ FIRST TIME THROUGH ONLY] Now I would like to ask you to consider which actions your organization would have taken if the Business Energy Rebates Program had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is "Very Unlikely," and a 10 indicating that it is "Very Likely."

[DO NOT ACCEPT A RANGE – ASK FR3 SEQUENCE IN ORDER/DO NOT RANDOMIZE]

FR3a_1. [ASK IF MEASURE CATEGORY <> LIGHTING] If the program rebate had not been offered, what is the likelihood that you would have implemented exactly the same energy-efficient [MEASURE CATEGORY] measures that you purchased through the Business Energy Rebates Program?

___ Response ___98 Don't Know ___99 Refused

FR3a_3. [ASK IF MEASURE CATEGORY=LIGHTING] If the program rebate had not been offered, what is the likelihood that you would have purchased the exact same model of lighting products?

___ Response ___98 Don't Know ___99 Refused

FR3b. [ASK IF MEASURE CATEGORY = LIGHTING AND TOTAL MEASURE CATEGORY QTY>1] If the program rebate had not been offered, what is the likelihood that you would have implemented exactly the same quantity of lighting products that you installed through the program?

___ Response ___98 Don't Know ___99 Refused

FR3c. [IF FR2≥5] If the program rebate had not been offered, what is the likelihood that you would have postponed implementing the [MEASURE CATEGORY] measures by at least one year?

___ Response ___98 Don't Know ___99 Refused

FR4. Using a scale from 0 to 10, where 0 means “No influence” and 10 means “Great influence,” please rate the influence of each of the following in your organization’s decision to implement energy-efficient [MEASURE CATEGORY] measures.

Factor (READ AND RANDOMIZE)	Responses
a. The program rebate	___ Response ___98 Don't Know ___99 Refused
b. Information received from a program representative	___ Response ___98 Don't Know ___99 Refused
[ASK IF OEM=YES] c. The assistance provided by your on-site energy manager in identifying and implementing the measure	___ Response ___98 Don't Know ___99 Refused

FR5a. When it comes to deciding on whether or not to implement energy efficiency measures, does your company use a payback period threshold as a decisional criterion? CODE ONLY ONE

- 1 Yes,
- 2 No
- 8 (Don't know)
- 9 (Refused)

FR5aa. [ASK IF FR5a=1] What is the maximum payback period acceptable in order to move forward with energy efficient upgrades? AVOID A RANGE.

RECORD RESPONSE [MONTHS/YEARS]

- 98 (Don't know)

FR5b. [ASK IF FR5a=1] Without the rebate, was the payback period short enough for the measure to be implemented? CODE ONLY ONE

- 1 Yes
- 2 No
- 98 (Don't know)
- 99 (Refused)

[Ask IF FR5b=1]

FR5c. Just to be sure I understand correctly, you are saying that the measure was already attractive enough in terms of financial payback to be implemented without the rebate? CODE ONLY ONE

- 1 Yes
- 2 No
- 98 (Don't know)
- 99 (Refused)

FR6. Which of the following, if any, does your company have in place for the facility where the measures were implemented as part of the BER Program? READ AND ROTATE - CODE ONLY ONE PER STATEMENT

A person responsible for monitoring or managing energy usage

Defined energy saving goals

A specific policy requiring that energy efficiency be considered when purchasing energy related equipment

1 Yes

2 No

8 (Don't know)

9 (Refused)

[If FR5a=1 and/or FR6b or c=1]

FR7. Has your company ever implemented energy efficiency projects that had a payback period longer than your standard payback time period ? CODE ONLY ONE

1 Yes

2 No

8 (Don't know)

9 (Refused)

Cross-Influence [CI Series]

READ AND ROTATE (CI1 + CI2a-c) AND (CI3 + CI4a-c) SEQUENCES

CI1. Before participating in the Business Energy Rebates program in [DATE], had your organization at any time in the past already participated in any other Efficiency Nova Scotia programs?

1 Yes

2 No

98 (Don't know)

99 (Refused)

For the following statements, please indicate whether you agree or disagree.

- CI2a. [IF CI1=1] Your company's previous participation in an Efficiency Nova Scotia program was a major factor in the decision to implement an energy-efficient [MEASURE CATEGORY] measure.
- 1 Agree
 - 2 Disagree
 - 98 (Don't know)
 - 99 (Refused)
- CI2b. [IF CI1=1] Because of your company's previous participation in an Efficiency Nova Scotia program and what was learned by participating in that program, a company representative asked a contractor or a technical staff member to examine the energy efficiency options for the facility.
- 1 Agree
 - 2 Disagree
 - 98 (Don't know)
 - 99 (Refused)
- CI2c. [IF CI1=1] Because of your company's previous participation in an Efficiency Nova Scotia program and what was learned by participating in that program, a company representative took into account the cost-effectiveness of energy efficient [MEASURE CATEGORY] measures when evaluating different options for the facility.
- 1 Agree
 - 2 Disagree
 - 98 (Don't know)
 - 99 (Refused)
- CI3. Before participating in the Business Energy Rebates program in [DATE], had you at any time in the past already seen Efficiency Nova Scotia promotional materials advertising the benefits of energy efficiency?
- 1 Yes
 - 2 No
 - 98 (Don't know)
 - 99 (Refused)

For the following statements, please indicate whether you agree or disagree.

CI4a. [IF CI3=1] The energy efficiency promotional materials distributed by Efficiency Nova Scotia were a major factor in your company's decision to implement energy-efficient [MEASURE CATEGORY] measures.

- 1 Agree
- 2 Disagree
- 98 (Don't know)
- 99 (Refused)

CI4b. [IF CI3=1] The energy-efficiency promotional materials distributed by Efficiency Nova Scotia prompted a company representative to ask a contractor or a technical staff member to examine the energy efficiency options for the facility.

- 1 Agree
- 2 Disagree
- 98 (Don't know)
- 99 (Refused)

CI4c. [IF CI3=1] The energy-efficiency promotional materials distributed by Efficiency Nova Scotia prompted a company representative to take into account the cost-effectiveness of energy efficient [MEASURE CATEGORY] measures when evaluating different options for the facility.

- 1 Agree
- 2 Disagree
- 98 (Don't know)
- 99 (Refused)

Satisfaction [S series]

- S1. Using a scale from 1 to 10 where 1 is “not at all satisfied” and 10 is “completely satisfied” how would you rate your satisfaction with the Business Energy Rebates program overall? [RECORD NUMBER, 98=Don't know, 99 Refused] DO NOT ACCEPT A RANGE
- S2. [IF S1<8] What was the most important reason you were not more satisfied with the program overall? [DO NOT READ. PROBE FOR SPECIFIC REASON. ACCEPT MULTIPLE RESPONSES] Probe: Any other reasons?
- 1 (Timely process/Took too long)
 - 2 (Too expensive)
 - 3 (I don't like the products/measures rebated)
 - 4 (Rebate/incentive is too small)
 - 5 (Too difficult to sign up/too much work)
 - 96 (Other: _____)
 - 98 (Don't know)
 - 99 (Refused)
- S3. On a scale of 1 to 10, where 1=‘not at all satisfied’ and 10=‘completely satisfied,’ how was your organization’s experience with each of the following aspects of the Business Energy Rebates Program? If your organization did not have experience with one of these aspects please tell me. [DO NOT RANDOMIZE] [97 = Not Applicable, 98 = Don't know/Don't recall, 99 = Refused]
- 1 The program application, forms and associated paperwork
 - 2 Interaction and communication with contractors or distributors
 - 3 Rebate amounts
 - 4 Time required to receive rebate
- S4. Why were you not more satisfied with the READ STATEMENTS IN ORDER AS APPLICABLE? [DO NOT READ. PROBE FOR SPECIFIC REASON. ACCEPT MULTIPLE RESPONSES]
- [ASK S4a IF S3a <8] The program application, forms and associated paperwork
- 1 (Difficult/too long to fill out)
 - 2 (Took too long/Time delay in processing)
 - 3 (Communication problems)
 - 96 (Other: _____)
 - 98 (Don't know)
 - 99 (Refused)

[ASK S4b IF S3b <8] Interaction and communication with contractors or distributors

- 1 (Lack of communication/availability with contractor/distributor)
- 2 (Less knowledgeable about the program)
- 3 (Took too long/Communication was slow)
- 96 (Other: _____)
- 98 (Don't know)
- 99 (Refused)

[ASK S4c IF S3c <8] Rebate amounts

- 1 (Rebate is too small/Expected higher rebate)
- 2 (Cost of measures was expensive)
- 96 (Other: _____)
- 98 (Don't know)
- 99 (Refused)

[ASK S4d IF S3d <8] Time required to receive rebate

- 1 (Took too long to process/get rebate)
- 2 (Lack of communication/follow-up)
- 96 (Other: _____)
- 98 (Don't know)
- 99 (Refused)

Barriers and Recommendations [B Series]

B1. Did you encounter any problems with the [MEASURE CATEGORY] energy efficiency measures you implemented as part of the Business Energy Rebates program?

- 1 Yes
- 2 No (SKIP TO B5)
- 98 (Don't know) (SKIP TO B5)
- 99 (Refused) (SKIP TO B5)

- B2. [ASK IF B1 = Yes] What were those problems? PROBE: Anything else? [DO NOT READ. ACCEPT ALL RESPONSES]
- 1 (Equipment malfunction)
 - 2 (Choosing the right equipment/unit)
 - 3 (Problems with installation)
 - 96 (Other _____)
 - 98 (Don't know)
 - 99 (Refused)
- B3. [ASK IF B1 = Yes] Were these problems resolved to your satisfaction?
- 1 Yes
 - 2 No
 - 98 (Don't know)
 - 99 (Refused)
- B4. [ASK IF B3=NO] What could have been done to resolve these problems? [RECORD ANSWER. 98 = Don't know, 99 = Refused]
- B5. Do you have any suggestions to improve the Business Energy Rebates Program? Consider all aspects of the program: process, measures covered, marketing, interactions with program staff, and program forms. PROBE: Anything else? [DO NOT READ. ACCEPT MULTIPLE]
- 1 (Provide more information/information sessions)
 - 2 (Better marketing/awareness)
 - 3 (Increase/better rebates)
 - 4 (Speed up process/receive rebate quicker)
 - 5 (Offer more measures rebated)
 - 6 (Make forms more user-friendly)
 - 7 (ENS staff should be more knowledgeable)
 - 8 (No recommendation)
 - 96 (Other – SPECIFY: _____)
 - 98 (Don't know)
 - 99 (Refused)
- B6. [ASK IF B5=1] What kind of information would improve the Business Energy Rebate Program? [RECORD ANSWER. 98 = Don't know, 99 = Refused]

Firmographics [F Series]

These final questions are asked for statistical purposes only. The information collected is strictly confidential.

F1. What is the main activity of your organization? [DO NOT READ—BUT CONFIRM WITH RESPONDENT THAT THE CATEGORY YOU CHOOSE IS CORRECT]

- 1 (Education)
- 2 (Food Sales (grocery))
- 3 (Food Service (restaurant))
- 4 (Health Care – Inpatient)
- 5 (Health Care – Outpatient)
- 6 (Lodging)
- 7 (Mercantile– Retail (Enclosed and Strip Malls))
- 8 (Mercantile – Retail (Other than Mall))
- 9 (Office)
- 10 (Public Assembly)
- 11 (Public Order and Safety)
- 12 (Religious Worship)
- 13 (Service)
- 14 (Warehouse / storage)
- 15 (Manufacturing)
- 16 (Building is vacant)
- 17 (Agriculture)
- 18 (Other (SPECIFY: _____))
- 98 (Don't know)
- 99 (Refused)

- F3. Approximately how many full-time equivalent workers DOES YOUR ORGANIZATION employ at all locations within Nova Scotia? DO NOT READ, CODE APPROPRIATE CATEGORY
- 1 (Fewer than 5)
 - 2 (5 to 9)
 - 3 (10 to 19)
 - 4 (20 to 49)
 - 5 (50 to 99)
 - 6 (100 to 249)
 - 7 (250 or more)
 - 98 (Don't know)
 - 99 (Refused)
- F5. Is your organization independent, or part of a larger organization?
- 1 Independent
 - 2 Part of a larger company/organization
 - 3 Other (_____)
 - 98 (Don't know)
 - 99 (Refused)
- F6. How many business locations does your organization have in Nova Scotia? [RECORD A NUMBER 1-99; 998 = Don't know, 999 = Refused]

END. Those are all the questions I have for you. I thank you very much for your time and cooperation and have a nice day!

Appendix III

BER: MAIL-IN PARTICIPANT SURVEY RESULTS

P1. What was the SINGLE most important reason your organization chose to implement energy-efficient [MEASURE CATEGORY] measures?

P1a. What was the SECOND most important reason your organization chose to implement energy-efficient [MEASURE CATEGORY] measures?

Motivations	2015		2016*		2017	
	Most Important Motivation	Most Important Motivation	Most Important Motivation	Second Important Motivation	Most Important Motivation	Second Important Motivation
Sample Size	74	74	70	70	70	70
Save on energy costs/bills	61%	19%	70%	9%	53%	26%
Update equipment	8%	14%	9%	16%	19%	9%
Quality of efficiency products	4%	8%	6%	27%	9%	19%
To improve energy efficiency	-	-	-	-	7%	-
Protect the environment	3%	14%	1%	14%	4%	7%
Take advantage of program rebates	15%	18%	6%	10%	3%	11%
Reduce maintenance costs	-	16%	6%	14%	3%	3%
Recommended by contractor	1%	-	-	-	-	1%
Improve comfort	-	-	-	-	-	7%
Others	8%	5%	3%	3%	3%	9%
None/No other reason	-	4%	-	7%	-	9%
Don't know	-	3%	-	-	-	-
*Wording change in 2016 (OLD WORDING: What was the single most important reason your company or organization chose to participate in the Business Energy Rebates program?)						

FR1. Had your organization already decided to implement energy-efficient [MEASURE CATEGORY] measures before you heard about the Business Energy Rebates Program?

FR1a. I just want to make sure I understand - Before you decided to participate in the Business Energy Rebate Program, you had already made the decision to implement energy efficient [MEASURE CATEGORY] measures?

Already Made Decision to Implement Energy Efficient Measures Prior to Program Component	2015	2016	2017
Sample Size	74	70	70
Yes	36%	50%	46%
No	58%	47%	50%
Don't know	5%	3%	4%

FR2. Efficiency Nova Scotia paid your organization \$[REBATE VALUE FROM SAMPLE BY CATEGORY] for the energy-efficient [MEASURE CATEGORY] measures. If your organization had not received the rebate from Efficiency Nova Scotia, would you have paid the full cost of the energy-efficient [MEASURE CATEGORY] measures?

Would Have Paid Cost of Project	2015		2016		2017	
	Sample Size	Mean*	Sample Size	Mean*	Sample Size	Mean*
Mean (0 = "Definitely Would Not Have Paid" 10 = "Definitely Would Have Paid")						
Paid cost of project	72	5.6	69	6.7	70	6.0
*Don't know/Refused excluded from calculations						

FR3a_2. Were you aware that the lighting products rebated through the Business Energy Rebates Program are premium products certified by Design Light Consortium or ENERGY STAR?

Aware that Lighting Products are Premium Certified Design Light Consortium or ENERGY STAR	2017
Sample Size*	43
Yes	49%
No	47%
Don't know	5%
*Base: Respondents who had lighting products installed	

FR3. Now I would like to ask you to consider which actions your organization would have taken if the Business Energy Rebates Program had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely,” and a 10 indicating that it is “Very Likely.”

Actions Taken in Absence of Program Component	2017***	
	Sample Size	Mean*
Mean (0 = “Very Unlikely” 10 = “Very Likely”)		
Implemented the exact same quantity of lighting products that you installed through the program component	41	6.7
Purchased the exact same model of lighting products	43	6.0
Implemented exactly the same energy-efficient [MEASURE CATEGORY] measures that you purchased through the Business Energy Rebates Program?	27	5.4
**Postponed implementing the [MEASURE CATEGORY] measures by at least one year?	51	3.6
*Don't know/Refused excluded from calculations		
**Base: Respondents who would have likely paid full cost of the energy-efficient measure [IF FR2≥5]		
***Results from 2016 are not presented due to wording changes in 2017		

FR4. Using a scale from 0 to 10, where 0 means “No influence” and 10 means “Great influence”, please rate the influence of each of the following in your organization’s decision to implement energy-efficient [MEASURE CATEGORY] measures.

Influence of Factors in Decision to Implement Energy-Efficient Measures	2016		2017	
	Sample Size	Mean*	Sample Size	Mean*
Mean (0 = “No influence” 10 = “Great influence”)				
The program rebate	69	7.3	69	7.6
The assistance provided by your on-site energy manager in identifying and implementing the measure	-	-	2	7.0
Information received by a program representative	67	5.8	64	5.7
*Don't know/Refused excluded from calculations				

FR5a. When it comes to deciding on whether or not to implement energy efficiency measures, does your company use a payback period threshold as a decisional criterion?

Payback Period Threshold	2016	2017
Sample Size	70	70
Yes	53%	53%
No	46%	39%
Don't know	1%	9%

FR5aa. What is the maximum payback period acceptable in order to move forward with energy efficient upgrades?

Maximum Payback Period	2016	2017
Sample Size*	37	37
.25 years	3%	5%
1 year	-	3%
1.5 years	3%	-
2 years	19%	11%
3 years	30%	30%
4 years	14%	5%
5 years	16%	24%
6 years	3%	-
7 years	8%	5%
10+ years	-	9%
Don't know	5%	8%
Mean**	3.6 years	4.5 years
*Base: Company uses a payback period threshold as a decisional criterion **Don't know removed from calculation		

FR5b. Without the rebate, was the payback period short enough for the measure to be implemented?

FR5c. Just to be sure I understand correctly, you are saying that the measure was already attractive enough in terms of financial payback to be implemented without the rebate?

Payback Period was Short Enough	2016	2017
Sample Size	37	37
Yes	38%	35%
No	46%	46%
Don't know	16%	19%

FR6. Which of the following, if any, does your company have in place for the facility where the measures were implemented as part of the BER Program?

Processes in Place in Facilities Where Measures Were Implemented	2016		2017	
Sample Size	70		70	
	Yes	No/Don't know	Yes	No/Don't know
A specific policy requiring that energy efficiency be considered when purchasing energy related equipment	47%	53%	60%	40%
A person responsible for monitoring or managing energy usage	56%	44%	50%	50%
Defined energy saving goals	33%	67%	47%	52%

FR7. Has your company ever implemented energy efficiency projects that had a payback period longer than your standard payback time period?

Implemented an Energy Efficiency Project with a Longer Payback Period	2016	2017
Sample Size*	56	58
Yes	32%	24%
No	61%	66%
Don't know	7%	10%
*Base: Company uses a payback period threshold as a decisional criterion AND/OR company has defined energy saving goals OR company has a specific policy requiring energy efficiency be considered when purchasing energy related equipment		

CI1. Before participating in the Business Energy Rebates program in [DATE], had your organization at any time in the past already participated in any other Efficiency Nova Scotia programs?

Previous Participation in Another ENS Program Component	2016	2017
Sample Size*	70	70
Yes	51%	47%
No	40%	51%
Don't know	9%	1%

CI2a. The company's previous participation in an Efficiency Nova Scotia program was a major factor in the decision to implement an energy-efficient [MEASURE CATEGORY] measure.

Previous Participation in Another ENS Program Component	2016	2017
Sample Size*	36	33
Agree	75%	76%
Disagree	25%	21%
Don't know	-	3%
*Base: Respondents who previously participated in another ENS program component		

CI2b. Because of the company's previous participation in an Efficiency Nova Scotia program and what was learned by participating in the program, a company representative asked a contractor or a technical staff member to examine the energy efficiency options for the facility.

Impact of Previous ENS Program Component Participation	2016	2017
Sample Size*	36	33
Agree	78%	73%
Disagree	22%	24%
Don't know	-	3%
*Base: Respondents who previously participated in another ENS program component		

- C12c. Because of your company's previous participation in an Efficiency Nova Scotia program and what was learned by participating in the program, a company representative took into account the cost-effectiveness of energy efficient [MEASURE CATEGORY] measures when evaluating different options for the facility.

Impact of Previous ENS Program Component Participation	2016	2017
Sample Size*	36	33
Agree	89%	91%
Disagree	11%	9%
*Base: Respondents who previously participated in another ENS program component		

- C13. Before participating in the Business Energy Rebates program in [DATE], had you at any time in the past already seen Efficiency Nova Scotia promotional materials advertising the benefits of energy efficiency?

Previously Seen Energy Efficiency Promotional Materials Distributed by ENS	2016	2017
Sample Size	70	70
Yes	84%	93%
No	14%	7%
Don't know	1%	-

- C14a. The energy efficiency promotional materials distributed by Efficiency Nova Scotia were a major factor in the company's decision to implement energy-efficient [MEASURE CATEGORY] measures.

Impact of Previously Seen ENS Energy Efficiency Promotional Materials	2016	2017
Sample Size*	59	65
Agree	61%	68%
Disagree	37%	32%
Don't know	2%	-
*Base: Respondents who previously saw ENS energy-efficiency promotional materials		

- CI4b. The energy-efficiency promotional materials distributed by Efficiency Nova Scotia prompted a company representative to ask a contractor or a technical staff member to examine the energy efficiency options for the facility.

Impact of Previously Seen ENS Energy Efficiency Promotional Materials	2016	2017
Sample Size*	59	65
Agree	61%	62%
Disagree	37%	35%
Don't know	2%	3%
*Base: Respondents who previously saw ENS energy-efficiency promotional materials		

- CI4c. The energy-efficiency promotional materials distributed by Efficiency Nova Scotia prompted a company representative to take into account the cost-effectiveness of energy efficient [MEASURE CATEGORY] measures when evaluating different options for the facility.

Impact of Previously Seen ENS Energy Efficiency Promotional Materials	2016	2017
Sample Size*	59	65
Agree	83%	77%
Disagree	15%	23%
Don't know	2%	-
*Base: Respondents who previously saw ENS energy-efficiency promotional materials		

- S1. Using a scale from 1 to 10 where 1 is “not at all satisfied” and 10 is “completely satisfied” how would you rate your satisfaction with the Business Energy Rebates program overall?

Satisfaction with BER Mail-in Overall	2016	2017
Sample Size	70	70
Mean*	8.6	9.0
*Don't know/Refused excluded from calculations		

S2. What was the most important reason you were not more satisfied with the program overall?
Any other reasons?

Key Reasons Not More Satisfied**	2016 (#)	2017 (#)
Sample Size*	10	7
Too difficult to sign up/too much work	1	2
Timely process/Took too long before getting rebate	3	2
Equipment was not qualified	-	1
Didn't deal directly with ENS	-	1
Don't like location of equipment	-	1
Communication problems leading to believe rebate would be higher	2	-
Too expensive	1	-
I don't like the products/measures rebated	1	-
Rebate/incentive is too small	1	1
Others	1	1
*Base: Respondents who were not satisfied with the program component (NOT SATISFIED: S1<8)		
**Multiple responses		

S3. On a scale of 1 to 10, where 1='not at all satisfied' and 10='completely satisfied', how was your organization's experience with each of the following aspects of the Business Energy Rebates Program?

Satisfaction with Aspects of BER	2016		2017	
	Sample Size	Mean*	Sample Size	Mean*
Mean (1 = 'Not at all satisfied', 10 = 'Completely satisfied')				
Interaction and communication with contractors, distributors or consultants	65	8.7	67	8.6
Time required to receive rebate	69	7.9	68	8.5
The program application, forms and associated paperwork	67	8.5	65	8.4
Rebate amounts	69	8.0	70	8.4
*Don't know/Not applicable/Refused excluded from calculations				

S4a. Why were you not more satisfied with the program application, forms and associated paperwork?

Reasons Not More Satisfied with Application, Forms and Paperwork	2016 (#)	2017** (#)
Sample Size*	15	18
Difficult/too long to fill out	5	15
Communication problems	2	3
Didn't deal with ENS directly	-	1
Would prefer to fill out forms online	-	1
Took too long/Time delay in processing	5	1
Others	2	2
Don't know	1	-
*Base: Respondents who were not satisfied with program component application, forms and associated paperwork (NOT SATISFIED: S3a<8) **Multiple responses		

S4b. Why were you not more satisfied with interaction and communication with contractors or distributors?

Reasons Not More Satisfied with Interaction and Communication with Contractors or Distributors	2016 (#)	2017** (#)
Sample Size*	9	10
Took too long/Communication was slow	1	4
Less knowledgeable about the program	2	4
Contractors didn't provide all the information to complete the application	-	1
Had to ensure the most energy efficient product was being used	-	1
The contractor tried to overcharge me	-	1
Lack of communication/availability with contractor/distributor	5	-
Others	1	-
*Base: Respondents who were not satisfied with interaction and communication with contractors or distributors (NOT SATISFIED: S3b<8) **Multiple responses		

S4c. Why were you not more satisfied with the rebate amounts?

Reasons Not More Satisfied with Rebate Amounts	2016 (%)	2017** (#)
Sample Size*	21	16
Rebate is too small/Expected higher rebate	86%	13
Cost of measures was expensive	14%	2
Others	10%	2
Don't know	-	1
*Base: Respondents who were not satisfied with the rebate amounts (NOT SATISFIED: S3c<8)		
**Multiple responses		

S4d. Why were you not more satisfied with the time required to receive rebate?

Reasons Not More Satisfied with the Time Required to Receive Rebate	2016 (%)	2017** (#)
Sample Size*	24	13
Took too long to process/get rebate	75%	11
Lack of communication/follow-up	13%	3
Applications were too long to fill out and confusing	-	1
Others	13%	-
*Base: Respondents who were not satisfied with the time required to receive rebate (NOT SATISFIED: S3d<8)		
**Multiple responses		

B1. Did you encounter any problems with the [MEASURE CATEGORY] energy efficiency measures you implemented as part of the Business Energy Rebates program?

Barrier Faced	2015	2016	2017
Sample Size	74	70	70
Yes	18%	4%	9%
No	82%	96%	90%
Don't know	-	-	1%

B2. What were those problems? Anything else?

Specific Barriers to Participation	2015 (#)	2016 (#)	2017** (#)
Sample Size*	13	3	6
Equipment malfunction	-	2	5
Received poor/inaccurate information	2	-	1
Problems with installation	4	-	1
Choosing the right equipment/unit	5	-	-
Cost of equipment/unit	1	-	-
Rebate was too small/smaller than expected	1	-	-
Others	1	1	-
*Base: Respondents who had problems with measures **Multiple responses			

B3. Were these problems resolved to your satisfaction?

Problems Resolved	2015 (#)	2016 (#)	2017 (#)
Sample Size*	13	3	6
Yes	9	2	6
No	4	1	-
*Base: Respondents who had problems with measures			

B5. Do you have any suggestions to improve the Business Energy Rebates Program? Consider all aspects of the program: process, measures covered, marketing, interactions with program staff, and program forms. Anything else?

Suggestions to Improve BER*	2015	2016	2017
Sample Size	74	70	70
Make forms more user-friendly	11%	9%	11%
Increase/better rebates	-	6%	10%
Better marketing/awareness	11%	9%	9%
Provide more information/information sessions	12%	4%	7%
Offer more measures rebated	1%	9%	6%
Better communication	26%	3%	6%
Help within finding contractors/suppliers	-	-	4%
ENS staff should be more knowledgeable	5%	1%	3%
Speed up process/receive rebate quicker	9%	6%	1%
Make the whole process easier/more efficient	-	4%	1%
Inform/educate contractors	4%	-	1%
Others	7%	10%	7%
None/No recommendations/Don't know	57%	63%	51%
*Multiple responses			

B6. What kind of information would improve the Business Energy Rebate Program?

Types of Information that Would Improve BER	2016 (#)	2017 (#)
Sample Size*	3	2
Better marketing/awareness	1	2
Better communication	2	-
Prices of equipment/measures	1	-
*Base: Respondents that suggest 'more information' as a way to improve BER		

F1. What is the main activity of your organization?

Principal Building Activity	2015	2016	2017
Sample Size	74	70	70
Farming/Agriculture	9%	6%	13%
Property management/Real estate	-	4%	11%
Mercantile/Retail (other than mall)	11%	11%	10%
Lodging	4%	9%	10%
Construction	-	7%	9%
Manufacturing	7%	14%	7%
Food service (restaurant)	8%	3%	6%
Education	4%	4%	4%
Recreation	-	4%	4%
Wholesale	-	-	4%
Health care	4%	3%	3%
Government	1%	1%	3%
Mercantile/Retail (enclosed and strip malls)	4%	4%	1%
Automotive repair	1%	4%	1%
Transportation	-	4%	1%
Warehouse/Storage	-	1%	1%
Service	27%	4%	-
Public Assembly	-	4%	-
Religious worship	-	1%	-
Property management	7%	-	-
Food sales (grocery)	4%	-	-
Food processing/manufacturing	1%	-	-
Public order and safety	1%	-	-
Others	5%	9%	10%

F3. Approximately how many full-time equivalent workers does your organization employ at all locations within Nova Scotia?

Full-Time Employees	2015	2016	2017
Sample Size	74	70	70
Fewer than 5	22%	26%	40%
5 to 9	18%	10%	10%
10 to 19	12%	19%	7%
20 to 49	12%	11%	10%
50 to 99	14%	11%	11%
100 to 249	8%	9%	6%
250 or more	8%	10%	14%
Don't know	7%	4%	1%

F5. Is your organization independent, or part of a larger organization?

Type of Company	2015	2016	2017
Sample Size	74	70	70
Independent	77%	84%	73%
Part of a larger company/organization	19%	14%	21%
Others	4%	1%	6%

F6. How many business locations does your organization have in Nova Scotia?

Number of Locations	2015	2016	2017
Sample Size	74	70	70
1-5	84%	83%	86%
6 or more	12%	17%	11%
Don't know	4%	-	3%
Average*	3.1	5.0	4.4
*Don't know/Refused excluded from calculations			

Appendix IV

BER: MAIL-IN ON-SITE VISIT SAMPLING METHODOLOGY AND PROTOCOL

Sampling Methodology

A total of 82 on-site visits were conducted in 2017 to evaluate BER Mail-in.

The 2017 BER sample included 82 total visits rolled out as an initial sample of 51 and a second sample of 31. The initial sampling plan was developed based on the July 2017 tracking report which included all completed projects to date. The tracking report contained a total of 138 projects implemented by a total of 119 participants. Only the Laundry measure category was not included in the July 2017 tracking report. The Evaluator calculated the square root of the tracked savings and used these percentages to determine the sample size per measure category.

The second sample was calculated in the same manner as the first sample, but using an updated tracking report from October 2017. The second sample was based on the 209 projects completed up to that date. The results of the final sample calculations are summarized in Table 1 below. The HVAC and Lighting measures received the majority of visits since these measure categories comprised 89 percent of the total tracked savings in BER Mail-in.

Table 1: Total Number of Projects and Tracked Savings Used for Final On-site Visit Sampling²

Measure Category	Tracked Savings		Total Sample	First Sample Size	Second Sample Size ³	Actual Sample Size
	kWh	% Square Root of Savings ⁴	n	n	n	n
Agriculture Technologies	167,810	5.7%	5	0	1	1
Compressed Air	6,511	1.1%	1	0	1	1
HVAC	3,695,645	27.0%	22	18	10	28
Commercial Kitchen	123,461	4.9%	4	2	4	6
Commercial Laundry	5,111	1.0%	1	0	0	0
Commercial Lighting	4,989,578	31.3%	25	24	10	34
Commercial Water Pumping	7,848	1.2%	1	1	0	1
Commercial Refrigeration	683,433	11.6%	9	3	1	4
Solar Thermal	12,700	1.6%	1	1	0	1
Motors and VSDs	703,959	11.8%	9	2	4	6
Total	10,433,682	100.0%	80	51	31	82

In total, the Evaluator reviewed 82 individual projects. The actual sample deviated from the planned sample in four categories due to a limited number of projects. Remaining site visits were reassigned to new categories to best reflect the distribution of savings.

On-site Visit Protocol

The on-site visit protocol was only slightly modified from the 2016 BER protocol since eligible measures were similar. The main changes made for 2017 included collecting more detailed information on hours of use for lighting measures during and outside business hours. Each measure category contains a section for general project information common to all measures followed by sections on measure-specific variables. The general section documents the facility type and contact information. The measure-specific data sections are based on the parameters required for the savings calculations, as documented in the 2017 CIRx Screening Tool v1.32. This data consists of, but is not limited to, measure types, quantity, model number, wattages or capacity, runtime hours, and operation during the peak demand period. The protocol columns are filled out prior to on-site visits with the project documentation saved in the DSMDS, allowing the Evaluator to record additional details if on-site conditions do not match.

² As of November 2016.

On-Site Visit Protocol

1. General Information

Date of visit:			
Project Name:			
Project Tracking sheet #:			
Company Name:			
Contact Name:			
Address:			
Telephone:			
Type of facility:	Retail:	☐ Manufacturing/ Industrial:	☐ Grocery/ Supermarket: ☐
	College/ University:	☐ Multi-Unit Res.:	☐ Other (Specify): ☐
Name of Contact Met with:			
Operation during Peak Period (b/w 5-7pm in Dec/Jan/Feb)?		Yes ☐	No ☐
If "yes", determine % Load Operational During Peak Period:			
Project Type:	Early Replacement ☐	End of Useful Life ☐	New / No Replacement ☐
Spillover Questions Completed:		Yes ☐	No ☐

³ Calculated using each measure category percentage of the tracked savings. A rounding error explains the one visit difference between the expected sample size and the actual sample size.

⁴ As of October 2017, when the second sample was selected.

2. Building Heating/Cooling System Description

Heating Systems: *Please fill the table below for each heating system at the site*

	Heating system 1	Heating system 2
Heat source		
% of heat		
Type of system		

Cooling Systems: *Please fill the table below for each cooling system at the site*

	Cooling system 1	Cooling system 2
% of cooling		
Type of system		
If no prior AC, was AC install planned before HP?		
Secondary Systems changed after HP? (If yes, add system details to notes)		

Notes:

3. Facility Operation Hours and Lighting Usage

Business Hours (Mon-Fri)	
Open Weekends?	
Business Hours Weekends	
Staff Early open	
Staff Late Close	
Cleaning Hours per Week	
Days/yr with no occupancy (i.e holidays or weekends)	
Working Days	
Annual HOU	
Are heating/cooling systems setback during unoccupied times?	
Notes	

**Normal week/holidays lighting
operation schedule (hours per day):**

Please fill the table below for each lighting schedule reported by the site contact as usage could vary for each section of the facility. Use additional sheets if necessary.

Weekday - Hours/Day with Regular Schedule	Weekend - Hours/Day with Regular Schedule	Hours/Day with Holiday Schedule	Hours/Day with No Occupancy	Notes

Notes:

4. Measures information

Lighting : *Collect the information in the table below if lighting measures were installed. Use on-site observation and contact declaration. Use additional sheets if required. Econoler will then compare the information collected with the information in the tracking sheet.*

Location	In the Tracking Sheet
	Validated Onsite
Is cooling installed in the section with the lighting measure?	☐ Yes ☐ No
Is heating installed in the section with the measure?	☐ Yes ☐ No
The percentage of lighting that remains on when the facility is closed:	
Validate if lamps are still installed and not burnt:	
If some are burnt or missing, indicate how many:	
When was the lamp removed or when did it burn?	
Is the facility manager planning to have them replaced?	
If, not why?	
Is Lighting Installed Inside, Outside, or in a refrigerated area?	
Are lights used seasonally?	
Explain if Quantity Found Onsite Differs from that Indicated in the Tracking Sheet:	
Notes (Occupancy sensor?)	
<i>Use the table below to record the information on the lighting measures installed on site. For each type of equipment, indicate the number of equipment with a specific wattage. Use additional sheets if required.</i>	

New equipment installed						Baseline equipment					
Type	Quantity		Wattage/Unit		Notes:	Type	Quantity		Wattage		Additional Info
	Tracking Sheet	On-Site validation	Tracking Sheet	On-Site validation			Tracking Sheet	On-Site validation	Tracking Sheet	On-Site validation	

Additional information captured in the Notes sections of the protocol varies by category type, but may include any of the following:

- › Number of lamps per fixture and length of lamps for linear measures.
- › Are the lighting measures located inside or outside?
- › If existing strips were T12 HO, indicate length.

Motors and VFDs:

Motors

Total number of motors installed:

	In the Tracking Sheet	Validated On-Site
Explanation if quantities are different:		
Location:		
Motor Type:		
Motor Size [hp]:		
National Electrical Manufacturers Association (NEMA) Nominal Efficiency (nameplate):		
Approx. product run time [hr/week]:		
Existing Function?		
Do the new motors operate at least 2,000 hours a year?		
Are the motors controlled by a VFD? Specify RPM:		
Specify the type of application:		
Is the new motor operational? If not, explain:		
Total number of VFDs installed:		
	VFD 1	VFD 2
Location		
Validate that the new VFDs do not replace old VSDs?		
Validate that the new VFDs are operational?		
If not, why and since when?		
Was the VFD commissioned? (Y/N):		
NEMA Eff %		
Control method: (Inlet Damper or Throttling, Differential Pressure):		
Specify the hp of the motor controlled by the VFDs:		

Specify the type of equipment controlled:
(Supply fan, return fan, exhaust fan, chilled water pump, boiler feed water, or other (Specify)):

Hours of use *(Indicate the corresponding schedule number):*

Approx. hours of operation [h/yr]:

Specify Manufacturer and Model Number of VFD:

Describe how the VSD reduces energy consumption and demand

HVAC:

Total number of AC & Air-Source Heat Pumps (Split & Unitary) installed:

Total number of Ground & Water Source Heat Pumps installed:

Are there any other heating and cooling systems than the ones being replaced/installed? (note % of heating/cooling being provided)

	Tracking Sheet HVAC 1	Validated On-Site HVAC 1	Tracking Sheet HVAC 2	Validated On-Site HVAC 2	Tracking Sheet HVAC 3	Validated On-Site HVAC 3
AC & Air-Source Heat Pumps						
Location on site:						
Manufacturer:						
Model number:						
Number of units						
Space heating source (electricity, fuel, etc.):						
HSPF V (HSPF IV x 1.15)						
Seasonal Energy Efficiency Ratio (SEER):						
Energy Efficiency Ratio (EER):						
Nominal kBtu/h per unit:						
Full Load Hours per year:						

	Tracking Sheet HVAC 1	Validated On-Site HVAC 1	Tracking Sheet HVAC 2	Validated On-Site HVAC 2	Tracking Sheet HVAC 3	Validated On-Site HVAC 3
New Capacity (tons or kBTU/hr)						
kBTU/unit conversion						
Validate if the HVAC systems are properly installed and still operational:						
If no, why, and since when?						
Is unit < 65kBTU/h? (Y/N):						
Capacity @ 5F (kBTU/hr)						
COP @ 5F						
ASHP > 65 BTU/h, Ground & Water Source Heat Pumps, Air-To Water Heat Pumps						
Manufacturer:						
Model number:						
Quantity of units:						
Explain if quantity is different:						
Original heat source (Electricity or other (specify)):						
Specify if open or closed loop:						
Specify if water-to-air, water-to-water, or air-to-water:						
Energy Efficiency Ratio (EER):						
Coefficient Of Performance (COP):						
Nominal heating capacity [kBtu/h]:						
Nominal cooling capacity [kBtu/h]:						
Hours of use for equipment (Indicate the corresponding schedule number for each section):						
Heating set point and setback (if any) temperature [°C] :						
Cooling set point and setback (if any) temperature [°C] :						
Validate if the HVAC systems are properly installed and still operational:						
If no, why, and since when?						

HVAC Hotel Occupancy Sensor

Existing control: _____

Is HVAC system <65kBTU/h? _____

Manufacturer: _____

Model number: _____

Quantity: _____

Explanation if quantity is different: _____

With building integrated control? [Y/N]: _____

Number of hotel rooms: _____

Typical vacancy rate: _____

Are occupancy sensors operational? _____

Dual Enthalpy Economizer Controls

Existing control: _____

HVAC system size: _____

Manufacturer: _____

Model number: _____

Quantity: _____

Explanation if quantity is different: _____

With building integrated control? [Y/N]: _____

EER: _____

Operational Testing Completed?: _____

Refrigeration: *Collect the information in the table below **if refrigeration measures were installed**. Use on-site observation and contact declaration. Use additional sheets if required. The information collected will then be compared with the information in the tracking sheet by Econoler. Additionally, record Manufacturer and Model Number.*

ECM Measure

Location:	_____
kW of Evap fan:	_____
Quantity:	_____
Explanation if quantity is different:	_____
Is fan inside low, med or high temp cooler?:	_____
Any issues with fans?	_____

**Strip-curtains, Cooler night covers,
Open to closed cooler Conversion**

Manufacturer?	_____
Model number?	_____
Quantity of open case only [ft]:	_____
Explanation if quantity is different:	_____
Low, Medium or High Temp Cases?	_____
Number of hours/day that case cover/strip curtain is used:	_____
If open-to-closed measure, confirm anti-sweat heaters (Y/N):	_____

Zero-energy doors and frames

Manufacturer?	_____
Model number?	_____
Low, Medium or High Temp?	_____
Quantity of Doors:	_____
Explanation if quantity is different:	_____

Control Measures:

Manufacturer? _____

Model number? _____

Quantity of controllers: _____

Explanation if quantity is different: _____

Quantity of Doors Controlled: _____

Explanation if quantity is different: _____

Number of Evaporator Fans: _____

kW of Defrost Element per Evap Fan: _____

Low, Medium, or High Temp? _____

Humidity or Conductivity based Control? _____

Is there a circulating fan inside cooler? _____

Refrigeration Compressor

Manufacturer: _____

Model Number: _____

Compressor Size (btu/h): _____

Compressor Type (scroll, discus): _____

Low, Medium, or High Temp? _____

Cooler Volume: _____

Replacing hermetic or semi-hermetic? _____

Is this new construction (Y/N)? _____

Refrigerant Type: _____

EER: _____



Outside air economizers for walk-in coolers

Manufacturer:	
Model Number:	
Quantity:	
Explanation if quantity is different:	
Cooler Volume:	
Quantity of Economizers:	
Explanation if quantity is different:	
Compressor Type?	
Compressor Size (HP)?	
Floating Heat Pressure Control?	
Quantity of evaporator fans:	
Recirc. Fan inside cooler?	
Evap Fan Control?	
Cooler temperature setpoint	
kW of Economizer Fan:	

Refrigerated vending machine controllers

Manufacturer:	
Model Number:	
Quantity:	
Explanation if quantity is different:	

Agriculture: *Collect the information in the table below **if agriculture measures were installed**. Use on-site observation and contact declaration. Use additional sheets if required. The information collected will then be compared with the information in the tracking sheet by Econoler. Additionally, record Manufacturer and Model Number, and all Technical Data (Operating Temp, CFM, Size, Control Info)*

High Efficiency Fans – High Volume Low Speed, Ventilation, Circulation

Type (HVLS or vent/circ)?	_____
Location	_____
Manufacturer:	_____
Model Number:	_____
Quantity:	_____
Explanation if quantity is different:	_____
If not, why and since when?	_____
Fan diameter [ft]:	_____
Fan Power:	_____
Airflow (Vent/Circ only):	_____
Hours of use [hr/yr]:	_____

Dual & Natural Ventilation

Type (Dual or natural)?

Facility type:

Barn Hours of Use:

Livestock Capacity:

Explanation if quantity is different:

Livestock Waterer

Type (Low or Zero energy):

Location

Old Heater Wattage [W]:

New Heater Wattage [W]:

Hours of operation:

Quantity:

Explanation if quantity is different:

Agriculture heat pad

Location

Quantity:

Explanation if quantity is different:

Heat Pad Wattage [W]:

Heat Lamp Wattage [W]:

Hours of operation:

Engine block heater timer

Quantity:

Explanation if quantity is different:

Engine block heater wattage [W]:

Hours per night:

Timer active hours:

Dairy scroll compressor

Location _____

Manufacturer: _____

Model Number: _____

Quantity: _____

Explanation if quantity is different: _____

Compressor HP: _____

Hours of Operation per day: _____

Number of cows milked per day (and # of dry cows): _____

Does it Replace an Existing Compressor? _____

Confirm cooling temp (1-13C)? (Y/N) _____

Milk pre-cooler/heat recover – Number installed:

Location _____

Product type _____

Number of cows milked per day (and # of dry cows): _____

Hours/Day Equipment Operates: _____

If HRU – did it replace electric water heater? Pre-Cooler - did it replace existing unit?

Yes	☐	No	☐

VSD on milk vacuum pump – Number installed:

Location

Number of cows milked/day:

Milking setup (parlor, stanchion or tie stall):

Pump type (rotary vane or blower):

Pump Motor HP:

Pump motor efficiency:

Quantity:

Explanation if quantity is different:

Milking hours/day (excluding wash time):

Milk at least 50 cows? (Y/N):

Pump motor > 5 HP? (Y/N):

Does it replace a pre-existing VSD? (Y/N):

Compressed Air: *Collect the information in the table below **if compressed air measures were installed**. Use on-site observation and contact declaration. Use additional sheets if required. The information collected will then be compared with the information in the tracking sheet by Econoler. Additionally, record Manufacturer and Model Number, and all Technical Data (Operating Temp, CFM, Size, Control Info)*

Compressed Air Products Installed

Cycling refrigerated air dryer

Manufacturer:

Model Number:

Compressor HP Rating:

Dryer Capacity (CFM):

Quantity installed: Verify <300 cfm capacity

Explanation if quantity is different:

Compressor operation [hr/week]:

Is the new dryer operational? If not, explain

Is dryer <600CFM capacity? Y/N

VSD screw compressor

Location

Manufacturer:

Model Number:

Quantity Installed:

Is the equipment still used?

If not, why?

Hp rating [hp]: Verify < 40 hp

Compressor operation [hr/week]:

Air-entraining air nozzle

Location

Manufacturer:

Model Number:

Quantity Installed:

Is the equipment operational?

If not, explain?

Compressor control type:

Capacity [cfm]: Verify <14cfm @100psi

Compressor operation [hr/week]:

No-loss drain

Location

Quantity Installed:

Manufacturer:

Model:

Is the equipment operational?

If not, explain?

Compressor type:

System pressure [psi]:

Orifice Diameter (Inches):

Compressor operation [hr/week]: Timer?

**Air tank for load / No-load screw
compressor**

Location	
Manufacturer	
Quantity Installed:	
Is the equipment operational?	
If not, why and since when?	
Compressor type:	
Compressor hp rating [hp]:	
Compressor capacity [CFM]:	
Air receiver tank size [gallons]:	
Compressor operation [hr/week]:	

Kitchen: *Collect the information in the table below **if commercial kitchen measures** were installed. Use on-site observation and contact declaration. Use additional sheets if required. The information collected will then be compared with the information in the tracking sheet by Econoler. Additionally, record Manufacturer and Model Number, and all Technical Data (Operating Temp, CFM, Size, Control Info)*

Commercial Dish Washers

Quantity Installed:	
Location:	
Product type	
Manufacturer:	
Model number:	
Is the equipment used for commercial purpose?	
Is the equipment still used?	
If not, why and since when?	
High or low temp?	
Validate the equipment is ENERGY STAR certified:	
Booster water heater fuel type (if applicable):	
DHW heating source:	
Operation [days/year]:	
Operation [number of racks washed/day]:	

Commercial Fryers

Standard capacity commercial fryer

Quantity Installed: _____

Location: _____

Manufacturer: _____

Model number: _____

New fryer efficiency: _____

New fryer idle energy rate: _____

Specify if electric or gas? _____

Does it replace an electric fryer? _____

Is the equipment still used? _____

If not, why and since when? _____

Validate the equipment is ENERGY STAR certified: _____

Operation [days/year]: _____

Operation [hours/day]: _____

Commercial Hot Food Holding Cabinet

Manufacturer: _____

Model Number: _____

Quantity: _____

Explanation if quantity is different: _____

Validate the equipment is ENERGY STAR certified: _____

Interior Volume (ft³) _____

Is the equipment still used? _____

If not, why and since when? _____

Operation [days/year]: _____

Operation [hours/day]: _____

Commercial Griddles

Location	_____
Product Type	_____
Manufacturer	_____
Model Number	_____
Width Installed (ft):	_____
Quantity:	_____
Explanation if quantity is different:	_____
Specify if electric or gas?	_____
Does it replace an electric griddle?	_____
Is it a new installation?	_____
Is the equipment still used?	_____
If not, why?	_____
Validate the equipment is ENERGY STAR certified:	_____
Griddle efficiency	_____
Griddle Idle Energy Rate	_____
Operation [days/year]:	_____
Operation [hours/day]:	_____

Commercial Refrigeration/Freezer

Location	_____
Manufacturer:	_____
Model Number:	_____
Volume (ft ³)	_____
Quantity:	_____
Explanation if quantity is different:	_____
Product type	_____
Validate the equipment is ENERGY STAR certified:	_____
Is the equipment still used?	_____
If not, why?	_____

Commercial Ice Makers

Ice making head

Location _____

Quantity Installed: _____

Product Type _____

Manufacturer: _____

Model number: _____

Harvest [lbs/day]: _____

Is the equipment still used? _____

If not, why and since when? _____

Does it replace non- certified ENERGY STAR icemaker? _____

Validate the equipment is ENERGY STAR certified: _____

Remote condensing unit

Quantity Installed: _____

Product type _____

Manufacturer: _____

Model number: _____

Harvest [lbs/day]: _____

Is the equipment still used? _____

If not, why and since when? _____

Does it replace non- certified ENERGY STAR ice maker? _____

Validate the equipment is ENERGY STAR certified: _____

Self-contained

Quantity Installed:

Product type

Manufacturer:

Model number:

Harvest [lbs/day]:

Is the equipment still used?

If not, why and since when?

Does it replace non- certified ENERGY
STAR ice maker?Validate the equipment is ENERGY STAR
certified:**Steam Cookers**

Quantity Installed:

Location:

Manufacturer:

Model number:

Product Type:

Operation Days/yr:

Operation Hours/yr:

Number of pans per unit:

Number of pans per day:

Explanation if different:

Validate the equipment is ENERGY STAR
certified:

Commercial Convection Ovens

Standard convection commercial oven

Location: _____

Manufacturer: _____

Model number: _____

Product Type: _____

Quantity Installed: _____

Hours oven is operating: _____

Preheats per day: _____

Explanation if different: _____

Specify if electric or gas: _____

Specify if full size or half size: _____

Is the equipment still used? _____

If not, why and since when? _____

Does it replace an electric convection oven? _____

Is it a new installation? _____

Validate the equipment is ENERGY STAR certified: _____

Griddles

Location: _____

Manufacturer: _____

Model number: _____

Quantity Installed: _____

Validate the equipment is ENERGY STAR certified: _____

Operation [days/year]: _____

Operation [hours/day]: _____

Size (Feet) _____

Is the equipment still used? _____

If not, why? _____

Commercial Kitchen Ventilation Hoods

VSD for kitchen exhaust fans

Location	_____
Manufacturer:	_____
Model number:	_____
Quantity Installed:	_____
Explanation if quantity is different:	_____
Equipment Controlled by VSD:	_____
Existing Control Method	_____
Hours of use:	_____
Size of the motor controlled by the VSD [hp]:	_____
Explanation if different:	_____
Is the equipment still used?	_____
If not, why?	_____
Is the equipment controlled by T° and optical sensors located in exhaust hood?	_____
Was VSD commissioned? [Y/N]:	_____

Laundry: *Collect the information in the table below if **commercial laundry measures** were installed. Use on-site observation and contact declaration. Use additional sheets if required. The information collected will then be compared with the information in the tracking sheet by Econoler. Additionally, record Manufacturer and Model Number, and all Technical Data (Operating Temp, CFM, Size, Control Info)*

Water heating source: _____

Commercial Washing Machines Installed

Location	
Quantity Installed:	
Manufacturer:	
Model number:	
Size [cubic feet/unit]:	
Is the equipment used for commercial purpose?	
Water heating source:	
Is the equipment still used?	
If not, why?	
Validate the equipment is ENERGY STAR certified:	
Operation [cycles/week]:	

Appendix V

BER : INSTANT REBATES PARTICIPANT SURVEY QUESTIONNAIRE

Could I speak with the person in your organization who would have been involved with the Efficiency Nova Scotia Business Energy Rebates Program?

- 1 Yes **[GO TO INTRODUCTION]**
- 2 No **[SAY "Perhaps you can help me anyway." GO TO INTRODUCTION]**

Introduction

Hello, I am with Corporate Research Associates, and we are performing an evaluation of energy efficiency services provided by Efficiency Nova Scotia. Our records indicate that you or your organization recently participated in Efficiency Nova Scotia's Business Energy Rebates Program by purchasing rebated [PRODUCT] at a participating distributor. We would appreciate your help in answering questions related to these products. The information you provide will be used to help Efficiency Nova Scotia evaluate and improve its programs. The survey will take about 5-10 minutes. Is this a good time for you?

Verification and Recall (V Series)

- V1. Our records indicate that your organization received an instant rebate from Efficiency Nova Scotia for [PRODUCT] bought at [DISTRIBUTOR] in [MONTH]. Is this correct?
1. Yes (Go TO V3)
 2. No
- V2. Is there someone else at your organization who would know about the decision to purchase these [PRODUCT]?
1. Yes (Ask for name: _____ and telephone #: _____) (Thank, terminate, record and keep data; schedule interview with best contact)
 2. No (Thank, terminate, record and keep data)
- V3. Are you the person in your organization who is most knowledgeable about deciding to purchase these [PRODUCT]?
1. Yes (If Yes go to P Series)
 2. No

- V4. We would like to talk to the person who is the most knowledgeable about deciding to purchase these [PRODUCT]. Could you give me the name and telephone number of this person? [Probe if respondent is unsure who best to forward the call to. This individual may be an engineer, equipment contractor, or utility account manager].

Name: _____

Telephone #: _____

(Note: Thank, terminate, record and keep data. Schedule interview with best contact regarding experience with the program.)

Program Participation (P Series)

- P1. What was the SINGLE most important reason your organization chose to buy [PRODUCT] rather than a standard [STANDARD PRODUCT]?
96. (Specify: _____)
98. (Don't know)
98. (Refused)
- P1a. [DO NOT POSE IF 98 OR 99 IN P1] What was the SECOND most important reason your organization chose to buy [PRODUCT] rather than a standard [STANDARD PRODUCT]?
- 96 No other reason
- P2. Did your distributor recommend [PRODUCT] to you?
1. Yes
2. No
98. (Don't know)
99. (Refused)
- P3. Were you aware that you received a rebate when purchasing these [PRODUCT]?
1. Yes (Go to P5)
2. No
98. (Don't know)
- P4. [ASK IF P3=No or DK] I just want to make sure I understand – When you purchased [PRODUCT], you were unaware that a rebate was given to reduce the product's total cost?
- 1 Unaware of the rebate
- 2 Aware of the rebate
- 98 Don't know
- 99 Refused

P5. [ASK IF P3=Yes or P4=2] Were you aware that the rebate was offered by Efficiency Nova Scotia as part of its Business Energy Rebates Program?

1. Yes
2. No

Free-Ridership (FR Series)

FR1a. [ASK IF AWARE (P3=1 or P4=2)] Had your organization **already** decided to purchase [PRODUCT] **before** knowing that these products were rebated?

1. Yes
2. No
98. (Don't know)
99. (Refused)

FR1b. Had your organization **already** decided to purchase [PRODUCT] **before** knowing the price of those products?

1. Yes
2. No
98. (Don't know)
99. (Refused)
- 97 (Did not get any quotes)

FR2. Efficiency Nova Scotia offered a rebate for the purchase of efficient lighting products. If your organization had not received the rebate and the cost for [PRODUCT] had been about \$[REBATE AVERAGE VALUE BY CATEGORY] higher, would you have paid the full cost of the [PRODUCT]? Please answer on a scale of 0 to 10, with a 0 indicating that you "Definitely **Would Not Have Paid**" and a 10 indicating that you "Definitely **Would Have Paid**." PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE

___ Response ___ 98 Don't Know ___ 99 Refused

FR3. Were you aware that the [PRODUCT] you purchased were premium products certified by Design Light Consortium or ENERGY STAR?

1. YES
2. NO
8. (DON'T KNOW)
9. (Refused)

[ASK FR3a to c IF AWARE (P3=1 or P4=2)]

READ FIRST TIME THROUGH ONLY: Now I would like to ask you to consider which actions your organization would have taken if the rebate had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely,” and a 10 indicating that it is “Very Likely”

FR3a. If the rebate had not been offered, what is the likelihood that you would have purchased the exact same model of premium lighting products?

___ Response ___98 Don't Know ___99 Refused

FR3b. [ASK IF TOTAL MEASURE CATEGORY QTY>1] If the rebate had not been offered, what is the likelihood that you would have purchased exactly the same quantity of lighting products that you bought?

___ Response ___98 Don't Know ___99 Refused

FR3c. [ASK IF FR2≥5] If the rebate had not been offered, what is the likelihood that you would have postponed the purchase of the lighting products by at least one year?

___ Response ___98 Don't Know ___99 Refused

FR4. Using a scale from 0 to 10, where 0 means “No influence” and 10 means “Great influence”, please rate the influence of each of the following in your organization’s decision to purchase [PRODUCT].

Factor (READ AND RANDOMIZE)	Responses
a. [ASK IF AWARE (P3=1 or P4=2)] The program rebate	___ Response ___98 Don't Know ___99 Refused
b. [ASK IF P5=1] Information received by a program representative on high-efficiency lighting products	___ Response ___98 Don't Know ___99 Refused
c. Information received by a distributor on high-efficiency lighting products	___ Response ___98 Don't Know ___99 Refused

Cross-Influence [CI Series]

READ AND ROTATE (CI1 + CI2a-c) AND (CI3 + CI4a-c) SEQUENCES

CI1. Before buying the rebated lighting products in [DATE], had your organization at any time in the past already participated in any other Efficiency Nova Scotia programs?

- 1 YES
- 2 NO
- 98 (Don't know)
- 99 (Refused)

For the following statements, please indicate whether you agree or disagree.

CI2a. [IF CI1=1] The organization's previous participation in an Efficiency Nova Scotia program was a major factor in the decision to purchase [PRODUCT].

- 1 Agree
- 2 Disagree
- 98 (Don't know)
- 99 (Refused)

CI2b. [IF CI1=1] Because of the company's previous participation in an Efficiency Nova Scotia program and what was learned by participating in the program, a company representative asked a contractor or a distributor about efficient lighting options for your facility.

- 1. Agree
- 2. Disagree
- 98. (Don't know)
- 99. (Refused)

CI2c. [IF CI1=1] Because of your company's previous participation in an Efficiency Nova Scotia program and what was learned by participating in the program, a company representative took into account the cost-effectiveness of [PRODUCT] when evaluating different options for the facility.

- 1. Agree
- 2. Disagree
- 98. (Don't know)
- 99. (Refused)

- CI3. Before participating in the Business Energy Rebates program, had you at any time in the past already seen Efficiency Nova Scotia promotional materials advertising the benefits of energy efficiency?
- 1. Yes
 - 2. No
 - 98. (Don't know)
 - 99. (Refused)

For the following statements, please indicate whether you agree or disagree.

- CI4a. [IF CI3=1] The energy efficiency promotional materials distributed by Efficiency Nova Scotia were a major factor in the company's decision to purchase [PRODUCT].
- 1. Agree
 - 2. Disagree
 - 98. (Don't know)
 - 99. (Refused)
- CI4b. [IF CI3=1] The energy-efficiency promotional materials distributed by Efficiency Nova Scotia prompted a company representative to ask a contractor or a distributor about efficient lighting options for your facility.
- 1. Agree
 - 2. Disagree
 - 98. (Don't know)
 - 99. (Refused)
- CI4c. [IF CI3=1] The energy-efficiency promotional materials distributed by Efficiency Nova Scotia prompted a company representative to take into account the cost-effectiveness of [PRODUCT] when evaluating different options for the facility.
- 1. Agree
 - 2. Disagree
 - 98. (Don't know)
 - 99. (Refused)

Decision Criteria [D Series]

I have only a few more questions.

- D1. Generally speaking, when it comes to deciding on whether or not to implement energy efficiency lighting, does your organization use a payback period threshold as a decisional criterion?
1. YES
 2. NO
 8. (DON'T KNOW)
 9. (Refused)
- D2. [ASK IF D1=1] What is the maximum payback period acceptable in order to move forward with energy efficient lighting upgrades? AVOID A RANGE - RECORD RESPONSE
- [MONTHS/YEARS]
- 98 (Don't know)
- D3. Which of the following, if any, does your organization have in place for the facility where the efficient lighting products were implemented? READ AND ROTATE - CODE ONLY ONE PER STATEMENT
- a. A person responsible for monitoring or managing energy usage
 - b. Defined energy saving goals
 - c. A specific policy requiring that energy efficiency be considered when purchasing energy related equipment
1. YES
 2. NO
 8. (DON'T KNOW)
 9. (Refused)

END. Those are all the questions I have for you. I thank you very much for your time and cooperation and have a nice day!

Appendix VI

BER: INSTANT REBATES PARTICIPANT SURVEY RESULTS

P1. What was the SINGLE most important reason your organization chose to buy [PRODUCT] rather than a standard [STANDARD PRODUCT]?

P1a. What was the SECOND most important reason your organization chose to buy [PRODUCT] rather than a standard [STANDARD PRODUCT]?

Motivations	2017	
	Most Important Reason	Other Reasons*
Sample Size	60	60
Save on energy costs/bills	43%	17%
To improve energy efficiency	32%	5%
Quality of efficiency products	7%	20%
What the customer/owner wanted	3%	2%
Take advantage of program rebates	3%	8%
Recommended by contractor	2%	-
Protect the environment	2%	3%
Update equipment	2%	20%
Reduce maintenance costs	2%	7%
To replace non-working equipment	-	3%
Others	5%	12%
None/No other reason	-	3%
*Multiple Responses		

P2. Did your distributor recommend [PRODUCT] to you?

Distributor Recommend Product	2017
Sample Size	60
Yes	67%
No	32%
Don't know	2%

P3. Were you aware that you received a rebate when purchasing these [PRODUCT]?

P4. I just want to make sure I understand – When you purchased [PRODUCT], you were unaware that a rebate was given to reduce the product's total cost?

Aware of Rebate	2017
Sample Size	60
Yes	92%
No	7%
Don't know	2%

P5. Were you aware that the rebate was offered by Efficiency Nova Scotia as part of its Business Energy Rebates Program?

Aware Rebate was Part of BER	2017
Sample Size*	55
Yes	95%
No	5%
*Base: Respondents who were aware of rebate	

FR1a. Had your organization **already** decided to purchase [PRODUCT] **before** knowing that these products were rebated?

FR1b. Had your organization **already** decided to purchase [PRODUCT] **before** knowing the price of those products?

Already Made Decision to Purchase Product Before Knowing about Rebate	2017
Sample Size*	55
Yes	56%
No	40%
Don't know	4%
*Base: Respondents who were aware of rebate	
Already Made Decision to Purchase Product Before Knowing about Price	2017
Sample Size	60
Yes	47%
No	53%

FR2. Efficiency Nova Scotia offered a rebate for the purchase of efficient lighting products. If your organization had not received the rebate and the cost for [PRODUCT] had been about \$[REBATE AVERAGE VALUE BY CATEGORY] higher, would you have paid the full cost of the [PRODUCT]? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely **Would Not Have Paid**” and a 10 indicating that you “Definitely **Would Have Paid**.”

Would Have Paid Cost of Project	2017	
	Sample Size	Mean*
Mean (0 = “Definitely Would Not Have Paid” 10 = “Definitely Would Have Paid”)		
Paid cost of project	58	6.1

FR3. Were you aware that the [PRODUCT] you purchased were premium products certified by Design Light Consortium or ENERGY STAR?

Aware Product was Certified by Design Light Consortium or ENERGY STAR	2017
Sample Size	60
Yes	63%
No	37%

FR3. Now I would like to ask you to consider which actions your organization would have taken if the rebate had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is "Very Unlikely," and a 10 indicating that it is "Very Likely."

Actions Taken in Absence of Program	2017	
	Sample Size	Mean****
Mean (0 = "Very Unlikely" 10 = "Very Likely")		
If the rebate had not been offered, what is the likelihood that you would have purchased exactly the same quantity of lighting products that you bought**	50	6.0
If the rebate had not been offered, what is the likelihood that you would have purchased the exact same model of premium lighting products*	55	5.8
If the rebate had not been offered, what is the likelihood that you would have postponed the purchase of the lighting products by at least one year***	44	3.6
*Base: Respondents who were aware of rebate **Base: Respondents who purchased more than one product ***Base: Respondents who would have likely paid full cost of the energy-efficient measure [IF FR2≥5] ****Don't know/Refused excluded from calculations		

FR4. Using a scale from 0 to 10, where 0 means “No influence” and 10 means “Great influence”, please rate the influence of each of the following in your organization’s decision to purchase [PRODUCT].

Influence of Factors in Decision to Implement Energy-Efficient Measures	2017	
	Sample Size	Mean***
Mean (0 = “No influence” 10 = “Great influence”)		
The program rebate*	55	7.4
Information received by a program representative on high-efficiency lighting products	58	6.8
Information received by a program representative on high-efficiency lighting products**	50	5.6
*Base: Respondents who were aware of rebate **Base: Respondents who were aware rebate was offered by ENS as part of program ***Don’t know/Refused excluded from calculations		

CI1. Before buying the rebated lighting products in [DATE], had your organization at any time in the past already participated in any other Efficiency Nova Scotia programs?

Previous Participation in Another ENS Program	2017
Sample Size	60
Yes	75%
No	23%
Don’t know	2%

CI2a. The organization’s previous participation in an Efficiency Nova Scotia program was a major factor in the decision to purchase [PRODUCT].

Previous Participation in Another ENS Program	2017
Sample Size*	45
Agree	69%
Disagree	31%
*Base: Respondents who previously participated in another ENS program	

C12b. Because of the company's previous participation in an Efficiency Nova Scotia program and what was learned by participating in the program, a company representative asked a contractor or a distributor about efficient lighting options for your facility.

Impact of Previous ENS Program Participation	2017
Sample Size*	45
Agree	76%
Disagree	24%
*Base: Respondents who previously participated in another ENS program	

C12c. Because of your company's previous participation in an Efficiency Nova Scotia program and what was learned by participating in the program, a company representative took into account the cost-effectiveness of [PRODUCT] when evaluating different options for the facility.

Impact of Previous ENS Program Participation	2017
Sample Size*	45
Agree	84%
Disagree	13%
Don't know	2%
*Base: Respondents who previously participated in another ENS program	

C13. Before participating in the Business Energy Rebates program, had you at any time in the past already seen Efficiency Nova Scotia promotional materials advertising the benefits of energy efficiency?

Previously Seen Energy Efficiency Promotional Materials Distributed by ENS	2017
Sample Size	60
Yes	90%
No	10%

CI4a. The energy efficiency promotional materials distributed by Efficiency Nova Scotia were a major factor in the company's decision to purchase [PRODUCT].

Impact of Previously Seen ENS Energy Efficiency Promotional Materials	2017
Sample Size*	54
Agree	57%
Disagree	43%
Don't know	-
*Base: Respondents who previously saw ENS energy-efficiency promotional materials	

CI4b. The energy-efficiency promotional materials distributed by Efficiency Nova Scotia prompted a company representative to ask a contractor or a distributor about efficient lighting options for your facility.

Impact of Previously Seen ENS Energy Efficiency Promotional Materials	2017
Sample Size*	54
Agree	65%
Disagree	31%
Don't know	4%
*Base: Respondents who previously saw ENS energy-efficiency promotional materials	

CI4c. The energy-efficiency promotional materials distributed by Efficiency Nova Scotia prompted a company representative to take into account the cost-effectiveness of [PRODUCT] when evaluating different options for the facility.

Impact of Previously Seen ENS Energy Efficiency Promotional Materials	2017
Sample Size*	54
Agree	89%
Disagree	11%
Don't know	-
*Base: Respondents who previously saw ENS energy-efficiency promotional materials	

- D1. Generally speaking, when it comes to deciding on whether or not to implement energy efficiency lighting, does your organization use a payback period threshold as a decisional criterion?

Payback Period for Decision Making	2017
Sample Size	60
Yes	70%
No	27%
Don't know	3%

- D2. What is the maximum payback period acceptable in order to move forward with energy efficient lighting upgrades?

Maximum Payback Period	2017
Sample Size	42
6-11 months	2%
1 year	29%
2 years	24%
3 years	2%
4 years	5%
5 years	21%
Don't know	17%
Average*	2.6 years
*Excludes Don't know responses	

- D3. Which of the following, if any, does your organization have in place for the facility where the efficient lighting products were implemented?

Processes in Place in Facilities Where Measures Were Implemented	2017	
Sample Size	60	
	Yes	No/Don't know
A person responsible for monitoring or managing energy usage	55%	45%
A specific policy requiring that energy efficiency be considered when purchasing equipment	55%	45%
Defined energy saving goals	48%	52%

Appendix VII

BER: INSTANT REBATES INTERVIEW GUIDE WITH DISTRIBUTORS

Interview Date and Time	
Company name	
Name	
Area code and phone number	
Email	
Interview Length	

Introduction

Thank you for taking the time to speak with me. Today, I am interested in your opinion regarding Efficiency Nova Scotia's Business Energy Rebates program, from your perspective as a program partner. As you may recall, Econoler, in partnership with Corporate Research Associates, is conducting a program evaluation again this year for the Business Energy Rebates program.

We would appreciate your collaboration in answering questions related to your involvement in this program. The information you provide will be used to help Efficiency Nova Scotia evaluate and improve the program. Our discussion should last approximately thirty minutes. Is this a good time for you?

Please note that your responses will be kept strictly confidential and that we will not share the information you provide with any other party in a way that could identify your individual or corporate responses.

Identification and Screening of Respondent

11. I'd like to speak with someone in your company/store who is knowledgeable about the stocking and supplying of specific products that were rebated by the program. These products are 1) linear LED fixtures, 2) LED downlight fixtures, 3) LED linear lamps and 4) general-use/decorative LED lamps. Would that person be you?
 - › Person responsible available [CONTINUE]
 - › Person responsible currently unavailable [ARRANGE CALL BACK WITH THE RIGHT PERSON]
 - › No person responsible for stocking or management of products [CONTINUE INTERVIEW WITH STORE MANAGER/HEAD OFFICE CONTACT - CONTINUE]
 - › Don't know [CONTINUE INTERVIEW WITH STORE MANAGER/HEAD OFFICE CONTACT - CONTINUE]
 - › Refused [THANK AND TERMINATE]

Note that I will be asking the same questions for each of these product categories; we will discuss each product category one at a time. But first, I would like to discuss the LEDs lamps and fixtures in general.

Section M: Market Evolution

M1. In 2011, sales of LED lamps and fixtures were low in Nova Scotia. In your opinion, to what extent have the following factors contributed to the increase in market share of LED lamps and fixtures in the past six years? Please rate each factor's influence using a percentage, with all four totalling 100%.

Regulations and legislations	_____%
Awareness-raising of environmental issues among clients	_____%
Price reductions	_____%
Appeal of the technology/Technology improvements	_____%
Total	100%

M2. In your opinion, to what extent have the programs and activities from Efficiency Nova Scotia influenced each of those same factors? Rate Efficiency Nova Scotia's influence using a percentage from 0 to 100%.

Awareness-raising of environmental issues among clients	_____%
Price reductions	_____%
Appeal of the technology/Technology improvements	_____%

M3. The Business Energy Rebates Program started in 2011. Since its inception, what impact, if any, has the program had on...

1. the number of LED lamps and fixtures models offered in your store?
2. the type of LED lamps and fixtures models offered in your store?
3. your staff's overall knowledge of these products?

Section A: Linear Led Fixtures

Ask If Linear Led Fixtures Were Rebated Through The Program

I have a few questions about your sales of **linear LED fixtures** that are promoted by the Business Energy Rebates Program. This category includes the following measures (as defined in Efficiency Nova Scotia's rebate schedule): low-bay luminaires, troffers and linear ambient luminaires. Those fixtures would all be Design Light Consortium (DLC) certified. Our records indicate that you sold _____ linear LED fixtures as part of the BER Instant Rebates program up to September 2017, **[READ IF SALES DATA AVAILABLE]** while you sold _____ units for the year in 2016.

A1. **[ASK IF SALES DATA AVAILABLE]** If the current trend is maintained, you should sell **[FROM SAMPLE: fewer / more]** linear LED fixtures by the end of 2017 than the number of units you sold in 2016. Does this sound accurate? If so, what explains this shift? **[PROBE: market trend, more competitors offering these products, etc.]**

A1a. **[ASK IF SALES DATA NON AVAILABLE]** If the current trend is maintained, do you think you will sell more, less or the same number of linear LED fixtures by the end of 2017 than the number of units you sold in 2016? If "more" or "less", how do you explain the difference? **[PROBE: market trend, more competitors offering these products, etc.]**

A2. In 2017, the Business Energy Rebates Program provided a per-unit incentive ranging from \$10 to \$50, depending on the type of linear LED fixtures. If this incentive had not been offered this year, would the number of linear LED fixtures you will sell in 2017 have been about the same or lower?

1 Same [GO TO A2a]

2 Lower [GO TO A2b]

98 (Don't know) [GO TO A4]

99 (Refused) [GO TO A4]

A2a. **[IF SAME]** Just to confirm... without the program incentive, you would have sold the same number of linear LED fixtures this year?

A2b. **[IF LOWER]** In your estimation, by what percentage would the number of linear LED fixtures you sold have been lower in 2017 if the Business Energy Rebates Program incentive was not available?

RECORD PERCENTAGE ____%

RECORD EXPLANATION:

A4. I am interested in understanding the impact of the Business Energy Rebates program on customers' product choice. Using a scale from 0 to 10, where 0 is "not at all important" and 10 is "extremely important", how would you rate the program's influence on your customers' choice of linear LED fixtures instead of fluorescent tube fixtures?

RECORD RATING: _____

RECORD EXPLANATION:

A6. Is the incentive ranging from \$10 to \$50 per fixture sufficient to encourage customers who would not have done so otherwise to purchase linear LED fixtures? Why?

- A7. Through the Business Energy Rebates Program, only products meeting program's criteria, such as DLC or ENERGY STAR certifications, are eligible for rebate. I would like to understand the impact of the program on the models of products your company carries. Using a scale from 0 to 10, where 0 is "not at all important" and 10 is "extremely important", how would you rate the program's influence on the proportion of DLC certified linear LED fixtures carried by your company?

RECORD RATING: _____

RECORD EXPLANATION:

Section B: LED Downlight Fixtures

Ask if LED downlight fixtures were rebated through the program

I have a few questions about your sales of **LED downlight fixtures** that are promoted by the Business Energy Rebates Program. This category includes the following measures (as defined in Efficiency Nova Scotia's rebate schedule): LED downlight recessed, LED downlight solid state retrofit, LED downlight surface mount, LED Wall Sconces, and LED ceiling mount fixtures. Those fixtures would all be ENERGY STAR certified fixtures that replace standard incandescent, CFL or halogen fixtures. Our records indicate that you sold _____ LED downlight fixtures as part of the BER Instant Rebates program up to September 2017, **[READ IF SALES DATA AVAILABLE]** while you sold _____ units for the year 2016.

- B1. **[ASK IF SALES DATA AVAILABLE]** If the current trend is maintained, you should sell **[FROM SAMPLE: fewer / more]** LED downlight fixtures by the end of 2017 than the number of units you sold in 2016. Does this sound accurate? If so, what explains this shift? **[PROBE: market trend, more competitors offering these products, etc.]**
- B1a. **[ASK IF SALES DATA NON AVAILABLE]** If the current trend is maintained, do you think you will sell more, less or the same number of LED downlight fixtures by the end of 2017 than the number of units you sold in 2016? If "more" or "less", how do you explain the difference? **[PROBE: market trend, more competitors offering these products, ability to purchase LEDs at a good price, etc.]**
- B1b. What percentage of the LED downlight fixtures you sold through the program was purchased for residential application so far in 2017?

B2. In 2017, the Business Energy Rebates Program provided a per-unit incentive ranging from \$8 to \$30, depending on the type of LED downlight fixture. If this incentive had not been offered this year, would the number of LED downlight fixtures you will sell in 2017 have been about the same or lower?

1 Same [GO TO B2a]

2 Lower [GO TO B2b]

98 (Don't know) [GO TO B4]

99 (Refused) [GO TO B4]

B2a. [IF SAME] Just to confirm...without the program incentive, you would have sold the same number of LED downlight fixtures this year?

B2b. [IF LOWER] In your estimation, by what percentage would the number of LED downlight fixtures you sold have been lower in 2017, if the Business Energy Rebates Program incentive had not been available?

RECORD PERCENTAGE ____%

RECORD EXPLANATION:

B4. I am interested in understanding the impact of the Business Energy Rebates program on customers' product choice. Using a scale from 0 to 10, where 0 is "not at all important" and 10 is "extremely important", how would you rate the program's influence on your customers' choice of LED downlight fixtures instead of incandescent or halogen fixtures?

RECORD RATING: _____

RECORD EXPLANATION:

B6. Is the incentive ranging from \$8 to \$30 per fixture sufficient to encourage customers who would not have done so otherwise to purchase LED downlight fixtures? Why?

B7. Through the Business Energy Rebates Program, only products meeting program's criteria, such as DLC or ENERGY STAR certifications, are eligible for rebate. I would like to understand the impact of the program on the models of products your company carries. Using a scale from 0 to 10, where 0 is "not at all important" and 10 is "extremely important", how would you rate the program's influence on the proportion of ENERGY STAR certified LED downlight fixtures carried by your company?

RECORD RATING: _____

RECORD EXPLANATION:

Section C: LED Linear Lamps**Ask if LED linear lamps were rebated through the program**

I have a few questions about your sales of LED linear lamps that are promoted by the Business Energy Rebates Program. This category includes lamps such as two-foot and foot-foot linear replacement lamps and retrofit kits for ambient lighting. Those lamps would all be Design Light Consortium (DLC) certified. Our records indicate that you sold _____ LED linear lamps as part of the BER Instant Rebates program up to September 2017, **[READ IF SALES DATA AVAILABLE]** while you sold _____ units for the year 2016.

- C1. **[ASK IF SALES DATA AVAILABLE]** If the current trend is maintained, you should sell **[FROM SAMPLE: fewer / more]** LED linear lamps by the end of 2017 than the number of units you sold in 2016. Does this sound accurate? If so, what explains this shift? **[PROBE: market trend, more competitors offering these products, etc.]**
- C1a. **[ASK IF SALES DATA NON AVAILABLE]** If the current trend is maintained, do you think you will sell more, less or the same number of LED linear lamps by the end of 2017 than the number of units you sold in 2016? If “more” or “less”, how do you explain the difference? **[PROBE: market trend, more competitors offering these products, ability to purchase LEDs at a good price, etc.]**
- C2. In 2017, the Business Energy Rebates Program provided a per-unit incentive ranging from \$2.50 to \$5, depending on the type of LED linear lamp. If this incentive had not been offered this year, would the number of LED linear lamps you will sell in 2017 would have been about the same or lower?
- 1 Same [GO TO C2a]
 - 2 Lower [GO TO C2b]
 - 98 (Don't know) [GO TO C4]
 - 99 (Refused) [GO TO C4]
- C2a. **[IF SAME]** Just to confirm... without the program incentive, you would have sold the same number of LED linear lamps this year?
- C2b. **[IF LOWER]** In your estimation, by what percentage would the number of LED linear lamps you sold have been lower in 2017, if the Business Energy Rebates Program incentive had not been available?

RECORD PERCENTAGE ____%

RECORD EXPLANATION:

- C4. I am interested in understanding the impact of the Business Energy Rebates program on customers' product choice. Using a scale from 0 to 10, where 0 is "not at all important" and 10 is "extremely important", how would you rate the program's influence on your customers' choice of LED linear lamps instead of fluorescent lamps?

RECORD RATING: _____

RECORD EXPLANATION:

- C6. Is the current incentive ranging from \$2.50 to \$4 per lamp sufficient to encourage customers who would not have done so otherwise to purchase LED linear lamps? Why?
- C7. Through the Business Energy Rebates Program, only products meeting program's criteria, such as DLC or ENERGY STAR certifications, are eligible for rebate. I would like to understand the impact of the program on the models of products your company carries. Using a scale from 0 to 10, where 0 is "not at all important" and 10 is "extremely important", how would you rate the program's influence on the proportion of DLC certified LED linear lamps carried by your company?

RECORD RATING: _____

RECORD EXPLANATION:

Section D: General-Use/Decorative LED Lamps

Ask if general-use/decorative LED lamps were rebated through the program

I have a few questions about your sales of **general-use/decorative LED lamps** that are promoted by the Business Energy Rebates Program. This category covers A19, globe and chandelier bulbs. Those lamps would all be ENERGY STAR certified. Our records indicate that you sold _____ general-use/decorative LED lamps up to September 2017, **[READ IF SALES DATA AVAILABLE]** while you sold _____ units for the year 2016.

- D1. **[ASK IF SALES DATA AVAILABLE]** If the current trend is maintained, you should sell [FROM SAMPLE: fewer / more] **general-use/decorative LED lamps** by the end of 2017 than the number of units you sold in 2016. Does this sound accurate? If so, what explains this shift? **[PROBE:** market trend, more competitors offering these products, etc.]
- D1a. **[ASK IF SALES DATA NON AVAILABLE]** If the current trend is maintained, do you think you will sell more, less or the same number of **general-use/decorative LED lamps** by the end of 2017 than the number of units you sold in 2016. If "more" or "less", how do you explain the difference? **[PROBE:** market trend, more competitors offering these products, etc.]

D2. In 2017, the Business Energy Rebates Program provided a per-unit incentive of \$3 to \$4, depending on the type of general-use/decorative LED lamps. If this incentive had not been offered this year, would the number of **general-use/decorative LED lamps** you will sell in 2017 have been about the same or lower?

1 Same [GO TO D2a]

2 Lower [GO TO D2b]

98 (Don't know) [GO TO D4]

99 (Refused) [GO TO D4]

D2a. **[IF SAME]** Just to confirm... without the program incentive, you would have sold the same number of general-use/decorative LED lamps this year?

D2b. **[IF LOWER]** In your estimation, by what percentage would the number of general-use/decorative LED lamps you sold have been lower in 2017 if the Business Energy Rebates Program incentive was not available?

RECORD PERCENTAGE ____%

RECORD EXPLANATION:

D4. I am interested in understanding the impact of the Business Energy Rebates program on customers' product choice. Using a scale from 0 to 10, where 0 is "not at all important" and 10 is "extremely important," how would you rate the program's influence on your customers' choice of general-use/decorative LED lamps instead of incandescent bulbs or CFLs?

RECORD RATING: _____

RECORD EXPLANATION:

D6. Is the current incentive of \$3 per lamp sufficient to encourage customers who would not have done so otherwise to purchase general-use/decorative LED lamps? Why?

D7. Through the Business Energy Rebates Program, only products meeting program's criteria, such as DLC or ENERGY STAR certifications, are eligible for rebate. I would like to understand the impact of the program on the models of products your company carries. Using a scale from 0 to 10, where 0 is "not at all important" and 10 is "extremely important", how would you rate the program's influence on the proportion of ENERGY STAR certified general-use/decorative LED lamps carried by your company?

RECORD RATING: _____

RECORD EXPLANATION:

Section S: Satisfaction and Recommendation

Ask all respondents

S1. On a scale from 1 to 10 (where 1 = not at all satisfied and 10 = very satisfied)...

- › How would you rate your satisfaction with each of the following aspects?
- › If less than 8, please explain the reason(s) for your score.

Aspects of the program	Score	Reason
S1. The overall program		
S2. The program support and communications provided by ENS		
S3. The rebate processing, tracking and reporting		

S4. Finally, do you have any suggestions to improve the program?

Record: _____

☐ No suggestion at this time

Those are all the questions I have for you today. Would you like to add anything else regarding the program or talk about any other topic that was not covered during the interview?

THANK YOU FOR TAKING THE TIME TO TAKE PART IN THIS INTERVIEW.

Appendix VIII

BER: MAIL-IN EFFECTIVE USEFUL LIFE

This appendix presents the revised equivalent effective useful life (EUL) of product types offered in the BER-Mail-in service. First, the EUL of lighting products are presented, followed by the other types of measures rebated through the program.

Lighting Measures

The Evaluator reviewed the tracked EUL values of each lighting measure type. The EUL was obtained by dividing the rated lifetime of lamps or fixtures by the annual HOU, and then adjusted to account for increases in baselines throughout the lifetime of the measure to obtain the equivalent EUL. This value corresponds to the number of years by which the first-year savings estimate is multiplied to obtain lifetime energy savings. A summary of the revised equivalent EUL values by product type are presented in Table 5 at the end of this subsection. The following provides details on the methodology for establishing equivalent EUL values for LED lamps and fixtures.

The Evaluator used the annual HOU values from BER Instant Rebates since there are no fixed HOU values determined for Mail-in. The Evaluator also consulted the specification sheets of the most popular products of each measure type to establish their rated lifetimes.

Changes in regulation and baseline evolution

The Evaluator examined the possibility of the baseline increasing over the lifetime of the product for general-use lamps, decorative lamps, reflector lamps, and LED downlight fixtures (for which the typical baseline would be a fixture using general-use or reflector lamps). This analysis was based on current and projected Canadian regulations for general service lamps. For other measures, since no major upgrades in energy efficiency requirements are planned in Canada, it was assumed that the baseline will remain unchanged throughout the measure EUL.

The current Canadian regulation bans the import of 40 W, 60 W, 75 W and 100 W incandescent general-use lamps, imposes minimum efficiency to be achieved by efficient incandescent light bulbs (also called halogen incandescent light bulbs),⁵ and reflects U.S. federal legislation.

The U.S. Energy Independence and Security Act (EISA) will raise the minimum efficiency of general service lamps in 2020.⁶ This regulation will affect general-use, decorative and reflector lamps generating more than 310 lumens, for which a minimum efficiency of 45 lumens/watt is expected.

⁵ Natural Resources Canada. *Energy Efficiency Regulations. General Service Lamps and Modified Spectrum Incandescent Lamps*, www.nrcan.gc.ca/energy/regulations-codes-standards/products/6869 (Last accessed January 24, 2018).

⁶ US EPA. "Summary of the Energy Independence and Security Act. Public Law 110-140 (2007)". Online: www.epa.gov/laws-regulations/summary-energy-independence-and-security-act.

Natural Resources Canada has included an update to the general service lamps minimum energy performance requirement in Amendment 16 which is planned for pre-consultation in 2019⁷ (and should therefore be applied within a few years thereafter). This update will likely align the Canadian regulation with EISA 2020. Since this regulation will effectively ban the import and fabrication of efficient incandescent light bulbs, these are still expected to be available in retail outlets until incandescent stocks are depleted for up to two years after the legislation is implemented. With this information, the Evaluator reached the conclusion that the baseline change will occur in 2024.

The following paragraphs discuss the lamp types for which baseline increases will occur during their EUL, namely general-use and decorative lamps, reflector lamps, non-recessed downlight fixtures, and recessed downlight fixtures.

General-use and decorative lamps

The methodology used for establishing the equivalent EUL of general-use and decorative lamps is based on the information presented in Table 2 and the equation below. The equivalent EUL calculation is based on 9 W lamps being the most common product purchased for these list categories in 2017 BER Instant Rebates. The baseline technology is a mix of 60 W incandescent lamps and 43 W halogen incandescent lamps, which yields an average baseline of 52 W.

Since incandescent lamps can no longer be replaced by incandescent lamps, there is a first increase in the baseline upon burnout. The Evaluator assumes these lamps have a remaining lifetime of 1,000 hours, which translates to 0.23 years with an annual HOU of 4,410 hours. However, since BER Mail-in targets commercial participants, the Evaluator assumes that some participants might have incandescent lamps stocked, and therefore the duration of this baseline was increased to a full year. Based on the LED A-type lamp rated life of 25,000 hours, the EUL of this product is 5.7 years, meaning the corresponding baseline will not be affected by the change in legislation occurring seven years from now in 2024. Therefore, halogen incandescent lamps are considered to be the baseline technology for the remaining lifetime of LED A-type lamps. With the information presented in Table 2 **Erreur ! Source du renvoi introuvable.**, the following equation sets the equivalent EUL of general-use lamps at 4.7 years.

$$\begin{aligned} \text{Equivalent EUL} &= \frac{\Delta W_{\text{Halogen Incandescent and Incandescent}} \times 1 \text{ years} + \Delta W_{\text{Halogen Incandescent}} \times 4.7 \text{ years}}{\Delta W_{\text{Halogen Incandescent}}} \\ &= 4.7 \text{ years} \end{aligned}$$

⁷ Natural Resources Canada. "Forward Regulatory Plan 2017-19". Online: <http://www.nrcan.gc.ca/energy/regulations-codes-standards/18318>, (last modified July 25, 2017).

Table 2: Baseline Evolution During the Effective Useful Life of LED A-type Lamps

Typical Replaced Lamp (W)	Typical Efficient Lamp (W)	Halogen Incandescent and Incandescent Baseline 1 year (2017)		Halogen Incandescent Baseline 4.7 years (2018-2022)	
		Baseline (W)	Displaced Wattage (W)	Baseline (W)	Displaced Wattage (W)
43	9	52	43	43	34

Reflector lamps

LED reflector lamps typically replace halogen lamps. Their average rated life is estimated at 25,000 hours, which translates to an EUL of 5.7 years. The baseline for this lighting product will therefore not increase throughout its EUL and so the equivalent EUL is equal to the EUL of 5.7 years.

Non-recessed downlight fixtures

Since non-recessed LED downlight fixtures replace fixtures using A-type lamps, the methodology for establishing their equivalent EUL is similar to what was described for A-type lamps. Once again, the equivalent EUL calculation is based on an example with 9 W LED lamps and their first baseline increase occurs one year following the anticipated burnout of incandescent lamps. However, since their rated life of 50,000 hours and corresponding EUL of 11.3 years are longer, their baseline is affected by the change in regulation occurring in 2024. In other words, a second baseline increase will occur in 2024 (after changing from a baseline mix of 43 W halogen incandescent lamps and 60 W incandescent lamps to a 43 W halogen incandescent baseline in 2018). Starting in 2024 and for the remaining lifetime of the fixture (4.3 years), the baseline will be a 20 W CFL equivalent lamp. The equation and Table 3 below present the information used to calculate the equivalent EUL of 6.8 years.

Equivalent EUL

$$\begin{aligned}
 &= \frac{\Delta W_{\text{Halogen Incandescent and Incandescent}} \times 1 \text{ year} \times \Delta W_{\text{Halogen Incandescent}} \times 6 \text{ years} \times \Delta W_{\text{CFL}} \times 4.3 \text{ years}}{\Delta W_{\text{Halogen Incandescent}}} \\
 &= 6.8 \text{ years}
 \end{aligned}$$

Table 3: Baseline Evolution During the Effective Useful Life of LED A-type Lamps for Downlight Fixtures

Typical Replaced Lamp (W)	Typical Efficient Lamp (W)	Halogen Incandescent and Incandescent Baseline 1 year (2017)		Halogen Incandescent Baseline 6 years (2018-2023)		CFL Equivalent Baseline American Legislation ⁸ 4.3 years (2024-2028)	
		Baseline (W)	Displaced Wattage (W)	Baseline (W)	Displaced Wattage (W)	Baseline (W)	Displaced Wattage (W)
43	9	52	43	43	34	20	11

Recessed downlight fixtures

LED recessed downlight fixtures typically replace fixtures housing reflector lamps for which the baseline technology is halogen lamps. The EUL of LED recessed downlight fixtures is established at 11.3 years based on a rated life of 50,000 hours. The equivalent EUL calculation is based on the typical case 12 W LED reflector lamp replacing a 43 W halogen lamp. As previously mentioned, Canadian regulations are expected to change in 2024, which will increase the baseline to an equivalent CFL. Therefore, after 43 W halogen lamps being the baseline technology for seven years, 20 W CFL equivalent lamps will become the baseline for the remaining lifetime of LED recessed downlight fixtures (4.3 years). The equivalent EUL of 8.8 years was calculated with the information presented in Table 4.

$$\text{Equivalent EUL} = \frac{\Delta W_{\text{Halogen}} \times 7 \text{ years} + \Delta W_{\text{CFL}} \times 4.3 \text{ years}}{\Delta W_{\text{Halogen}}} = 8.8 \text{ years}$$

Table 4: Baseline Evolution During the Effective Useful Life of LED Reflector Lamps in Downlight Fixtures

Typical Replaced Lamp (W)	Typical Efficient Lamp (W)	Halogen Baseline 7 years (2017-2023)		CFL Equivalent Baseline American Legislation ⁹ 4.3 years (2024-2028)	
		Baseline (W)	Displaced Wattage (W)	Baseline (W)	Displaced Wattage (W)
43	12	48	31	20	13

Other lighting products

For products other than general-service lamps, there is no indication that regulations will significantly change over the lifetime of these products. Furthermore, in the case of linear ambient luminaires, linear replacement lamps, and metal halide lamps, the typical baseline products are already more efficient than the current regulation, which further suggests that a change in regulations would not affect the baseline efficiency in the near future.

⁸ As imposed by U.S. federal legislation. Incandescent Equivalent 2nd Tier EISA 2007.

⁹ As imposed by U.S. federal legislation. Incandescent Equivalent 2nd Tier EISA 2007.

ENS tracked an EUL value of 10 years for occupancy sensors. The Evaluator found that the most common values used in other jurisdictions for occupancy sensors is either eight or 10 years, based on a 2007 GDS report¹⁰ and the Database for Energy Efficiency Resources (DEER) 2008¹¹ respectively. The Evaluator therefore agrees with ENS that an EUL of 10 years is justified.

A summary of the EUL and equivalent EUL of all lighting product types offered in BER Mail-in is presented in Table 5.

¹⁰ GDS Associates. *Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures*, June 2007.

¹¹ Database for Energy Efficiency Resources (DEER), *DEER 2008 EUL Table*, 2008.

Table 5: Revised Equivalent Effective Useful Life Values by Lighting Measure Category

Lighting Measure	List Category	Rated Life (hours)	Annual HOU	Tracked EUL (years)	EUL (years)	Equivalent EUL (years)
BER Instant Rebate Measures						
Linear LED Fixtures	1 x 4 Luminaires	50,000	4,410	14	11.3	11.3
	2 x 2 Luminaires & Retrofit Kits					
	2 x 4 Luminaires & Retrofit Kits					
	Linear Ambient & Low Bay Luminaires					
Linear LED Lamps	4-foot Replacement Lamps	50,000	4,410	10	11.3	11.3
	2-foot Replacement Lamps					
General-use and Decorative LED Lamps	LED Decorative (chandelier)	25,000	4,410	13.6 or 14	5.7	4.7
	LED Omnidirectional (A-lamp and globe)					
Reflector LED Lamps	Small LED Reflector Lamp - PAR, MR, MRX 16	25,000	4,410	13.6	5.7	5.7
	Small LED Reflector Lamp - PAR, R 20					
	Large LED Reflector Lamp - PAR, BR, R 30/30L					
	Large LED Reflector Lamp - PAR, BR, R 38/40					
LED Downlight Fixtures	LED Recessed	50,000	4,410	14	11.3	8.8
	LED Ceiling Mount, LED Surface Mount, LED Solid State Retrofit, LED Inseparable Solid State Luminaire, LED Wall Sconces, LED Wall Sconce Retrofit	50,000	4,410	14 or 14.2	11.3	6.8
Outdoor LED Fixtures	Outdoor Full-cutoff Wall-mounted Area Luminaires	50,000	4,380	18	11.4	11.4
	Flood and Spot Luminaires	75,000	4,380	15	17.1	17.1
Directional and Architectural LED Fixtures	Track or Mono-point Directional Luminaires	50,000	4,410	10	11.3	11.3
Occupancy Sensors	Ceiling Remote-mounted	-	-	10	10	10
	Wall Remote-mounted					
	Fixture Mounted					
	Wall Switch					
	Exterior					

Lighting Measure	List Category	Rated Life (hours)	Annual HOU	Tracked EUL (years)	EUL (years)	Equivalent EUL (years)
Additional BER Mail-In Measures						
Linear LED Fixtures	High-bay Luminaires	100,000	4,410	12	22.7	22.7
	Troffers	90,000	4,410	14	20.4	20.4
Case Lighting	Case Lighting for Sign Retrofit Applications	50,000	4,410	15	11.3	11.3
Refrigerated Case Lighting	Strip Lighting	70,000	4,410	8	15.9	15.9
Outdoor LED Fixtures	Fuel Pump Canopy Luminaires	50,000	4,380	15	11.4	11.4
	LED Replacement for HID Lamps	50,000	4,380	18	11.4	11.4
	Non-cutoff and Semi-cutoff Wall-mounted Area Luminaires	80,000	4,380	18	18.3	18.3
	Pole/Arm-mounted Area Luminaires	60,000	4,380	8	13.7	13.7
	Parking Garage Luminaires	100 000	4,380	18	22.8	22.8
Other	Stairwell and Passageway Luminaires	60,000	4,380	14	13.7	13.7

Other Products

For product types other than lighting, the Evaluator established the EULs listed in Table 6. The EUL values of all measures eligible for the program component were reviewed based on the findings of a literature review. When establishing the EUL for a given measure, the Evaluator considered the most common values found in technical reference manuals, evaluation reports and relevant studies. The sources that based EUL estimates on measured data or other reliable methods were preferred when available.

Table 6: Revised Equivalent Effective Useful Life Values by Measure Category

Measure Category	Measure	Revised EUL (years)	Reference
Agriculture	Agriculture heat pads	10	IESO PMA, 2015 ¹²
	Dairy scroll compressors	15	PA Consulting Group, 2009 ¹³
	Energy efficient ventilation and circulation fans	15	GDS, 2007 ¹⁴ PA Consulting Group, 2009
	Heat reclaimer units	15	Pennsylvania TRM, 2016 ¹⁵
	High-volume low-speed fans	15	PA Consulting Group, 2009 DEER, 2008
	Low-energy and zero-energy livestock waterers	10	PA Consulting Group, 2009
	Milk pre-coolers	15	PA Consulting Group, 2009
	Natural and dual ventilation	15	IESO PMA, 2015
	Tractor engine block heater timers	5	Minnesota TRM, 2016 ¹⁶
	VFD for milk vacuum pumps	15	DEER, 2008 PA Consulting Group, 2009
Compressed Air	Air entraining air nozzles	15	PA Consulting Group, 2009
	Air receiver for load/no load screw compressors	15	PA Consulting Group, 2009 ERS 2005 ¹⁷
	Cycling air dryers	10	PA Consulting Group, 2009
	No loss drains	15	ERS, 2005
	VFD screw compressors	15	ERS, 2005

¹² Independent Electricity System Operator. *IESO Prescriptive Measures and Assumptions List*, October 2015. Accessed January 10, 2018 from IESO database.

¹³ PA Consulting Group. *Focus on Energy Evaluation Business Programs: Measure Life Study*, August 25, 2009.

¹⁴ GDS Associates. *Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures*, June 2007.

¹⁵ Pennsylvania Public Utility Commission, *Technical Reference Manual – State of Pennsylvania*, June 2016. Errata Update February 2017.

¹⁶ Minnesota Department of Commerce Division of Energy Resources, *State of Minnesota Technical Reference Manual for Energy Conservation Improvement Programs Version 2.1 Final*, December 2016.

¹⁷ Energy & Resource Solutions. *Measure Life Study Report prepared for The Massachusetts Joint Utilities*, 2005.

Measure Category	Measure	Revised EUL (years)	Reference
HVAC	Air source heat pumps greater than or equal to 65,000 BTU/hr;	18	GDS, 2007
	Air source heat pumps less than 65,000 Btu/hr (excluding air-to-water)	18	GDS, 2007
	Air-to-water heat pumps;	18	GDS, 2007
	Commercial heat pump clothes dryers	11	DEER, 2014
	Ground source heat pumps;	25	Estimation by the DOE ¹⁸
	HVAC hotel occupancy sensors	8	DEER, 2008
	Packaged terminal heat pumps (PTHP)	15	GDS, 2007
	Water source heat pumps;	15	GDS, 2007 ERS, 2005 DEER, 2008, 2014
HVAC/Kitchen	Dual-enthalpy economizer controls	10	ERS, 2005 GDS, 2007
IT & Datacenters	Server-based power management software	5	Illinois TRM, 2017 ¹⁹ Pennsylvania TRM, 2016
Kitchen	Demand controlled kitchen exhausts	15	PG&E Workpapers, 2004, 2007, 2012 DEER, 2014
	Dishwashers	10 or 15	ENERGY STAR Calculator ²⁰ 10 for under the counter, 15 for door type
	Freezers/refrigerators	12	DEER, 2008, 2011, 2014 ENERGY STAR Calculator GDS, 2007
	Fryers	12	DEER, 2008, 2011 ENERGY STAR Calculator PG&E, 2007
	Griddles	12	DEER, 2008, 2011 ENERGY STAR Calculator
	Hot food holding cabinets	12	DEER, 2008, 2011 ENERGY STAR Calculator PG&E, 2007

¹⁸ U.S. Department of Energy, *Geothermal Heat Pumps*, <https://energy.gov/energysaver/heat-and-cool/heat-pump-systems/geothermal-heat-pumps#306534-tab-1> (last accessed February 15, 2018).

¹⁹ Illinois Energy Efficiency Stakeholder Advisory Group, *Illinois Statewide Technical Reference Manual for Energy Efficiency Version 6.0*, February 2017.

²⁰ ENERGY STAR, *Commercial Food Service Equipment*, https://www.energystar.gov/products/commercial_food_service_equipment (last accessed January 19, 2018).

Measure Category	Measure	Revised EUL (years)	Reference
	Ice machines	10	DEER, 2008, 2011, 2014 PA Consulting Group, 2009
	Ovens	12	DEER, 2008, 2011 ENERGY STAR Calculator PG&E, 2007
	Steam cookers	12	DEER, 2008, 2011 ENERGY STAR Calculator
Laundry	Commercial clothes dryers (NG conversion)	14	Vermont TRM, 2015 ²¹
	Commercial washing machines	11	DEER 2011 Department of Energy, 2016 ²²
Motors and VFDs	Brushless DC motors	15	PA Consulting Group, 2009 ERS, 2005 DEER, 2008
	Energy efficient motors	15	DEER, 2014
	Variable Frequency Drives	15	DEER, 2008 ERS, 2005 Navigant, 2013 ²³
Pumping	High efficiency circulator pumps	15	PA Consulting Group, 2009
Refrigeration	Display case strip curtains	4	DEER, 2014
	Door heater controls	12	DEER, 2004 and 2008
	Efficient refrigeration compressors	15	DEER, 2014 ERS, 2005
	Evaporator fan motor controls	10	ERS, 2005
	Intelligent freezer defrost controls	10	ERS, 2005
	Refrigerated vending machine controllers	5	DEER, 2008, 2014 ERS, 2005
	Refrigeration economizers	15	Illinois TRM, 2017 Vermont TRM, 2015
	Vertical refrigeration open to closed cooler conversions	12	DEER, 2008
	Zero energy doors	12	DEER 2008
Solar	Solar water heaters	20	ENERGY STAR ²⁴
Water Heating	Electric to natural gas water heating	15	DEER, 2014
	Heat pump water heaters	10	DEER, 2008, 2014

²¹ Efficiency Vermont, *Technical Reference User Manual Measure Savings Algorithms and Cost Assumptions*, March 2015.

²² William Goetzler et al., *Energy Savings Potential and RD&D Opportunities for Commercial Building Appliances*, U.S. Department of Energy, June 2016.

²³ Navigant. *Incremental Cost Study Phase Two Final Report*. Burlington, MA, 2013.

²⁴ ENERGY STAR, *Save Money and More with ENERGY STAR Qualified Solar Water Heaters*, https://www.energystar.gov/products/water_heaters/water_heater_solar/benefits_savings (last accessed January 15, 2018).

Appendix IX

BER: ALGORITHM FOR FREE-RIDERSHIP CALCULATION

The figures below present the algorithms for calculating the free-ridership level of BER Mail-in and Instant rebates measures. The participant survey questionnaires included questions designed to assess the planning, quantity, efficiency, timing, cost and influence of the program. Each group of questions was transposed into a level of program attribution, which was used to calculate the free-ridership level associated with each participant. The BER Instant Rebates distributor interview guide included questions designed to assess the quantity, cost and influence of the service.

BER Mail-in Participant Survey

FR2. If your organization had not received the rebate from ENS, would you have paid the full cost of the energy-efficient measures? (Scale 0 to 10)	IF DK OR REF: FR2 = EMPTY OTHERWISE: FR2 = Answer x 10%
FR3a_2. [ASK IF MEASURE CATEGORY=LIGHTING] Were you aware that the lighting products rebated through the Business Energy Rebates Program are premium products certified by Design Light Consortium or ENERGY STAR®?	IF 1. Yes: Use FR3a_1 or 3 IF 2. No OR DK OR REF: FR3a_1 or 3 = 0%
FR3a_1 or 3. [ASK IF MEASURE CATEGORY <> LIGHTING] If BER had not been offered, what is the likelihood that you would have implemented exactly the same energy-efficient measures that was rebated through the BER Program? (Scale 0 to 10) [ASK IF MEASURE CATEGORY=LIGHTING] If BER rebate had <u>not been</u> offered, what is the likelihood that you would have purchased the exact same model of lighting products? (Scale 0 to 10)	IF DK OR REF: FR3a_1 or 3 = EMPTY OTHERWISE: IF Pre-FR2 = Yes: FR3a_1 or 3 = (Answer x 10%) / 2 OTHERWISE: FR3a_1 or 3 = Answer x 10%
PA1 Score:	MEAN VALUE OF: (FR2; FR3a_1 or 3)
FR1. Had your organization already decided to implement energy-efficient measures before you heard about the BER Program?	IF Yes: Use FR1a IF DK OR REF OR No: FR1 = 0%
FR1a. [ASK IF FR1=1] I just want to make sure I understand - Before you decided to participate in BER, you had already made the decision to implement the energy-efficient measures?	IF Yes: FR1 = 100% IF DK OR REF OR No: FR1 = 0%
PA2 Score:	IF Pre-FR1 = Yes: FR1 / 2 OTHERWISE: FR1
FR4. Level of influence (Scale 0 to 10) Factors a, b and c	FR4 = MAX(FR4a; FR4b; FR4c)
PA3 Score:	(10 – FR4) x 10%
FR3c. [ASK IF FR2≥ 5] If the program rebate had not been offered, what is the likelihood that you would have postponed implementing the measures by at least one year?	FR3c = (10 – Answer) x 10% IF DK OR REF: FR3c = EMPTY

PA4 Score:	IF Pre-FR3 = Yes: FR3c / 2 OTHERWISE: FR3c
FR3b. [ASK IF MEASURE CATEGORY = LIGHTING AND TOTAL MEASURE CATEGORY QTY>1] If BER rebate had <u>not been</u> offered, what is the likelihood that you would have implemented exactly the same <u>quantity</u> of lighting products that you installed through BER?	FR3b = Answer x 10% IF DK OR REF: FR3b = EMPTY
PA5 Score:	FR3b
Inconsistency Test PA1	IF ABS(FR2 - FR3a_1 or 3) ≥ 50% PA1 = MIN (FR2; FR3a_1 or 3)
Inconsistency Test PA2	IF FR1a = 100% AND FR2 < 70% PA2 = EMPTY
Inconsistency Test PA5	IF FR2 < 70% PA5 = EMPTY
Free-Ridership	IF MIN(PA4; PA5) < MEAN (PA1; PA2; PA3) FR = MEAN (PA1; PA2; PA3; MIN(PA4; PA5)) OTHERWISE FR = MEAN (PA1; PA2; PA3)
CI2/4a. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] was a major factor in your decision to implement an energy-efficient measure. CI2/4b. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted a company representative to ask a contractor or a technical staff member to examine the energy efficiency options for the facility. CI2/4c. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted a company representative to take into account the cost-effectiveness of energy-efficient measures when evaluating different options for the facility. (Agree or Disagree)	CI = IF(CI2a OR CI4a = Agree; 1) + IF(CI2b OR CI4b = Agree; 1) + IF(CI2c OR CI4c = Agree; 1)
Revised Free-Ridership	IF CI = 0 OR 1, Revised FR = FR IF CI = 2, Revised FR = FR*.75 IF CI = 3, Revised FR = FR*.50

BER Instant Rebates Participant Survey

FR2. If your organization had not received the rebate and the cost for [PRODUCT] had been about \$[REBATE AVERAGE VALUE BY CATEGORY] higher, would you have paid the full cost of the [PRODUCT]? (Scale 0 to 10)	IF DK OR REF: FR2 = EMPTY OTHERWISE: FR2 = Answer x 10%
FR3a. If BER rebate had <u>not been</u> offered, what is the likelihood that you would have purchased the exact same model of premium lighting products? (Scale 0 to 10)	IF DK OR REF: FR3a = EMPTY OTHERWISE: FR3a = Answer x 10%
PA1 Score:	MEAN VALUE OF: (FR2; FR3a)
FR1b. Had your organization <i>already</i> decided to purchase [PRODUCT] <i>before</i> knowing the price of those products?	IF Yes: FR1 = 100% IF DK OR REF OR No: FR1 = 0%
PA2 Score:	FR1
FR4. Level of influence (Scale 0 to 10) Factors a, b and c	FR4 = MAX(FR4a; FR4b; FR4c)
PA3 Score:	(10 – FR4) x 10%
FR3b. [ASK IF TOTAL MEASURE CATEGORY QTY>1] If the rebate had <u>not been</u> offered, what is the likelihood that you would have purchased exactly the same <u>quantity</u> of lighting products that you bought?	FR3b = Answer x 10% IF DK OR REF: FR3b = EMPTY
FR3c. [ASK IF FR2≥ 5] If the program rebate had <u>not been</u> offered, what is the likelihood that you would have postponed the purchase of the lighting products by at least one year?	FR3c = (10 – Answer) x 10% IF DK OR REF: FR3c = EMPTY

PA4 Score:	Min (FR3b; FR3c)
Inconsistency Test PA1	IF ABS(FR2 - FR3a) ≥ 50% PA1 = MIN (FR2; FR3a)
Inconsistency Test PA2	IF FR1 = 100% AND FR2 < 70% PA2 = EMPTY
Free-Ridership	IF PA4 < MEAN (PA1; PA2; PA3): MEAN (PA1; PA2; PA3; PA4) OTHERWISE MEAN (PA1; PA2; PA3)
CI2/4a. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] was a major factor in your decision to implement an energy-efficient measure. CI2/4b. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted a company representative to ask a contractor or a technical staff member to examine the energy efficiency options for the facility. CI2/4c. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted a company representative to take into account the cost-effectiveness of energy-efficient measures when evaluating different options for the facility. (Agree or Disagree)	$CI = IF(CI2a \text{ OR } CI4a = \text{Agree}; 1) +$ $IF(CI2b \text{ OR } CI4b = \text{Agree}; 1) +$ $IF(CI2c \text{ OR } CI4c = \text{Agree}; 1)$
Revised Free-Ridership	IF CI = 0 OR 1, Revised FR = FR IF CI = 2, Revised FR = FR*.75 IF CI = 3, Revised FR = FR*.50

BER Instant Rebates – Distributor Interview

FR1. [ASK IF SALES DATA AVAILABLE] If the current trend is maintained, you should sell [FROM SAMPLE: fewer / more] [EFFICIENT PRODUCT] by the end of 2017 than the number of units you sold in 2016. Does this sound accurate? If so, what explains this shift? [ASK IF SALES DATA NON AVAILABLE] If the current trend is maintained, do you think you will sell more, less or the same number of [EFFICIENT PRODUCT] by the end of 2017 than the number of units you sold in 2016? If "more" or "less", how do you explain the difference?	IF DK OR REF: FR1 = EMPTY OTHERWISE: FR1 = Answer
FR2. In 2017, the Business Energy Rebates Program provided a per-unit incentive ranging from [REBATE RANGE], depending on the type of [EFFICIENT PRODUCT]. If this incentive had not been offered this year, would the number of [EFFICIENT PRODUCT] you will sell in 2017 have been about the same or lower? 1. Same [GO TO F2a] 2. Lower [GO TO F2b] 98. (Don't know) [GO TO F4] 99. (Refused) [GO TO F4]	IF DK OR REF: FR2 = EMPTY OTHERWISE: FR2 = Answer
FR2a. [IF FR2 = SAME] Just to confirm... without the program incentive, you would have sold the same number of [EFFICIENT PRODUCT] this year? RECORD EXPLANATION:	IF YES: FR2a = 0% OTHERWISE: Use FR2b
FR2b. [IF FR2 = LOWER] In your estimation, by what percentage would the number of linear [EFFICIENT PRODUCT] you sold have been <u>lower</u> in 2017 if the Business Energy Rebates Program incentive was not available? RECORD PERCENTAGE ____% RECORD EXPLANATION:	FR2b = Answer %
PA1 Score:	100 % – (FR2a or FR2b)
FR4. I am interested in understanding the impact of the Business Energy Rebates program on customers' product choice. Using a scale from 0 to 10, where 0 is "not at all important" and 10 is "extremely important", how would you rate the program's influence on your customers' choice of [EFFICIENT PRODUCT] instead of [BASELINE PRODUCT]? RECORD RATING: _____ RECORD EXPLANATION:	FR4 = Answer
PA2 Score:	(10 - FR4) x 10 %

FR6. Is the incentive ranging from [REBATE RANGE] per fixture sufficient to encourage customers who would not have done so otherwise to purchase [EFFICIENT PRODUCT]? Why?

FR6 = Answer

FR7. Through the Business Energy Rebates Program, only products meeting program's criteria, such as DLC or Energy Star certifications, are eligible for rebate. I would like to understand the impact of the program on the models of products your company carries. Using a scale from 0 to 10, where 0 is "not at all important" and 10 is "extremely important", how would you rate the program's influence on the proportion of DLC certified [EFFICIENT PRODUCT] carried by your company?

RECORD RATING: _____

RECORD EXPLANATION:

FR7 = Answer

PA3 Score:

(10 – FR7) x 10%

Inconsistency Test PA1, PA2, PA3

IF EXPLANATION DOES NOT FIT
PERCENTAGE/RATING
PA SCORE = EMPTY

Free-Ridership

MEAN (PA1; PA2; PA3)

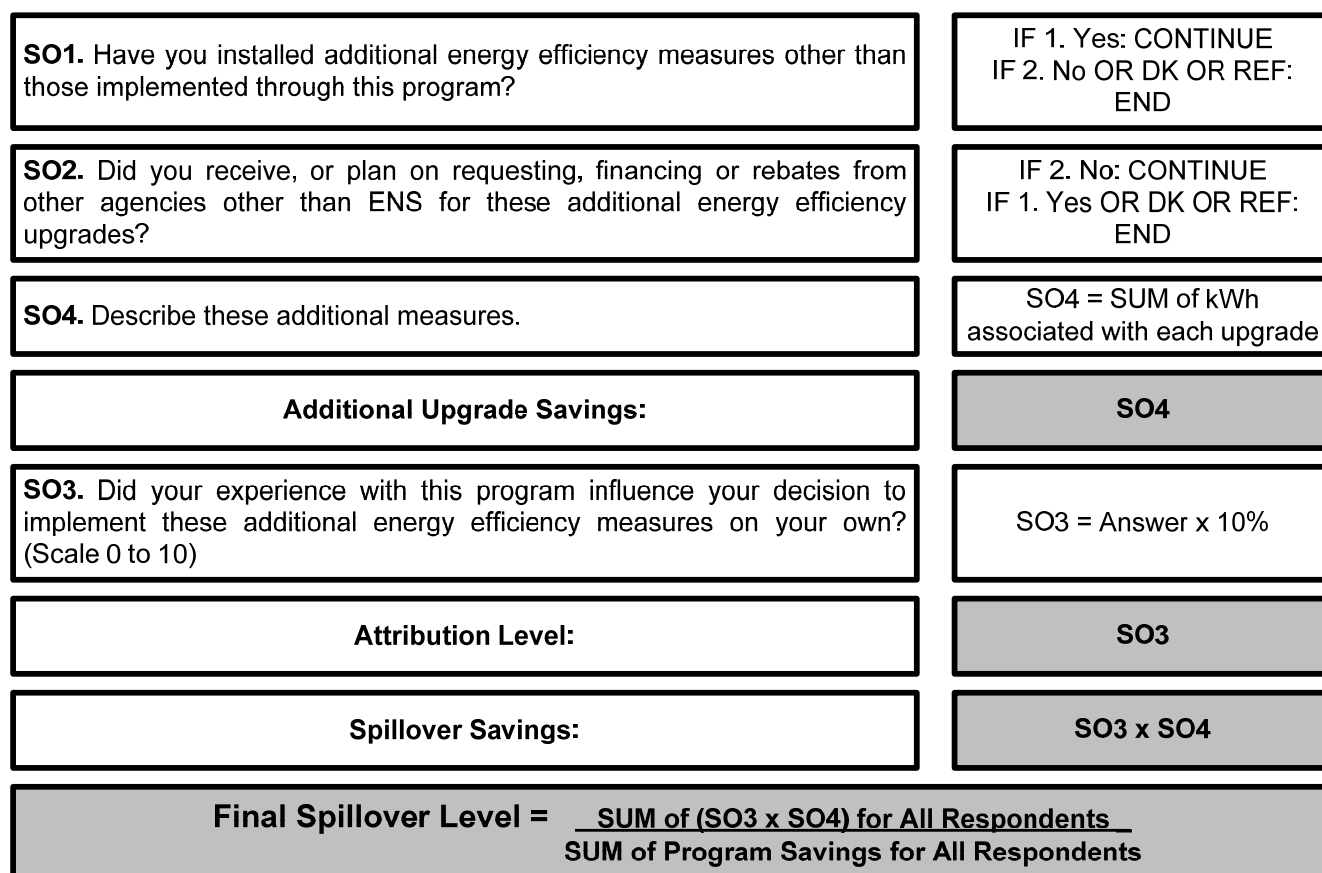
Appendix X

BER: ALGORITHM FOR INTERNAL SPILLOVER CALCULATION

Internal spillover for BER Mail-in was measured using a participant survey conducted during the on-site visits. Participants were asked whether, following their participation in BER, they implemented any additional energy efficiency measures, without benefitting from any rebates or financing offered by ENS programs. If a participant did admit to having implemented additional recommended measures, another question was asked to quantify the level of influence the program had on the participant's decision to implement these additional measures. The value established regarding this level of influence was used to determine the portion of the additional savings attributable to the program. Then for each additional energy efficiency measure identified, the participant was asked a set of questions designed to identify the additional energy efficiency measures implemented and to quantify their associated savings (type of measure, quantity, efficiency level, etc.).

The level of internal spillover was established by dividing the total quantity of the additional savings attributable to the program by the total quantity of savings achieved by the program for all the survey respondents.

The figure below illustrates the methodology used to calculate the internal spillover level.



Appendix XI

BER: ADJUSTMENT RATIO CALCULATION EXAMPLE

This appendix presents a sample calculation to demonstrate the process of revising energy and peak demand savings. Lighting measures accounted for over half the tracked energy and peak demand savings for BER Mail-in in 2017. Therefore, one of the lighting measures has been chosen to exemplify the calculation details for the following:

- › Algorithms for calculating energy and peak demand savings;
- › Comparison of the calculation of tracked energy and peak demand savings and the calculation of revised energy and peak demand savings; and
- › Algorithm for establishing the adjustment ratio.

Energy and Peak Demand Savings Algorithms

The following algorithms include the parameters required to determine the annual energy savings and the annual peak demand savings associated with a linear lamp replacement measure.

$$\text{Energy Savings} \left[\frac{\text{kWh}}{\text{yr}} \right] = \frac{((\text{Wattage}_{\text{Baseline}} \times \text{BF}) - (\text{Wattage}_{\text{Efficient}})) \times \text{Qty} \times \text{Hrs} \times \text{IE}}{1,000 \text{ W/kW}}$$

$$\text{Peak Demand Savings} \left[\frac{\text{kW}}{\text{yr}} \right] = \frac{((\text{Wattage}_{\text{Baseline}} \times \text{BF}) - (\text{Wattage}_{\text{Efficient}})) \times \text{Qty} \times \text{IE} \times \text{CF}}{1,000 \text{ W/kW}}$$

Where:

- › $\text{Wattage}_{\text{Baseline}}$: the existing nominal (bare) lamp wattage
- › $\text{Wattage}_{\text{Efficient}}$: the system wattage of the efficient lamp
- › BF : the ballast factor for fluorescent lamps (normal $\text{BF} = 0.88$)
- › Hrs : the annual hours of operation
- › Qty : the quantity of lamps
- › IE : the interactive effects factor based on the location of the lighting measure
- › CF : the coincidence factor
- › $1,000 \text{ W/kW}$: conversion from watts to kilowatts

Tracked Savings Calculation

For the existing lighting measure, ENS used the lamp wattage stated in the BER Mail-in participant application. The proposed measure wattage was obtained from the product specification sheet submitted with the application.

Table 7 presents the values used for the specific case of 295 W High Pressure Sodium lamps that were replaced with 170 W lamps.

Table 7: Tracked Variables for Example Calculation

Baseline Measure – 295 W High Pressure Sodium Lamp		
Parameter	Value	Source
Existing Lamp Quantity	33	Tracking Report
Decommissioned Lamp Wattage (W)	295	Tracking Report
Hours of Use per Week	40	Tracking Report
Hours of Use (hrs/year)	2,085	Calculation Based on 52 Weeks per Year
Interactive Effects Factor (energy)	1	Tracking Report
Interactive Effects Factor (demand)	1	Tracking Report
Peak Coincidence Factor	0	Tracking Report
Annual Energy Consumption (kWh)	20,303	Calculation
Annual Peak Demand (kW)	0	Calculation
New Measure – 170 W Lamp		
Proposed Lamp Quantity	33	Tracking Report
Proposed Lamp Wattage	170	Tracking Report
Proposed Hours per Week	40	Tracking Report
Hours of Use (hrs/year)	2,085	Calculation Based on 52 Weeks per Year
Interactive Effects Factor (energy)	1	Tracking Report
Interactive Effects Factor (demand)	1	Tracking Report
Peak Coincidence Factor	0	Tracking Report
Annual Energy Consumption (kWh)	11,700	Calculation
Annual Peak Demand (kW)	0	Calculation
Tracked Savings		
Tracked Energy Savings (kWh)	8,603	Tracking Report
Tracked Demand Savings (kW)	0	Tracking Report

Revised Savings Calculation

The revised savings calculations are based on three adjustments. The first adjustment was to revise hours of use based on participant declarations during the on-site visit.

The second adjustment was the revision of the total lamp quantity based on the on-site count.

The final adjustment was revising the interactive effects (IE) factor. Interactive effects factors are calculated by building type. Each building type is also broken down into IE factors for electric heating, electric cooling, and a combination of electric heating and cooling systems. The appropriate IE factors are then applied to each measure according to identified building type.

A summary of the IE factors that were used for the measure treated in this example, based on the fact that the measure was located in a retail building, is outlined in Table 8.

Table 8: Interactive Effects Factors

Building Type	IE Factor Peak Demand (If electrical heating)	IE Factor Energy	
		Electrical Heating	Electrical Cooling
Industrial	-30%	-23%	6%

These values were then included in the interactive effects equations below.

$$IE (energy) = 1 + (\% Elec. heat \times IEF_{energy} Elect heating + IEF_{energy} Cooling)$$

$$IE = 1 + (1 \times (-0.23) + 0.06)$$

$$IE = 0.83$$

$$IE (demand) = 1 + (\% Elec. heat \times IEF_{peak demand})$$

$$IE = 1 + (1 \times (-0.3))$$

$$IE = 0.7$$

The variables used in the calculation for the revised savings and the final results are summarized in Table 9.

Table 9: Revised Variables for Example Calculation

Baseline Measure – 295 W High Pressure Sodium Lamp		
Parameter	Value	Source
Existing Lamp Quantity	33	Validated On-site
Existing Lamp Wattage (W)	295	Validated On-site
Hours of Operation (hrs/year)	2,422	Calculated Based on the Detailed Schedule Provided during the On-site Visits
Revised Interactive Effects Factor (energy)	0.83	Industrial Bldg. with Electrical Heating and Cooling
Revised Interactive Effects Factor (demand)	0.7	Industrial Bldg. with Electrical Heating
Coincidence Factor	0	Validated On-site
Annual Energy Consumption (kWh)	19,570	Calculation
Annual Peak Demand (kW)	0	Calculation
New Measure – 170 W Lamp		
Efficient Lamp Quantity	36	Validated On-site
Efficient Lamp System Wattage (W)	170	Specification sheet
Hours of Operation (hrs/year)	2,422	Same as existing Fixtures
Revised Interactive Effects Factor (energy)	0.83	Industrial Bldg. with Electrical Heating and Cooling
Revised Interactive Effects Factor (demand)	0.7	Industrial Bldg. with Electrical Heating
Annual Energy Consumption (kWh)	12,303	Calculation
Annual Peak Demand (kW)	0	Calculation
Revised Savings		
Revised Energy Savings (kWh)	7,269	Calculation
Revised Demand Savings (kW)	0	Calculation

Adjustment Ratio Algorithm

The adjustment ratio is determined by comparing the revised savings values with the tracked savings values. Due to the revisions made to this measure, namely to the lamp quantity, ballast factor, interactive effects factors, and hours of operation, the calculated ratios were 0.845 for energy savings and 1 for peak demand savings.

$$\frac{\text{Revised ES}}{\text{Tracked ES}} = \frac{7,269 \text{ kWh}}{8,603 \text{ kWh}} = 0.845$$

$$\frac{\text{Revised Peak DS}}{\text{Tracked Peak DS}} = 1$$



ECONOLER

CUSTOM INCENTIVES PROGRAM

2017 DSM EVALUATION

EFFICIENCY NOVA SCOTIA

Final Report

March 15, 2018



ABBREVIATIONS

BDM	Business development manager
BER	Business Energy Rebates
BNI	Business, non-profit and institutional
COP	Coefficient of performance
CRA	Corporate Research Associates
DHW	Domestic hot water
DSM	Demand-side management
DSMDS	Demand-side management data system
EMIS	Energy Management Information System
ENS	Efficiency Nova Scotia
EUL	Effective useful life
HVAC	Heating, ventilation and air conditioning
M&V	Measurement and verification
NECB	National Energy Code for Buildings
NTGR	Net-to-gross ratio
PCF	Peak coincidence factor
SEM	Strategic Energy Management

DEFINITIONS

Accuracy	Reflects the proximity of measurements to the true value.
Adjustment ratio	The ratio of evaluated results to tracked results. This ratio expresses the adjustment made to tracked savings or other tracked values such as effective useful life.
Base case	To determine gross savings, a base case is established providing detailed information about the reference (e.g. pre-existing or standard) measure or equipment chosen to be compared with the efficient measure or equipment. For the reference measure or equipment, the base case may include such information as the hours of operation, wattage and the base consumption.
Bias	Systematic deviations of measurements from the true value.
Billing calibration	An activity that consists of adjusting the expected energy savings based on the relative difference between the results of the energy simulations and the actual energy consumption of the building or system.
Confidence interval	The estimated range of values which is likely to include the unknown population parameters.
Displaced wattage	The displaced wattage is defined as the difference between the wattage values of the baseline equipment or product and the efficient equipment or product.
EnerGuide rating	An EnerGuide (official brand of Natural Resources Canada) rating is a standard measure of the home's energy performance. It is a measure of the efficiency of the building only and does not take into account occupant behaviour. It shows how energy efficient the home is through modelled heat losses of the home, based on several factors including building envelope characteristics, heated volume, heating systems and air leakage.
Effective useful life	The period a measure is expected to be in service and provide both energy and peak demand savings. This value combines the equipment life and the measure persistence, which includes factors such as business turnover or early retirement.
Equipment life	The number of years installed equipment will operate before it fails.
Equivalent CO ₂	A unit of measurement indicating the amount of carbon dioxide to which various kinds of emitted greenhouse gases are equivalent in terms of warming effects. In this report, the gases' global-warming potential is estimated over a timescale of 100 years.
Equivalent effective useful life	The number of years by which the first-year savings estimate is multiplied to obtain lifetime energy savings. This value takes into account variations in annual energy savings throughout the effective useful life due to increased baselines.

Evaluated savings	Gross and net savings calculated by the Evaluator using the parameters (unitary savings values, installation rates, interactive effects, net-to-gross ratio, etc.) validated or measured during the evaluation process. Unless otherwise specified, the evaluated savings are the first-year savings.
Evaluation plan	The evaluation plan summarizes the program description, objectives, base cases, documentation, evaluation methodology, budget and schedule.
First-year savings	The first full year of energy savings generated by an energy efficiency measure.
Free-ridership	Percentage of gross savings attributable to participants who would have implemented the same or similar energy efficiency measures, with no change in timing, in the absence of the program.
Gross energy savings	Energy savings generated by energy efficiency measures, before applying the net-to-gross ratio.
Induced consumption	Energy consumption of appliances that would have been unplugged and not replaced by participants in the absence of the program.
Interactive effects	Effects on the energy consumption of other systems in the building (such as heating and cooling) due to the installation of an energy efficiency measure.
Internal spillover	Savings attributable to participants who continue to implement the energy efficiency measure introduced by a program after participating in it once, without participating in the program a second time.
In-service rate	The proportion of incentivized products that are installed and operating. This rate is usually applied to programs through which rebates are offered in-store and products are likely to be stored for a certain period before being installed, such as LED bulbs.
Lifetime energy savings	The energy savings that occur over the lifetime of an energy efficiency measure. Lifetime energy savings account for a measure's effective useful life and any increase in the baseline efficiency level (which reduces attributable annual savings) over its lifetime.
Line loss factor	The multiplier to convert savings at the customer meter to savings at the utility generator. It accounts for the electrical losses of the transmission and distribution system.
Margin of error	The amount of random sampling error.
Market effects	The impact of the program on the market (such as increased product availability, practices, and prices) that extends beyond changing the program participants' behaviour. This includes spillover among non-participants.
Net energy savings	Energy savings that can be reliably attributed to a program. This includes effects, such as free-ridership and spillover, that negatively or positively affect the energy savings attributable to a program.
Net-to-gross ratio	The ratio of net energy savings to gross energy savings.

Non-sampling error	Errors arising during the course of all survey activities other than sampling. Non-sampling errors tend to lead to bias in measurements and are very difficult to quantify.
Peak coincidence factor	The percentage of measure demand savings that coincide in time with the annual peak demand of the entire electricity system.
Peak demand savings	The demand savings that coincide in time with the expected annual peak demand period of the entire electricity system.
Precision	The extent to which repeated measurements agree with one another.
Random sampling error	The error in measurement due to the fact that measurements are taken from a subset of the population and not the entire population.
Sample size	The number of observations or replicates included in a statistical sample.
Secondary market impacts	Energy consumption of appliances that would have been transferred to the secondary market if said appliances had not been retired.
Tracked savings	Gross and net savings calculated by ENS in the tracking system, based on various parameters such as number of participants, unitary savings values, installation rates, interactive effects, and the net-to-gross ratio.
Unitary savings	Energy or peak demand savings established on a unitary basis. This unit can either be a product (e.g., an 8 W LED lamp), a capacity (e.g., one-ton capacity of an air-source heat pump) or a participant (e.g., one participant taking part in a behaviour-based program).

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EXECUTIVE SUMMARY

This report presents the results of the 2017 evaluation of the demand-side management (DSM) program, Custom Incentives, which is comprised of three components: (1) Custom, (2) Energy Management Information Systems (EMIS) and (3) Strategic Energy Management (SEM).

Table 1 below is an overview of the participation level, and the gross and net savings for each Custom Incentives program component as well as those for the whole program. It should be noted that no SEM project generated savings in 2017. Therefore, no savings were claimed for this component and it is not shown in the following table.

Table 1: 2017 Overall Participation and Savings for Custom Incentives

	Participation Level	Gross Savings	NTGR	Net Savings
Custom				
Energy Savings	58 projects completed	22.421 GWh	0.94	21.005 GWh
Lifetime Energy Savings		333.236 GWh	0.94	313.977 GWh
Peak Demand Savings		3.739 MW	0.97	3.637 MW
EMIS				
Energy Savings	4 participants	1.402 GWh	1.00	1.402 GWh
Lifetime Energy Savings		4.112 GWh	1.00	4.112 GWh
Peak Demand Savings		0.255 MW	1.00	0.255 MW
Total				
Energy Savings		23.823 GWh		22.407 GWh
Lifetime Energy Savings		337.348 GWh		318.089 GWh
Peak Demand Savings		3.994 MW		3.892 MW

Custom Overview

Custom provides business, non-profit and institutional (BNI) organizations with technical assistance, financial incentives and project financing to help reduce their electricity consumption and demand. The current suite of services offered through Custom can be broken down as follows:

Retrofit: Provides eligible organizations with technical and financial support to help them conduct scoping and feasibility studies, and implement technical changes at their facilities where a customized and flexible approach can be followed.

New Construction: Provides eligible organizations with incentives to help them achieve significant and predictable electricity savings in new BNI buildings, as well as in additions to buildings and major renovations in existing buildings.

Building Optimization: Supports the implementation of no-cost or low-cost energy-efficiency measures identified through a recommissioning process.

For each service, three types of savings can be claimed: (1) the partial savings (projects to be completed in the coming years), (2) the final savings of multi-year projects, and (3) the final savings of those projects started and completed in 2017.

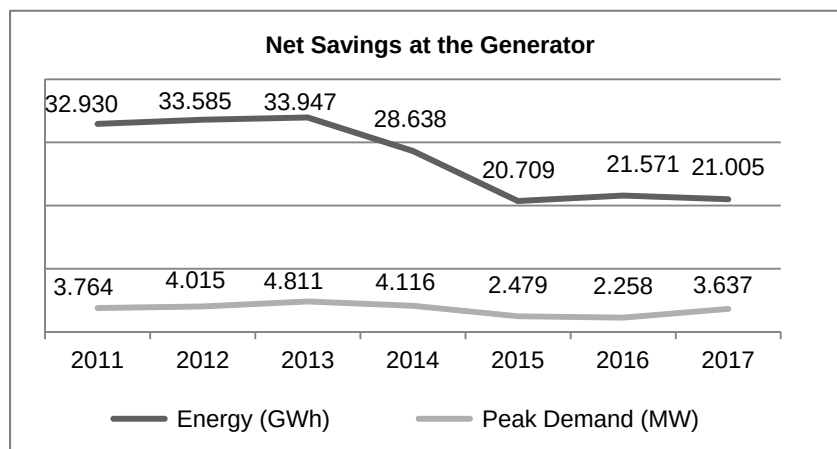
Custom Key Findings

Overall Custom Performance

Collectively, Retrofit, New Construction and Building Optimization aimed to achieve 24.8 GWh in net energy savings and 1.9 MW in net peak demand savings at the generator in 2017. The Evaluator found that together they achieved 21.005 GWh in net energy savings and 3.637 MW in net peak demand savings at the generator in 2017, with 78 projects generating savings and 58 projects completed. These savings represent 13,719 tonnes of CO₂ eq in terms of avoided greenhouse gas emissions annually. By applying a weighted average equivalent effective useful life (EUL) value of 14.9 years, Custom's net lifetime energy savings have been established at 313.977 GWh.

Figure 1 below illustrates the evolution in net energy and peak demand savings at the generator from 2011 through 2017.

Figure 1: Overview of Custom Performance, 2011-2017



Retrofit

The Retrofit service accounted for the majority of savings achieved through Custom and accounted for 79 percent of the Custom projects completed in 2017.

Retrofit Process Evaluation

As part of the 2017 evaluation, the Evaluator conducted a process evaluation of the Retrofit service by interviewing 10 Retrofit consultants and 15 Retrofit participants in the fall of 2017. Analysis of the data collected has yielded the following findings.

Awareness, Outreach and Reasons for Participation

Consultants involved in the Retrofit service have typically been aware of the service for several years and have participated in ENS programs regularly. Consultants and Business Development Managers (BDMs) were the most commonly cited sources for generating awareness among participants. Participants come from a variety of industries and install varying types of measures. Improving the energy performance of equipment was the primary rationale for participating in Retrofit followed closely by energy savings. Consultants and participants often identify these projects through their ongoing interactions with one another.

Retrofit Delivery

Consultants reported they were involved in all phases of a Retrofit project, however, the degree of their involvement in each phase varied. Most consultants agreed that the key aspect of their involvement was in preparing the feasibility study and service staff indicated that almost all participants that completed the feasibility study went on to complete an energy-saving project. All participants were satisfied with how their projects progressed, suggesting Retrofit delivery met the needs of participants.

Retrofit Successes

Consultants were satisfied with Retrofit requirements, their interactions with Efficiency Nova Scotia (ENS), and the expansion in business that Retrofit provided their firms. Participants provided multiple examples of aspects of Retrofit that they especially appreciated other than the incentives. This list included: help convincing decision-makers to go forward with a project; the technical assistance offered by Retrofit; and their interactions with ENS staff, especially the BDMs. A strong indication of the high satisfaction level is that all consultants and almost all participants indicated that they are or are planning to participate in the Retrofit service again. Moreover, one consultant and one participant, both with experience in using other efficiency programs elsewhere in Canada, described the ENS Retrofit service as exceptional in comparison to its peers.

Barriers to Participation

Financial considerations, specifically coming up with the upfront dollars needed to implement a project, were the only barriers to participation cited by respondents.

Suggestions for Retrofit Improvement

Perhaps because of the high levels of satisfaction with Retrofit, respondents made few suggestions on how to improve the service. A small number of respondents suggested ways to improve outreach, including reaching out to more industrial businesses and offering training to facilities' staff on low-cost and no-cost improvements they can make as part of their day-to-day work.

Retrofit Impact Evaluation

The 2017 evaluation includes a full technical review of the project documentation and on-site visits for a sample of 26 Retrofit projects. The efforts made by ENS to implement the 2016 evaluation recommendations have resulted in overall improvement in the availability and quality of project documentation. Also, as a result of this improvement, the adjustment ratio was closer to unity than in 2016, especially for peak demand savings.

The Evaluator's review of project files and on-site visits resulted in minor adjustments made to variables used for the calculation of gross energy savings, such as the hours of operation. The Evaluator also made adjustments to some measurement and verification (M&V) results which were not used properly to calculate savings. Two projects required special types of adjustments: one because the temperature of the equipment to be insulated was incorrect and the other because the main energy-saving measure had not been implemented. For the latter case, it seemed that the scope of the project had changed along the way and this information had not been reflected in the final project savings. All the projects reviewed were included in the adjustment ratio calculation, which yielded a value of 0.995 for energy savings, with a margin of error of 1.2 percent.

The peak demand savings required more adjustments than the energy savings, because many peak coincidence factors (PCFs) had to be changed. For one project, no peak demand savings were tracked, though they did occur; as a result, the Evaluator calculated this value. For two projects, spot measurements were used to establish the tracked savings; however, since no detail was available about the exact timing of the measurements, the Evaluator relied on the average demand reduction of the peak demand period to establish the revised value. The project mentioned in the previous paragraph whose main energy-saving measure was not implemented was excluded from the adjustment ratio calculation and a one-time adjustment was made instead. With this measure excluded, the Evaluator established an adjustment ratio of 1.119 for peak demand savings, with a margin of error of 9.5 percent.

Despite the overall improvement in the availability and quality of project documentation, other improvements should still be made to the M&V procedures, because four projects lacked supporting M&V documentation. Specifically, none of the four projects included any measured data; instead, ENS relied on information provided by manufacturers, assumptions made by the consultant and engineering estimates of easily measurable variables to calculate tracked energy savings. The lack of documented M&V data and information prevented the Evaluator from thoroughly revising the tracked savings of these projects, which accounted for 19.4 percent of the tracked energy savings and 15.9 percent of the peak demand savings of the sampled projects.

To establish the 2017 net-to-gross ratio (NTGR), the Evaluator used the average free-ridership of the past five years (9%), and the spillover was assumed to be nil since it has been measured to be nil for the past three years. As indicated in Table 2 below, the NTGR was estimated at 0.91 for Retrofit.

Table 2: Retrofit Net-to-gross Ratio

	Retrofit
Free-ridership Level	9%
Spillover Level	0%
Net-to-gross Ratio	0.91

For 2017, Retrofit generated 14.418 GWh in net energy savings and 1.045 MW in net peak demand savings at the generator. These savings represent 9,415 tonnes of CO₂ eq of avoided greenhouse gas emissions annually. Based on an average EUL of 13.6 years, the net lifetime energy savings were established at 196.090 GWh.

New Construction

In 2017, six projects were completed through the New Construction service. A detailed technical review was performed for five of the projects completed. All energy efficiency measures have been implemented. However, the Evaluator found discrepancies between the model used for the simulation and the reference building as well as errors in the subsequent savings calculations performed with the models' output values. Consequently, the five projects reviewed have been adjusted.

Significant adjustments were made for two projects because the reference building's natural gas consumption for heating had been manually converted to electricity without properly accounting for efficiency. For one of those projects, another major change was to modify the energy model to ensure the heating load was met throughout the heating season. Those changes resulted in downward adjustments to both projects, whose energy savings were decreased by respectively 38 and 43 percent. The remaining three projects saw their savings reduced because of incorrect modelling of heat pump systems. Overall, the revised energy savings for all five reviewed projects were 30 percent below the tracked value. The peak demand savings were, however, increased by a ratio of 3.41.

In 2017, New Construction generated 5.751 GWh in net energy savings and 2.520 MW in net peak demand savings at the generator. These savings represent 3,756 tonnes of CO₂ eq of avoided greenhouse gas emissions annually. Based on an average EUL of 19.7 years, the net lifetime energy savings were established at 113.288 GWh.

Building Optimization

In 2017, six projects were completed through the Building Optimization service and one project was listed with partial savings. In 2017, ENS made efforts to provide more support for participants to better understand Building Optimization's process. The impact should be noticeable in 2018.

The Evaluator conducted in-depth technical review and on-site visits for four of the six Building Optimization projects completed in 2017, which represented all projects completed at the time this evaluation started. For two of the projects reviewed, the Evaluator noticed that the documentation provided did not include all the necessary information on building operation parameters to allow for validating the baseline case. For one of the four projects reviewed, adjustments had to be made on the Reference building since an inappropriate energy model was used, which overestimated the hours during which the equipment could reasonably run. For another project, one of the measures was based on the assumption that the domestic hot water load would be lower after the project and this assumption could not be explained by the measure put in place. The savings for this measure were therefore considered nil. The changes made by the Evaluator resulted in a reduction of 19.3 percent and 47.4 percent to the tracked energy and peak demand savings respectively. These reductions were only applied to the four reviewed projects, because the small sample size did not allow for extrapolating.

The NTGR is assumed to be 1.00 for Building Optimization, since the interviews conducted with the participants during the on-site visits indicated no free-ridership for most participants.

In 2017, Building Optimization generated 0.836 GWh in net energy savings and 0.071 MW in net peak demand savings at the generator. These savings represent 546 tonnes of CO₂ eq of avoided greenhouse gas emissions annually. Based on an average EUL of 5.5 years, the net lifetime energy savings were established at 4.599 GWh.

Custom Energy Savings

Table 3 below compares the total tracked and evaluated savings for the Custom program component, which includes savings from the Retrofit, New Construction and Building Optimization services.

Table 3: Comparison of Tracked and Evaluated Savings at the Generator for Custom

	Initial Gross Savings	Adjusted Gross Savings	NTGR*	Net Savings
Energy Savings				
Tracked Savings from ENS	24.437 GWh	24.437 GWh	0.93	22.836 GWh
Evaluation Results	24.437 GWh	22.421 GWh	0.94	21.005 GWh
Peak Demand Savings				
Tracked Savings from ENS	2.757 MW	2.757 MW	0.96	2.635 MW
Evaluation Results	2.757 MW	3.739 MW	0.97	3.637 MW
* The NTGR was different for each component. The NTGRs listed in this table match the rounded averages obtained by dividing the net savings by the adjusted gross savings.				

The evaluated net savings for Custom are 8 percent below the tracked value. This reduction was mostly due to New Construction, which had its gross energy savings reduced by 27 percent this year. Retrofit, which accounted for 70 percent of Custom's gross savings, had only small adjustments made to its savings (about one percent). The reduction of 12 percent of Building Optimization's savings had a minimal impact on the overall difference between the tracked and the evaluated net savings. The 1 point of percentage increase in NTGR was only due to the difference in the weight of each service since the NTGR of each service remained the same in 2017 as in 2016.

There is a 38 percent difference between the evaluated and the tracked net peak demand savings for Custom. It is the adjustments made to New Construction's peak demand savings that explain most of this variation; those adjustments increased the evaluated savings by 1.012 MW for both the gross and the net savings.

Custom Recommendations

In 2017, Retrofit remained the biggest contributor to the overall Custom savings. The evaluation revealed that Retrofit service has satisfied participants and consultants by delivering valued services and support. As for the New Construction and Building Optimization services, again they had only a small number of projects implemented this year.

In addition to the general recommendations presented for all ENS program components in the 2017 DSM Programs Evaluation's Executive Summary, the Evaluator makes the following recommendations aimed at improving Custom. Recommendations to improve EMIS are presented further below in this executive summary. The recommendations are also included in Appendix I.

2017-Custom-R1. Continue relying on BDMs to assist participants and find new markets. The 2017 evaluation showed that many participants heard about Retrofit from a BDM and those who worked with a BDM were satisfied with their interactions. This support included providing answers to the participants' inquiries, especially about eligibility requirements, and informing about the latest service changes. In some cases, these relationships also resulted in identifying additional projects. The BDMs have successfully brought in numerous participants from the aquaculture industry and are looking for new markets to replicate this success. To maintain a high level of participation in Custom, the Evaluator recommends that ENS continue to expand outreach efforts via BDM contacts with specific business groups in the industrial and agricultural sectors.

2017-Custom-R2. Continue conducting an in-depth review of energy models as part of the evaluation and improve ENS staff's capacity to identify discrepancies in energy models. The more in-depth review of energy models conducted during the 2017 evaluation identified discrepancies in all five projects and resulted in significant downward adjustments to savings. Modelling of heat pump systems and manual calculations to adjust baselines were most problematic. This showed that a systematic review should be conducted, even if energy models are prepared by experienced consultants. The Evaluator also recommends that ENS provide tools and training to their staff so that they are better able to conduct technical reviews of energy models. Those tools could include checklists of parameters to validate for certain types of projects or building systems.

2017-Custom-R3. Establish clear objectives for Building Optimization. The Building Optimization projects reviewed this year differed widely in scope. Some projects involved detailed investigative work to tap into deep energy savings, while others were limited to replacing known broken equipment or repairing recently installed mechanical systems that had never worked as intended. While all projects generated savings and all participants benefited from Building Optimization, the participants' needs were quite different from one another. The Evaluator believes that clearly establishing the objectives of the service would result in providing the right level of support to each participant and maximizing the added value of ENS support, that is, involving specialized consultants in retrocommissioning only when detailed investigation of energy-saving opportunities is a project's objective. Better defining objectives and eligibility criteria would also clarify how the basecase should be established. For example, the project whose mechanical systems had never worked as intended had a basecase with such a high number of hours of use that the cooling towers would have provided far too much cooling to the building. An analysis of what should qualify as an acceptable Building Optimization project would allow for distinguishing between the ordinary repairs that a building owner needs to make his or her building function normally and the real energy-saving opportunities for improving energy performance above a minimum level. Better objective-setting would allow for allocating Building Optimization's financial and technical resources to those projects that will most benefit from them.

2017-Custom-R4. Better document the basecase conditions for Building Optimization projects. The Evaluator observed that the basecase conditions were sometimes not measured or documented (using photos, for instance). Since these conditions cannot be verified because they no longer exist after project implementation, the Evaluator recommends that ENS gather more information about the pre-implementation conditions to support savings evaluation afterwards.

Energy Management Information System

The main goal of EMIS is to assist industrial businesses and institutions in making real-time decisions about their processes by using energy consumption data from the systems metered. To achieve this goal, EMIS provides participants with the funding required to audit their systems (an EMIS audit), develop an energy management information system implementation plan (an EMIS implementation plan) and install the metering and monitoring equipment (implementation of the EMIS). This program component also provides training and organizational support for implementing management systems and processes to help transform energy performance information into action, thereby allowing participants to achieve energy savings.

The 2017 EMIS evaluation was based on a program component documentation review, interviews with the program manager and a review of four projects (including phone interviews with participants).

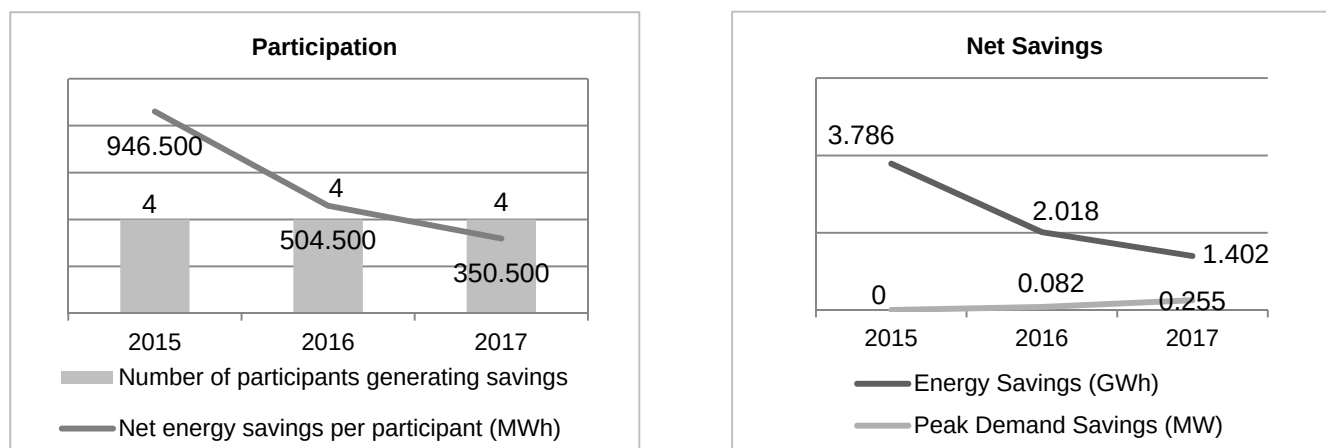
EMIS Key Findings

EMIS Performance

EMIS aimed to achieve 4.0 GWh in net energy savings and 0.1 MW in net peak demand savings at the generator for 2017. The Evaluator concluded that it achieved 1.402 GWh in net energy savings and 0.255 MW in net peak demand savings at the generator. These savings represent 916 tonnes of CO₂ eq in terms of avoided greenhouse gas emissions annually. By applying an equivalent EUL value of 2.9 years, EMIS's net lifetime energy savings have been established at 4.112 GWh.

As shown in Figure 2, four participants reported savings in 2017, and they were the same four participants that had generated savings in 2015 and 2016. Three additional projects were at different stages of EMIS and had not yet generated savings by the end of 2017.

Figure 2: EMIS Performance Overview, 2015-2017



EMIS Market Evaluation Highlights

The four participants were asked questions regarding their satisfaction with EMIS, any barriers they encountered and their improvement suggestions. Overall, satisfaction with EMIS was high among all the participants and few challenges and barriers were mentioned. As for recommendations for improving EMIS, participants suggested that ENS could better help them develop a growth and sustainability plan, help to involve participating facilities' maintenance staff in the process, and that ENS could provide more support and manpower during the installation process.

EMIS Energy Savings

In 2016, the Evaluator made a distinction between the cumulative energy savings¹ tracked by ENS and the incremental energy savings², and recommended that ENS track incremental savings rather than cumulative savings. Both incremental and cumulative savings were tracked in 2017. The incremental savings were the focus of the evaluation and the evaluated incremental savings correspond to the impact results reported for this program component. The cumulative savings were reviewed for all projects, but are only presented as valuable information to participants.

To evaluate the four projects with energy savings in 2017, the Evaluator reviewed their updated annual reports and savings calculation workbooks and then conducted phone interviews with participants to collect additional information on the measures implemented or the changes made to the facilities in 2017. The Evaluator then reviewed the baseline and the incremental baseline to ensure that the 2017 cumulative and incremental savings were valid.

¹ The annual savings achieved with respect to the baseline situation prior to the implementation of the EMIS.

² The additional annual savings not measured in previous years. Incremental savings result from new measures implemented during the evaluation year or from recent improvements to energy efficiency measures that were initiated in previous evaluation years. These savings are calculated by using the previous year's situation as the baseline.

Overall, the Evaluator thinks that the documentation was sufficient to allow for understanding how the savings were established. One element missing from the documentation was a monthly log documenting the changes made to each facility so that the changes affecting the baseline or incentivized projects from other ENS program components can be easily identified. ENS is aware of the need for monthly logs and is trying to find ways to encourage participants who already have contracts in place to provide this data to ENS. ENS has agreed to make future contract changes so that ENS is able to provide this data to the Evaluator for future participants. The Evaluator also noticed several discrepancies between savings tracked in the final tracking and the savings reported in the final annual reports. The Evaluator recommends that from now on, the final tracking sheet be updated with the values presented in the annual reports.

As part of the cumulative savings review, savings were adjusted for one of the four reviewed projects. This adjustment was a non-routine adjustment made to the baseline to account for the compressed-air Custom Retrofit projects impacting the performance of the compressed-air shut-down measure in the plant. The Evaluator had recommended that this project's baseline be reviewed in 2016, but this adjustment was not made by ENS. While reviewing this project, the Evaluator found that the production levels on weekends varied over time, affecting the potential energy savings for all the measures. The Evaluator recommends that from now on, production data be tracked for this project and used as an independent variable for the baseline regression. The Evaluator also determined that two additional projects were generating peak demand savings while none was initially tracked.

In 2017, incremental savings were calculated by the service provider by establishing an incremental baseline³, or were estimated by ENS by finding the difference between 2017 and 2016 cumulative savings. As part of the incremental savings review, savings were adjusted for the two projects for which incremental savings were estimated. To review the incremental savings, the Evaluator established an incremental baseline based on the 2016 data. This resulted in a decrease of incremental energy savings. As with the cumulative savings, the Evaluator established peak demand savings for two additional projects, resulting in an increase in peak demand savings. For the two projects with incremental savings calculated by the service provider, the Evaluator found that the incremental baselines used by the service provider were adequate.

Free-ridership and spillover effects were assumed to be nil for EMIS, based on the limited market penetration of energy management information systems. This assumption was confirmed by the participant interviews conducted in 2015. Hence, the net savings were equal to the gross savings.

Table 4 below compares the total tracked and evaluated incremental savings for EMIS in 2017.

³ Referring to the systems, time period, energy use, or conditions that provide a reference to which later performance of an energy conservation measure can be compared to obtain incremental savings.

Table 4: Comparison of Tracked and Evaluated Savings at the Generator

	Initial Gross Savings	Adjusted Gross Savings	NTGR	Net Savings
Energy Savings				
ENS Tracked Savings	1.752 GWh	1.752 GWh	1.00	1.752 GWh
Evaluation Results	1.752 GWh	1.402 GWh	1.00	1.402 GWh
Peak Demand Savings				
ENS Tracked Savings	0.137 MW	0.137 MW	1.00	0.137 MW
Evaluation Results	0.137 MW	0.255 MW	1.00	0.255 MW

In 2017, the Evaluator did not adjust the incremental savings of the two projects for which a proper incremental baseline approach was used by the service provider, but only adjusted the incremental savings for the two other projects (for which incremental savings were simply estimated as the difference between 2017 and 2016 cumulative savings). Overall, the change in the approach used to obtain energy savings for the two projects for which incremental savings were estimated rather than calculated resulted in a 20 percent reduction between evaluated and tracked energy savings.

The large increase in peak demand savings (86%) is attributable to the addition of peak demand savings to two projects that had not reported any. The NTGR used by ENS remained unchanged.

EMIS Recommendations

Overall, the Evaluator thinks that EMIS was effectively delivered again in 2017, as participant satisfaction was high and additional positive savings were achieved in the second or third year of their participation.

In addition to the general recommendations made for all ENS program components in the 2017 DSM Programs Evaluation Executive Summary and the two 2016 recommendations not yet fully implemented, the Evaluator has the following recommendations to make on how to improve EMIS. These recommendations are also listed in Appendix IX.

- 2017 EMIS-R1. Ensure that the tracking sheet is complete and accurate.** While reviewing the project documentation, the Evaluator found several discrepancies between the savings figures reported in the final tracking sheet and the savings figures documented in the annual savings reports. Also, two of the four projects claimed peak demand savings in their annual reports; however, this information was not tracked by ENS in the tracking sheet. The Evaluator recommends that, from now on, the final tracking sheet be updated with the final values documented in the annual reports and that annual peak demand savings be tracked.
- 2017 EMIS-R2. Design baseline regressions and plan M&V activities to ensure accurate savings calculations even when changes occur in the facility.** This year, the Evaluator discovered that one project had an increase in the weekend production time, which impacted potential energy savings for the measures implemented through EMIS. Since the production level variable was not documented, the Evaluator could not adjust the savings accordingly. To avoid such an issue, the Evaluator suggests that ENS and the service provider proactively identify and track independent variables so that the baseline remains relevant even when changes in operations occur. The Evaluator also recommends that M&V activities and non-routine adjustments be planned as needed. In the case of the Custom Retrofit compressed-air projects implemented after the baseline period for instance, ENS and the service provider could have planned on the implementation of those Custom Retrofit projects by gathering the baseline data before their implementation and made the necessary baseline adjustments afterwards.

INTRODUCTION

Efficiency Nova Scotia (ENS) is a franchise held by EfficiencyOne⁴ and is responsible for helping Nova Scotians improve the energy efficiency of their homes and workplaces. ENS designs, markets and delivers energy efficiency and conservation programs for various segments of the population. ENS receives funding for its activities from Nova Scotia Power and the Province of Nova Scotia. The funds received from Nova Scotia Power cover the costs of activities designed to help reduce electricity consumption, whereas funds from the Province of Nova Scotia are primarily used for activities designed to help reduce the use of other fuels by households with lower incomes.

Econoler was commissioned to evaluate ENS's 2017 demand-side management (DSM) program portfolio comprised of six electricity efficiency programs and assess the impact of energy efficiency codes and standards introduced in Nova Scotia. To carry out this assignment, Econoler collaborated with Research Into Action, Equilibrium Engineering, Corporate Research Associates (CRA) and Technosim.

Econoler served as team leader in the 2017 evaluation and was involved in every aspect of the evaluation. Specifically, Econoler was in charge of coordinating and supervising all activities, conducting final reviews of all data collection instruments, performing impact evaluation calculations, as well as preparing and reviewing the evaluation reports. Research Into Action carried out the process evaluations, while Equilibrium Engineering and Technosim conducted the on-site visits and contributed to some impact evaluation analyses. More specifically, Equilibrium Engineering was in charge of Retrofit projects, while New Construction and Building Optimization projects were reviewed by Technosim. CRA conducted the interviews and surveys with participants and partners, as well as analyzed and reported on the data collected from these activities. Throughout this report, this team is referred to as the Evaluator.

For each program, the Evaluator prepared a DSM evaluation report presenting the general findings, electrical first-year and lifetime energy savings, peak demand savings and avoided greenhouse gas emissions.

Table 5 below lists the various programs assessed as part of the 2017 evaluation and indicates their respective components and the types of evaluations conducted. In this table, "C" means a complete evaluation, and "R" indicates that reduced evaluation activities were performed, as compared to 2016. Section 1 of the DSM Programs Evaluation Executive Summary presents the scope of work in further detail, along with the rationale for the types of evaluations performed for each program component.

⁴ On January 1, 2015, ENS became a franchise owned by the Province of Nova Scotia and was licensed to the new not-for-profit organization EfficiencyOne.

Table 5: Types of Evaluations Conducted for Each Program Component

Program	Program Component	2016			2017		
		Process	Market	Impact	Process	Market	Impact
Residential Efficient Product Rebates Program	Appliance Retirement		C	C			R
	Instant Savings		C	C		R	R
Existing Residential Program	Home Energy Assessment		C	C		C	C
	Green Heat		C	C	C	C	C
	Efficient Product Installation		C	C		C	C
New Residential Program	New Home Construction		C	C		C	C
Efficient Product Rebates Program	Business Energy Rebates		C	C		C	R
Custom Incentives Program	Custom		C	C	C*	C	R
	Energy Management Information Systems	C	C	C		C	C
	Strategic Energy Management**	C	C	C			
Direct Installation Program	Small Business Energy Solutions	C	C	C		C	C
*The process evaluation specifically targets the Retrofit service of the Custom program component. ** Due to the start date of the latest Strategic Energy Management (SEM) cohort, SEM did not have any participants who achieved savings in 2017; therefore, no evaluation was conducted for 2017							

This evaluation report is for the Custom Incentives program, which is comprised of three components, including two which were evaluated in 2017: Custom and Energy Management Information Systems (EMIS). In both 2017 and 2016, Custom and EMIS underwent a complete market and impact evaluation. A process evaluation was added for Retrofit in 2017 because of the large savings attributable to this program component and because this program process has not been reviewed for many years. Each program component description, evaluation methodology and main evaluation findings are presented in the following sections.

1 CUSTOM OVERVIEW

This section describes the Custom program component, checks on the progress made in implementing the 2016 evaluation recommendations and gives an overview of participation history.

1.1 Description

Custom provides large business, non-profit and institutional (BNI) participants with technical assistance, financial incentives and project financing to help reduce their electricity consumption and demand.

Custom includes a number of different services. The current suite of services offered through Custom can be broken down as follows:

- › Retrofit
- › New Construction
- › Building Optimization

Retrofit provides eligible organizations with technical and financial support to help them conduct scoping and feasibility studies and implement technical improvements at their facilities, using a customized and flexible approach. This component's delivery has been structured in a way that enables participation no matter which phase a participant's projects are in, as long as their implementation has not yet started. Retrofit is meant to meet a wide range of participant requirements and support a variety of energy-efficiency initiatives. Additionally, Retrofit includes two tracks: Track 1 for eligible participants who have an annual energy consumption level under 350,000 kWh, and Track 2 for participants with an annual energy consumption level of 350,000 kWh or greater. Track 1 projects are expected to save between 5,000 and 20,000 kWh of electrical energy per year, whereas Track 2 projects typically save over 20,000 kWh per year. In terms of the participation process, Track 1 participants have fewer steps to complete for their projects. For example, a scoping or feasibility study and measurement and verification (M&V) are required for Track 2 projects, but are not required for Track 1 projects.

New Construction provides eligible organizations with incentives to help them achieve significant and predictable electricity savings in new BNI buildings, as well as in addition to buildings and major renovations in existing buildings. New Construction's delivery was designed in such a way as to get the participant involved from the preliminary design stage in order to have the energy efficiency measures effectively implemented and achieve maximum energy savings.

Introduced in 2014, Building Optimization was formerly known as Existing Building Commissioning. Building Optimization's goal is to achieve energy and peak demand savings through the appropriate and efficient functioning of the participating buildings' systems. Building Optimization supports the implementation of no-cost or low-cost energy efficiency measures identified through a recommissioning process, such as operating schedule changes and modification of operating parameters of key mechanical systems within a building. Building Optimization involves two stages, namely the investigation study and the project implementation. To identify the right recommissioning measures and effectively implement them, three application documents are required at different stages of the process, namely an Investigation Application, a Master List of Findings and an Implementation Application. Measurement and verification (M&V) must be performed and accounted for in an M&V report submitted by the service provider.

For all three services, Business Development Managers (BDMs) work with participants to assist them in moving projects forward and finding consultants. ENS claims savings for some projects over multiple years since certain phases or specific project measures do not become fully operational until the entire project is completed. There are three types of projects for which savings are claimed in 2017:

- › Projects that were not completed in 2017. For these projects, the portion of savings corresponding to the milestones achieved in 2017 is claimed (partial savings).
- › Projects that were started and completed in 2017. For these projects, all the project savings are claimed in 2017 (final savings – 2017 projects).
- › Multi-year projects that had partial savings claimed in the previous years and were fully completed in 2017. For these projects, the remaining portion of savings corresponding to the milestones achieved in 2017 is claimed (final savings – multi-year projects).

Together, Retrofit, New Construction and Building Optimization aimed to generate net electricity savings of 24.8 GWh and peak demand savings of 1.9 MW for 2017.

1.2 Follow-up on 2016 Evaluation Report Recommendations

The Custom program component was evaluated in 2016 and recommendations were made by the Evaluator for its improvement. Table 6 below provides a brief summary of the implementation status of each recommendation presented in the executive summary section of the 2016 evaluation report.

Table 6: Implementation Status of the Recommendations in the 2016 Executive Summary

2016 Recommendations for Custom	Status
2016 Custom-R1 - Develop tools to help service providers better promote and deliver Building Optimization	Implemented
2016 Custom-R2 - Identify the root causes of New Construction's low participation	Deferred
2016 Custom-R3 - Start using the new method for calculating interactive effects associated with Retrofit lighting projects	Implemented
2016 Custom-R4 - Ensure that a systematic review of Retrofit's peak demand savings calculations is performed	Implemented
2016 Custom-R5 - Implement a standardized process for validating M&V results and savings for Retrofit projects	Implemented
2016 Custom-R6 - Include an estimate of peak demand savings in the M&V plans for Building Optimization projects	Implemented

ENS has fully implemented five of the six recommendations. The methodology used for calculating interactive effects in Retrofit lighting projects (Recommendation 2016 Custom-R3) was implemented in 2017 and will continue to be applied to all new lighting projects from now on.

To implement Recommendation 2016 Custom-R1, ENS has been working with its marketing team to develop marketing materials that include case studies to help participants understand the benefits of a Building Optimization project and drive participation. The service providers have also been provided with a document that gives a brief overview of Building Optimization. The new materials developed by ENS have been tested with the service providers and received positive feedback.

ENS has also implemented Recommendation Custom R-6 to include peak demand savings estimates in Building Optimization's M&V plans. ENS took actions to further educate the Building Optimization service providers about the right ways to make estimates about the importance of peak demand savings in the M&V plans, and required them to provide peak demand savings calculations in the M&V plans.

A similar recommendation was made for Retrofit (Recommendation 2016 Custom-R4). ENS has worked to build internal expertise for estimating peak demand savings. This effort resulted in the development of a Demand Savings Guide for internal use and may also be shared with external users. ENS sees this initiative as an ongoing education effort, whose outcomes are expected to show over the next couple of years. To ensure the adoption of a more standardized and systematic approach to estimating savings for Retrofit (Recommendations 2016 Custom R4 and R5), ENS has developed various templates and tools to be used by Retrofit staff and the service providers to achieve better accuracy. These tools include a site visit checklist, a peak demand savings guide and a general M&V guide.

Recommendation 2016 Custom-R2 was meant to discover the real reasons for New Construction's low participation. Although changes were made to New Construction in 2017, whether these changes have had a positive impact on participation will not be observed until at least 2018. These changes included: (1) the requirement of holding a kick-off meeting with the entire design team and ENS before the project starts; (2) an incentive of up to \$10,000 for modelling and design work that has not been removed from the overall incentive mechanism; (3) a standard incentive amount per kWh; and (4) a baseline that conforms with the 2015 National Energy Code of Canada for Buildings (NECB). ENS will be following up with consultants and participants in Q1 2018, and monitoring any changes in New Construction participation.

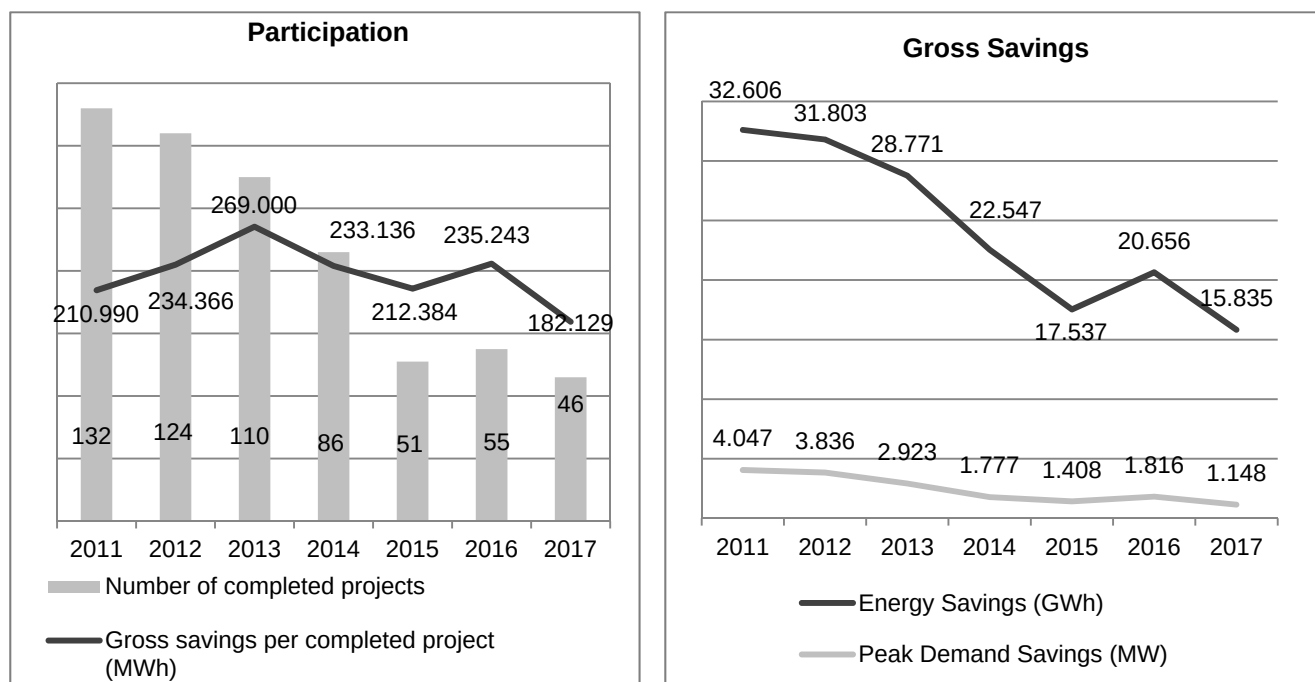
1.3 Participation History

Retrofit

In 2017, a total of 64 projects achieved savings through participation in Retrofit, of which 46 were completed projects and 18 claimed partial savings. The participation chart in Figure 3 displays the number of projects completed over the 2011-2017 period, and the corresponding average gross energy savings per completed project. As highlighted in this figure, the number of Retrofit projects is slightly lower than the past two years, and the gross savings per completed project have decreased. This was mainly due to the smaller sizes of the projects completed in 2017. Whereas four projects each generated gross energy savings higher than 1 GWh in 2016, only two of the projects completed in 2017 achieved this level of savings, thus leading to an overall decrease in gross energy and peak demand savings in 2017, as highlighted by the gross savings chart in Figure 3.

Noteworthy is that until 2014, many lighting projects were completed through Retrofit instead of through other ENS program components, such as Business Energy Rebates. This explains why the number of projects and the gross savings were much higher before 2014.

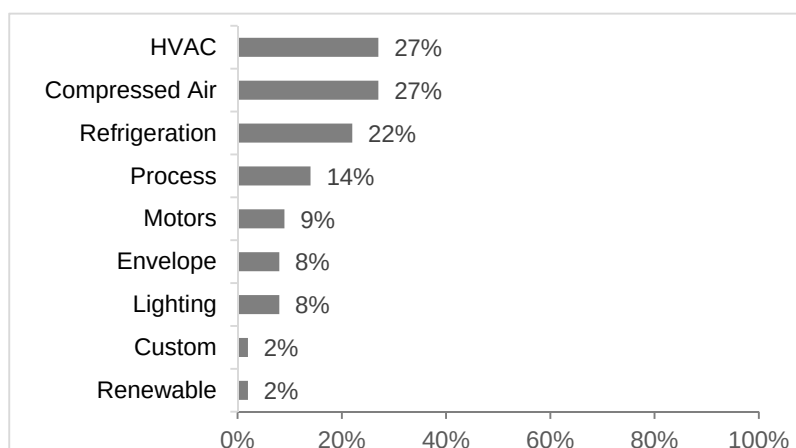
Figure 3: Overview of Participation in Retrofit (2011-2017)



As Figure 4 below illustrates, Retrofit projects were not concentrated in any one single type of measure and were comprised of various measures. Of all the Retrofit projects completed or claimed in 2017, the most common measures implemented were heating, ventilation and air conditioning (HVAC) (27%), compressed air (27%) and refrigeration (22%).

In 2016, HVAC and compressed air were also the most commonly implemented measures among Retrofit projects generating savings. However, refrigeration measures were not as common as in 2017. In 2016, seven projects included refrigeration measures, and they represented 9 percent of all projects. In 2017, the projects with refrigeration measures made up 22 percent of all projects.

Figure 4: Overview of 2017 Retrofit Projects by Type of Measure Involved

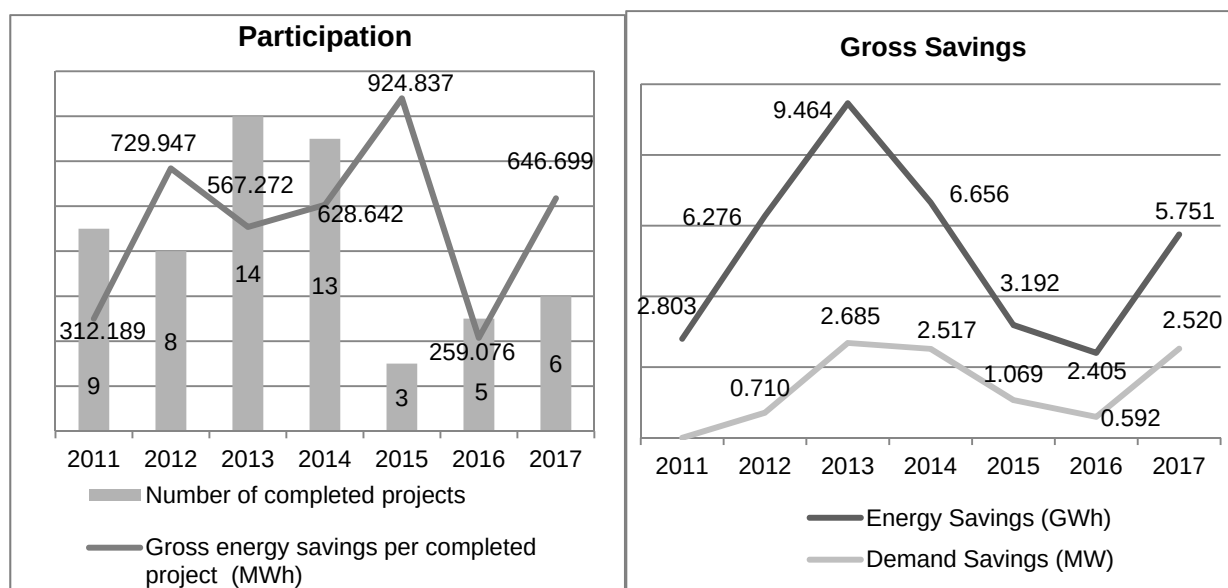


New Construction

A total of seven New Construction projects reported savings in 2017, of which six were completed and one reported partial savings. As shown in Figure 5, the gross energy savings per completed project varied widely from one year to another. This was due to the small number of projects, a situation in which a single significant project would have a large impact on the average gross savings per project.

Since 2014, the savings calculation approach has changed to take into account the original design intent of the participants when establishing the baseline, rather than assuming that the baseline is the current practice. This evolution led to the gradual adoption of a new methodology for calculating savings, which explains in part the disparities in gross energy savings per completed project for New Construction since 2015.

Figure 5: Overview of Participation in New Construction (2011-2017)

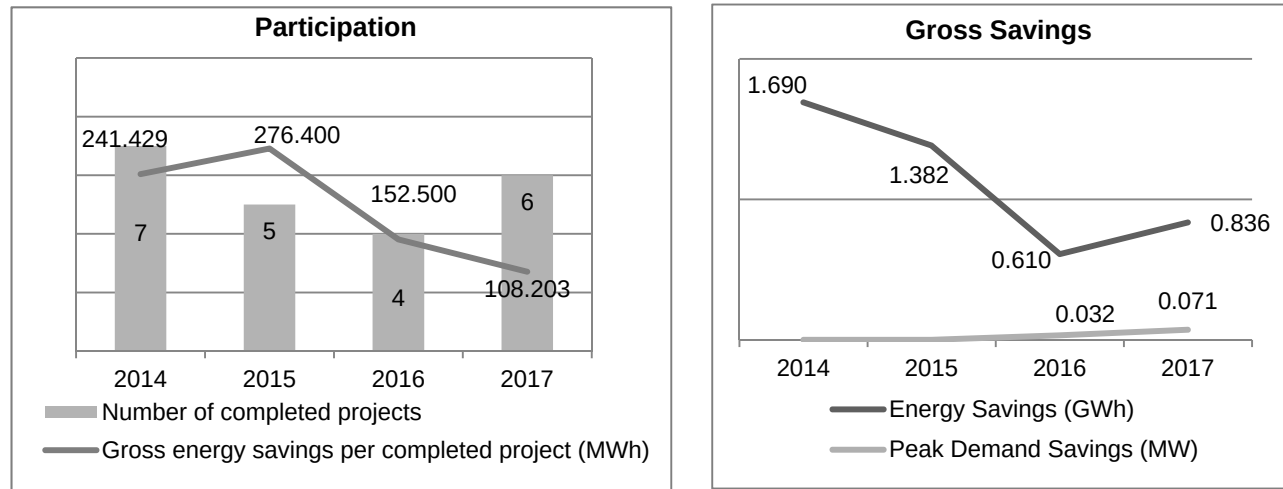


Building Optimization

A total of seven Building Optimization projects reported savings in 2017, of which six were completed and one reported partial savings. As shown in Figure 6, Building Optimization generated less energy savings per project in 2017 compared to the previous years. It should be noted that in 2015, one of the projects completed was a full-scale recommissioning of a large facility, which had significant impact on the average savings-per-project value, especially considering the small population size.

In 2016, Building Optimization was halted for a few months for ENS to make changes to its structure and branding in the hopes of attracting more participants. These changes had a modest impact on participation in 2017, because only two more projects were completed than in 2016.

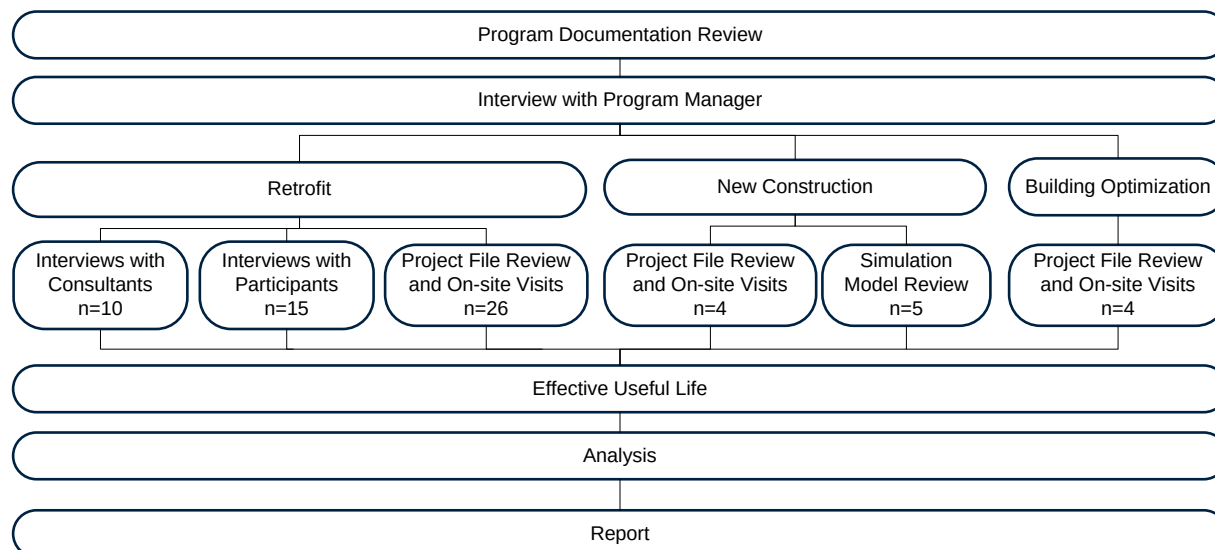
Figure 6: Overview of Participation in Building Optimization (2014-2017)



2 CUSTOM EVALUATION METHODOLOGY

This section describes the methodology used and the activities carried out for the 2017 Custom evaluation. Figure 7 below illustrates the research strategy and data collection activities carried out for each Custom service, namely Retrofit, New Construction and Building Optimization.

Figure 7: Methodological Model



The Evaluator first reviewed the program component's documentation and then held a meeting with the program manager in August 2017 to verify the implementation status of the previous evaluation recommendations and learn about the main changes made to the program component. Based on the information obtained from this meeting, a list of questions and topics to be included in the data collection instruments were prepared.

Once the program manager meeting and the program component documentation review were completed, specific evaluation activities were undertaken, as described in the following sub-sections.

For evaluation activities that yield quantitative results based on a sample, the Evaluator aimed to achieve a maximum margin of error of 10 percent, at a confidence level of 90 percent. This means that if measurement was conducted many times with different samples, the data would be within 10 percentage points above or below the percentage reported 90 percent of the time. Thus, the margin of error indicates the relative level of precision⁵ of the measurement, while its associated confidence level indicates the probability of a measure falling within this margin of error.⁶

⁵ Precision refers to how reproducible is a set of measurements. It does not take into account, however, how close the measured values are to the true values, as this would refer to accuracy.

⁶ As part of this evaluation, the confidence level and the margin of error only take random sampling errors into account; they do not reflect non-sampling errors or biases such as data entry errors, inaccurate responses from respondents or the inability to contact certain people.

As part of this evaluation, the Evaluator calculated the margin of error for survey samples, free-ridership levels, in-service rates and savings adjustment ratios where applicable. The margins of error are presented alongside the results in the applicable sections. Examples of calculations used to establish margins of error can be found in Appendix II of the 2017 DSM Programs Evaluation's Executive Summary.

Interviews with Retrofit Consultants

In October and November 2017, Research Into Action conducted 10 interviews with Retrofit consultants to understand, among other things, their involvement in Retrofit, the services they typically provide to participants, barriers to participant and consultant participation, service successes, challenges and opportunities, and the consultants' perception and level of satisfaction regarding Retrofit and ENS.

The guide used for the interviews with consultants is provided in Appendix II for reference purposes.

Interviews with Retrofit Participants

In October and November 2017, Research Into Action conducted 15 interviews with Retrofit participants to understand, among other things, their participation process and motivations for participating, their interactions with the consultants and ENS, any barriers or challenges met, and their perception and level of satisfaction regarding Retrofit.

The guide used for the interviews with participants is provided in Appendix III for reference purposes.

Project File Review and On-site Visits

In the fall of 2017, a full technical review of the project documentation and on-site visits were carried out for a sample of 2017 Retrofit, New Construction and Building Optimization participants.

A total of 26 Retrofit projects were reviewed. For each of these projects, the technical specifications of the new and old equipment, as well as their parameters of operation, were validated. In addition, the Evaluator collected information regarding the facilities' characteristics and operations on site.

Also, five New Construction projects were reviewed by conducting a full technical documentation review and on-site visits for four of them. These site visits allowed for validating the technical specifications and the operational parameters of the new energy-efficient equipment, collecting information on facility characteristics and operations, as well as collecting information on participant satisfaction and suggestions for improvements. In-depth interviews were also conducted with New Construction participants during on-site visits to collect information on the participant-specific baselines that were used to calculate net savings.

The Evaluator also reviewed four Building Optimization projects by conducting a technical review of the project documentation and on-site visits so as to make recommendations on the methodology used for documenting and calculating the savings and the approach used by ENS to support and verify such projects. Free-ridership level was assumed to be negligible for Building Optimization, and this assumption was validated during the participant interviews conducted during the on-site visits. Information related to participant satisfaction and suggestions for improvements were also collected during these interviews.

The on-site visit protocols used are provided in Appendices IV, V and VI. All the appendices are presented in the Custom Incentives Program – Appendices.

Simulation Model Review

In addition to the project file review, the Evaluator performed a simulation model review for the five sampled New Construction projects. This activity involved reviewing the simulation model against as-built drawings and results of the on-site verification. More specifically, space and domestic water heating fuel sources, building dimensions, building envelope characteristics, weather data, and process, electrical and mechanical equipment characteristics and control strategies were verified.

The simulation model review checklist used as a guideline is included in the on-site visit protocol for New Construction (see Appendix V).

Effective Useful Life Review

As part of the 2017 evaluation, to examine the effective useful life (EUL) values used by ENS to calculate lifetime energy savings, the Evaluator conducted a thorough literature review by consulting TRMs, evaluation reports and relevant studies. This activity was conducted for all three Custom services.

3 RETROFIT PROCESS AND MARKET EVALUATION

A review of Retrofit service data and interviews with the ENS Retrofit manager, 10 consultants, and 15 participants revealed that the Retrofit service is functioning well. Participants and consultants are largely satisfied with the service and support they receive from ENS, and both groups had few suggestions for ways to improve the existing service. The manager described a service that responds to participant needs and changes in the market.

The following subsections provide an overview of respondent characteristics and the results of analysis based on the data collected. This section ends with conclusions and recommendations for improvement for consideration.

3.1 Overview of Respondents

Consultants differed by type and were generally experienced users of ENS program components and specifically the Retrofit service. These respondents reported having from one to eight custom projects in the pipeline across various phases in 2017 (Table 7).

Table 7: Overview of Consultant Respondents

Respondent	Consultant Type	Years Aware of Custom	Reported Custom Projects in 2017
CRC4	Building Engineering	5 or more	8
CRC5	Building Engineering	5 or more	1
CRC6	Building Engineering	5 or more	3
CRC10	Building Engineering	2	6
CRC8	Energy Performance Contracting	5 or more	1
CRC3	Energy Performance Contracting	2	1
CRC1	Lighting	5 or more	1
CRC2	Refrigeration (aquaculture)	5 or more	3
CRC9	HVAC	5 or more	1
CRC7	Wholesaler	4	3

All consultant respondents were either senior technical staff (7) or owner/partners (3) of their businesses and largely became aware of the Retrofit service through general industry knowledge and awareness. For example, one respondent noted 30 years' experience and assumed there are efficiency programs in any place they work and could not tell how they specifically became aware of Retrofit.

Participant respondents represented a diverse set of industries, project types, and quantity of savings. All industrial participants completed air audit and upgrade projects whereas all the other participants completed varying kinds of projects. Three of the respondents completed two Custom projects and in all three cases, the participants completed the same type of project for each occurrence (Table 8).

Table 8: Overview of Participant Respondents

ID	Industry	Project Type(s)	Project Savings (MWh)	Number of Custom Projects
P2	Industrial	Air Audit	<100	1
P3	Industrial	Air Audit	100 to 499	1
P5	Industrial	Air Audit	100 to 499	1
P14	Industrial	Air Audit	100 to 499	1
P1	Property Mgt.	HVAC	> 1,000	1
P11	Property Mgt.	Booster Pumps	<100	2
P13	Property Mgt.	Shell	<100	1
P12	Education	Bldg. Renovation	500 to 999	2
P15	Education	Bldg. Renovation	> 1,000	1
P6	Education	HVAC	<100	1
P7	Govt. Infrastructure	Data Centre	100 to 499	1
P8	Govt. Infrastructure	HVAC	500 to 999	1
P9	Recreation	Snow-making	100 to 499	1
P10	Retail	Bldg. Renovation	100 to 499	2
P4	Agriculture	Aquaculture/Refrig.	100 to 499	1

3.2 Retrofit Awareness, Outreach, and Rationale for Participation

Most participants were aware of the Retrofit service prior to their recent participation and their awareness came from varied sources. Of the 14 participants for which the Evaluator could determine the length of time they have been aware of the service, 12 reported being familiar with the service for at least two years, and half were aware of it since its inception.

Participants reported awareness of the Retrofit service via a variety of sources and four of the 15 cited multiple sources. Consultants (6) and BDMS (5) were the most commonly cited sources of awareness, followed by common knowledge and word-of-mouth (4), Nova Scotia Power (3), and ENS outreach, such as email notifications (2).

Service awareness sources may change in subsequent years based on ENS's additional outreach efforts beginning in 2017. According to the program manager, an emphasis on outreach efforts led to an increase in new project initiation in 2017. This will likely yield some savings in late 2017, but more noticeably in 2018 and 2019 upon project completion. Projects started in 2017 may complete in 2018 and those participants will be more aware of the service and likely to participate in the future. A notable reason for the increase in project initiation has been the addition of new BDMs and the strategy that the service staff and BDMs have used to focus on specific vertical markets (e.g., aquaculture).

All consultants reported relying on existing clients that they communicate with regularly to identify Retrofit projects. In addition to their ongoing communication with existing clients, a small portion of providers conduct sales calls to potential participants (3), respond to referrals from existing clients (2), or referrals from a BDM (1).⁷ One respondent also uses trade shows to identify potential participants.

Improving the performance of existing equipment was the primary rationale for completing a Retrofit project. Eleven participants indicated they completed their project to improve a process, such as having compressed-air tools running at peak levels. Lowering utility bills for long-term savings was also a popular reason to participate (10), and far fewer participated for environmental reasons (2), such as a desire to reduce greenhouse gases.

3.3 Retrofit Delivery

Consultants reported they are involved in all phases of a Retrofit project; however, the degree of their involvement in each phase varies. Consultants confirm eligibility, prepare scoping and/or feasibility studies, are involved in implementation, and M&V. However, except for the eligibility-confirming phase, the degree to which they are involved in each phase can vary. These variations are as follows.

- › Scoping
 - Of the 10 respondents, three reported skipping a formal scoping phase and doing a feasibility study. For example, one respondent stated that the scoping work can happen over the phone and the two other respondents reported scoping was often unnecessary because the potential savings were relatively obvious.

⁷ BDMs do not refer participants directly to specific consultants. Rather, BDMs may provide several potential consultants that serve specific industries. Consultants may be interpreting this as BDM "referrals", but in reality they may have been chosen by a participant from a small list provided by BDMs.

- › Feasibility
 - Nine of the 10 respondents reported preparing feasibility studies and these nine characterized this phase as the key aspect of their participation in projects and the key value they deliver to participants.
 - However, one respondent noted that their firm was not ideally suited for preparing feasibility studies and was more interested in Business Energy Rebate (BER) participation.
- › Implementation and Installation
 - Consultants largely employ subcontractors to implement projects or rely on the participant to complete the installation work with internal staff or their own contractors. Of the eight respondents that discussed their role in the implementation phase, all eight mentioned hiring subcontractors for installation and two of those eight noted their staff would be responsible for implementation if it was a relatively small job or their schedule could accommodate taking the time needed.
- › Measurement and Verification (M&V)
 - Five of the eight respondents that reported details about their role in M&V mentioned designing the M&V plan or overseeing the analysis of the results of the M&V data collection.
 - Two respondents mentioned limited involvement in M&V. One respondent reported that M&V is typically in the purview of the installer. Another respondent explained that M&V is difficult for their firm to complete because they do not have the resources to complete this phase.

The type of support participants receive from their consultant varies according to the needs of the project and all participants reported high levels of satisfaction with their consultant. Single system projects such as air audits and single-measure upgrades typically require less interaction with consultants than do the longer-term multiple measure projects like major building renovations.

Of the 11 participants that completed single system projects, eight reported typically interacting with their consultant most in the early phases of a project and less so during implementation and M&V. During the early phase of the project, the participants and consultants communicate about the project scope, estimated savings and incentives, and scheduling of installation.

All four participants with longer term projects involving multiple measures reported interacting with their consultants on a regular basis throughout the project. Participants and consultants would check in on the progress of work, keep one another abreast of any paperwork needed to apply for incentives, and to coordinate schedules.

One participant provided an example of how a consultant delivered good service. In this case, the consultant provided the participant with an initial incentive estimate that turned out to be more than twice the eventual estimate and actual incentive provided by ENS. While this discrepancy in estimates could have led to hard feelings by the participant, the respondent noted how well the consultant explained their initial estimate, emphasizing that their estimate was preliminary and could be drastically different upon completion of the study. The consultant explained that the ENS estimate was the more important and thorough estimate. Furthermore, this consultant (and ENS) accommodated the participant's busy production schedule by postponing the M&V steps. The effective communication skills of the consultant and accommodating a busy and sometimes unpredictable schedule contributed to a highly satisfied Retrofit participant.

Regardless of the variation in how consultants participate in the Retrofit phases, once a participant receives a study, they are highly likely to complete a Retrofit project. According to service staff, about 85 percent of completed studies result in a Retrofit project and some portion of the remaining 15 percent may result in BER projects.

Consultants reported the M&V phase generally works well, reporting no systemic problems. All eight consultants reported satisfaction with the M&V process and six specified elements of M&V that they appreciated. Five specified that the process was straightforward and easy to follow and one of these consultants stated that M&V works well even on complicated projects with many measures and interactions. Additionally, one liked the fact that incentives were paid promptly post M&V. Two consultants reported using their own M&V tools instead of using anything ENS provides and another consultant reported understanding the regulatory requirement of M&V and therefore the rationale behind the specific details required during the M&V phase.

3.4 Retrofit Successes

All interviewed groups reported successes with the service and the subsequent sections describe those successes.

Consultants were satisfied with the service requirements, their interactions with ENS, and the expansion in business the service provided their firms. Almost all consultants are satisfied with the service requirements. Nine of the 10 consultants reported high levels of satisfaction with the service requirements describing the requirements as reasonable and the service paperwork as problem-free. The remaining respondent reported the process as difficult for their firm because their firm tends to do smaller scale single measure projects (\$30,000 to \$60,000) that do not warrant spending the time and resources needed to do the engineering studies.

All consultants indicated high levels of satisfaction with the Business Development team, reporting that they interact with BDMs regularly about Retrofit updates, project management, and future project opportunities. When managing a specific project, consultants generally interact with BDMs at the beginning of the project to explain procedures and manage expectations and then again towards the conclusion of the project when M&V is complete. Four noted that BDMs occasionally attend project initiation meetings with participants and the consultant, and three noted that BDMs sometimes refer consultants to participants.⁸

All 10 consultants indicated the service has increased the number of projects or the size of projects they complete and six of the 10 suggested that the service has helped their firms increase their offerings. For example, one of these six noted that the Retrofit service has led to their staff focusing on energy usage when serving participants as opposed to just completing one-for-one replacements. That focus has in turn led to new participants and expanded project scopes.

All participants were universally satisfied with the way their projects progressed. From verifying eligibility through measurement and verification, participants were pleased with their projects and 11 mentioned specific service elements they especially appreciated.

- › Five indicated the incentives available through the service enabled them to convince decision-makers to approve the project.
- › Three respondents representing three different project types appreciated the technical assistance offered by the service and one of these specifically mentioned the equipment loaned by ENS as a boon to their project.
- › Two specified notable improvements in the performance of equipment needed to run their business. For example, one mentioned their air tools work consistently across the plant as a result of fixing air leaks.
- › Two noted that the service and the incentives enabled them to complete additional efficiency projects they could not have completed without incentives.
- › Two respondents that had completed Retrofit projects in the past noted how the participation process has improved over time, particularly mentioning how digitization of service paperwork has been helpful.

Participants are aware of, make use of, and are highly satisfied with ENS resources, particularly their interactions with BDMs. Thirteen of the 15 participants referred to their BDMs by name during the interview and the two who did not name their BDMs completed single-system projects and had limited experience with ENS. One of these two participants reported, unprompted, that they would like to have regular contact with someone like a BDM to help their firm identify additional projects.

⁸ See footnote on page 15.

All 13 of the participants who recalled working with a BDM reported satisfaction with their BDM describing them as “timely,” “responsive,” and “helpful.” Ten of the 13 reported regular interactions with their BDM via check-in meetings, phone calls, and emails. In these regular interactions, BDMs inform participants about the latest service changes, and participants share with BDMs their ideas for upcoming energy-saving projects. If a project is underway during these meetings, the BDM and participant may talk about that project, but typically the conversations are about upcoming projects. The interaction with one BDMs was so successful for the participant that they were in the process of applying for an on-site energy manager (OEM).

Fourteen of the 15 participants indicated they are planning future ENS projects ranging from lighting, HVAC, pumps, and air audits. The one participant that did not indicate an interest in a project stated that they had a small facility and their recent Retrofit project addressed their sole major energy-using piece of equipment.

3.5 Barriers to Proceeding with a Project

Overcoming financial considerations was the most commonly cited reason businesses do not proceed with implementing a Retrofit project according to consultants. As suggested in Section 3.3 by service staff, businesses that get into the study phase of a project typically proceed with installing equipment via the Retrofit service or through the BER program component. However, nine consultants specified the following barriers businesses face when deciding to implement recommended measures.

- › All nine mentioned financial considerations as a challenge.
 - Eight noted upfront costs being too high.
 - Two specified long payback periods that make the project untenable to ownership.
 - One consultant that works with many property management firms noted the split incentive problem (namely, the building owner does not pay the utility bills and is therefore disinclined to invest heavily in efficiency).
 - One noted that some smaller businesses can struggle to get project financing.
- › Two respondents stated businesses can be reluctant to use new technology that they perceive to be unproven.
- › One respondent mentioned businesses sometimes do not have the time to implement the measures.

The Evaluator did not explicitly ask participants about barriers to proceeding with projects and no participants suggested barriers to proceeding with a project.

3.6 Suggestions for Retrofit Improvement

Market actors offered few suggestions for service improvement. Six participants, three consultants, and the program manager suggested ways to improve service outreach and processes. To improve service outreach and increase participation, respondents suggested the following.

- › Two participants and one consultant would like to see greater promotion of the service in the market. The program manager echoed this, noting that ENS has only reached slightly more than half the large industrial businesses in Nova Scotia and has only recently emphasized reaching out to agricultural businesses in the province.
- › A participant would like to see ENS provide training to facilities staff about ways to operate buildings at maximum efficiency. This participant stated their staff would benefit from learning about the low-cost and no-cost ways in which a building can operate more efficiently.
- › Service staff noted that they hope to increase participation and do more non-lighting projects. To achieve this goal, the service is continuing to work on identifying measures that may appeal to specific markets and working to support those measures with staff specialists. The service staff would like to repeat what they have successfully done in the aquaculture market, where they identified refrigeration measures used in that market and worked with consultants and BDMS to generate interest in those measures. Furthermore, ENS's technical specialists have been encouraged to focus on market niches that have led to new participants. Currently, the service team has specialists (project owners) with expertise in new construction, refrigeration/aquaculture, building optimization, and industrial applications, including compressed air. These specialists have been helpful in supporting participants in these specific areas.

To improve service processes, respondents suggested the following.

- › Two consultant respondents noted that Retrofit does not accommodate small projects well. Both respondents noted that projects with savings in the \$2,000-to-\$5,000 range are not worth the effort to go through Retrofit. Any savings for these projects are lost by paying for the studies and the M&V. One respondent suggested removing M&V from projects worth less than a certain amount to make smaller projects more appealing to participants and consultants. It should be noted, however, that ENS does not require a scoping and/or feasibility study, nor M&V for smaller projects that fall under Track 1.
- › Additionally, a property manager and a government respondent, each with multiple properties, would like assistance to be offered for gas, oil, and water projects. These respondents are aware that ENS's mandate is electric projects, but they would like to see the province or other entity support efficiency services for other utilities.

4 RETROFIT IMPACT EVALUATION

The objective of the 2017 Retrofit impact evaluation was to determine the service's gross and net electrical energy and peak demand savings. As explained in the program component description, Retrofit includes three types of savings: (1) partial savings (projects to be completed in future years), (2) final savings of 2017 projects and (3) final savings of multi-year projects. In 2017, 18 projects achieved partial savings, 39 final savings projects were started and completed in 2017, and 7 multi-year projects claimed final savings in 2017.

4.1 Sampling Methodology for Retrofit

The Evaluator selected a sample of 26 projects from a total of 46 completed projects with final savings as of November 2017. All the projects with partially claimed savings were excluded from the project reviews because they will be covered by the next evaluation, where these projects can be reviewed as completed projects.

Three projects were listed as Building Optimization projects, but they each had an overlap with Retrofit. These projects have been considered as Retrofit projects and included in this component's sample because Retrofit encompasses most of the measures included in existing building commissioning, of which at least one is a Building Optimization measure.

Because a high proportion of projects with final savings was included in the sample, the Evaluator could not use a systematic stratified sampling methodology similar to the one used in 2016 and in previous years. Instead, the Evaluator made an effort to ensure that the selected projects represented a variety of measure categories and to sample a higher proportion of the largest projects.

The project sample included projects from all measure categories except renewables. Of the 46 completed projects, the compressed-air measure category had the biggest number with 8 projects, all of which were sampled by the Evaluator. Heating, ventilation and air-conditioning (HVAC), and refrigeration measures were the second and third biggest groups each with 6 projects sampled. The mix of measure categories sampled was diverse enough and the adjustment ratios were close enough to unity to allow for applying a single gross adjustment factor to the entire Retrofit population.

Gross Savings

Gross savings correspond to changes in energy consumption that result from the actions taken by Retrofit participants, regardless of why they participated.⁹ For each project, ENS tracks the annual gross savings and the equipment parameters specific to each project. This section presents a summary of the adjustments made to specific projects.

⁹ Definition adapted from the National Renewable Energy Laboratory, *The Uniform Methods Project Chapter 23: Estimating Net Savings: Common Practices*, September 2014, p. 3, available at: http://energy.gov/sites/prod/files/2015/02/f19/UMPCChapter23-estimating-net-savings_0.pdf (Last accessed November 19, 2015).

4.1.1 Project Review Findings

The final tracked gross energy and peak demand savings results for Retrofit 2017 were reviewed and adjusted by the Evaluator. The overall adjustment ratios for energy and peak demand savings were calculated by comparing the tracked project savings to the Evaluator's calculations for the 26 sampled projects. The adjustment ratios were applied to the tracked savings of all the projects with both partial and final savings for 2017.

It should be noted that in 2017, the number of projects in the compressed-air category had a significant increase, reaching a total of eight projects and representing 18 percent of the total tracked savings for completed projects, thus becoming the biggest single-measure category. The other adjustments covered various measure categories and no other single-measure category required special attention. As a result, this report discusses the adjustments made for only two main retrofit project categories, namely compressed-air and "other". An additional general findings section is included to discuss trends observed in the 2017 evaluation.

Adjustments Made to Compressed-air Projects

Of the eight compressed air projects in the sample, four projects required adjustment. The adjustments made by the Evaluator were typically changes to a single operating variable, such as hours of operation, or the peak coincidence factor. Two projects required adjustments to their energy savings. Of those two, one project required an adjustment to the reported M&V results, because the consumption data about one of the five compressors in the plant should have been subtracted from rather than added to the energy measurement calculations. For the other project, the main adjustment was to slightly increase the hours of operation from 18.5 to 20.8 hours per day. Although both projects had project adjustment ratios greater than 10 percent (0.746 and 1.132), the overall impact on the category was less than 1 percent since those projects' tracked energy savings were small.

The other 2 projects required an adjustment to their peak demand savings. The adjustment made to one project involved applying a revised PCF of 0.77 to the operation of a relatively small compressor that was not being used for continuous production. The second project required making an adjustment that involved calculating the difference in the average metered power consumption to calculate the peak demand savings, instead of applying the kVA values indicated in the verification report, for which no supporting measurement or power factor value was available. These adjustments resulted in a small reduction in peak demand savings for both projects.

Adjustments made to the compressed-air projects resulted in adjustment ratios that were comparable to those calculated for the entire sample (0.990 for energy savings and 0.921 for peak demand savings). Overall, the compressed-air projects were well documented, easy for the Evaluator to follow, and contained some form of M&V. In some instances, there were changes to the project scope that were observed on site but had not been identified in the project documentation provided by ENS. The Evaluator recommends that ENS implement a change-tracking document to allow the project manager to track and update the demand-side management data system (DSMDS) accordingly.

Adjustments Made to Other Retrofit Projects

Those projects in the “other Retrofit” category involved a mixture of process, motor/drive, refrigeration, HVAC and insulation measures. Of the 18 projects sampled in this category, five required an adjustment to their savings. For three of the five projects, energy savings adjustments were made and all five projects had an adjustment made to their peak demand savings. The adjustments made to the energy savings were small and the overall adjustment ratio for this category of projects was established at 0.996. Demand adjustments for this category were more substantial because one project had a significant adjustment, thus resulting in an overall ratio of 0.741 for the peak demand savings.

Regarding those adjustments made to the energy savings for the projects in this category, two were small changes made to the savings based on the M&V data. The single major adjustment made to energy savings was for a process-insulation project that involved wrapping a large process water-holding tank. The consultant used the tank set-point temperature of 35°C instead of the measured average temperature of 24°C, thus resulting in a higher heat loss rate than would be expected if the typical tank temperature had been applied. Because the annual savings for this project were small in comparison to the other four projects, this project's adjustment factor of 0.490 had no significant impact on the overall category ratio.

The largest reduction in peak demand savings was made to a project whose peak demand savings were calculated based on the demand difference due to more efficient refrigeration equipment plus the difference in pump power. Since no refrigeration equipment was changed, there should have been no peak demand savings from the reduced cooling energy consumption. The only peak demand savings for this project came from the difference in pump power consumption. A second adjustment was a result of the Evaluator choosing to use the difference in the average of the measured loads instead of two spot measurements reported in the project proposal yet without any detail about how they were obtained; this choice resulted in a more conservative peak demand savings value. A third major adjustment resulted in a positive increase in peak demand savings and it was made by using the average demand difference between the two design options. Because the equipment was running as part of a continuous process, the average demand was reasonable and representative. This was a large adjustment because the consultant had not claimed any peak demand savings for the project.

The documentation of the “other retrofit” category projects was sufficient, and the necessary paperwork was available. The Evaluator had no major difficulty verifying the key operating variables during the site visits. As mentioned above about the compressed-air category, the Evaluator had to request additional information for a couple of projects and the information was subsequently provided by ENS. The only major adjustment was made to account for the changes in the actual equipment installed by the participant. Again, the use of a change-tracking document or process for Retrofit projects, would help improve the overall adjustment ratio and limit large scope changes.

General Findings

Since the adjustment ratios for the compressed-air and other projects were not statistically different, the Evaluator calculated the ratios for all projects together. The adjustment ratio for energy savings covered all the reviewed projects and was established at 0.995, with a margin of error of 1.2 percent. For peak demand savings, a one-time adjustment was made for the refrigeration project, whose main measure had not been implemented. By excluding this measure, an adjustment ratio of 1.128 with a margin of error of 9.5 percent was established. When including the one-time adjustment, the overall peak demand savings adjustment ratio is 1.000.

Although the energy adjustment ratio for 2017 were close to the average of the past evaluations, it should be mentioned that four projects were not adjusted in 2017 due to a lack of supporting M&V documentation. Of these four projects, two were handled by one consultant, the third was a large multi-facility performance contract and the fourth was a high-speed door project at a refrigerated facility. For all these four projects, the lack of actually documented M&V made it difficult for the Evaluator to adjust the tracked savings with any degree of certainty. Specifically, none of the four projects included any actually measured data; instead, information provided by manufacturers, assumptions made by the consultant and engineering estimates of easily measurable variables were used. Of the entire sample, these four projects accounted for 19.4 percent of the tracked energy savings and 16.4 percent of the peak demand savings.

M&V documentation has improved in overall quantity, yet the consultants are still defining the format and the kinds of information they consider to be relevant. To facilitate documenting M&V, ENS has developed tools, such as an M&V guide to be used for all 2018 projects. The Evaluator expects that this new document will help standardize M&V documentation and improve the effectiveness of the internal review process.

Implementing a change management process would provide an effective method for tracking the adjustments made from the moment when the PDA is signed to the moment when a project is finalized in the DSMDS. It should be expected that some projects would change their scope due to funding, market conditions, or management. A process for handling and updating tracked savings should be put in place to improve the quality, accuracy and effectiveness of M&V.

4.1.2 Interactive Effects

Because interactive effects vary significantly from one Retrofit project to another, they are generally taken into account in the project engineering calculations used to obtain initial gross savings. The calculation of the lighting projects' interactive effects follows a standardized approach based on a methodology published in the ASHRAE Journal.¹⁰

¹⁰ Rundquist, Robert A. et al., "Calculating Lighting and HVAC Interactions", in *ASHRAE Journal*, November 1993, pp. 28-37.

4.1.3 Effective Useful Life

Lifetime energy savings are now applied to all the energy efficiency measures and products offered in the ENS program portfolio. In Custom's evaluation, the Evaluator reviewed the values tracked by ENS, which are listed in Table 9 below.

Table 9: Tracked EUL Values by Measure Category

Compressed Air	4
HVAC	20
Process (Industrial)	10
Refrigeration	15
Lighting	11.41
Renewables	20
Motors and VSDs	15
Envelope	20
Custom – Other	10
Water Heating	15

Currently, these EUL values are not shown for each project in the Custom tracking sheet. For each project reviewed, the Evaluator assigned the corresponding EUL value based on the measure category identified in the tracking sheet.

The Evaluator then compared those values to the evaluated values established for the specific measures involved in each of the 26 sampled projects. The evaluated EUL values were established based on a literature review and an analysis of each project's baseline. When establishing the EUL for a given measure, the Evaluator considered the most common and relevant values found in technical reference manuals, evaluation reports or other types of studies.

The Evaluator also analyzed whether any projects had a dual baseline, which means such measures' baseline efficiencies will increase in the course of their EUL. For example, an old motor near the end of its useful life is replaced by a high-efficiency motor. The first-year savings are calculated based on the difference in efficiency between the old inefficient motor and the new high-efficiency one. If the old motor has to be replaced in five years, then the baseline after the first five years would be a new standard-efficiency motor. An increase in the baseline can be taken into account by reducing the EUL value applied to the first-year energy savings so that the equivalent EUL value can be multiplied by the first-year savings to establish the lifetime energy savings. When reviewing the 26 Retrofit projects sampled, the Evaluator did not encounter any dual-baseline case. While the dual-baseline could occur with future Retrofit projects or non-sampled projects, cases involving the dual-baseline do not seem common.

An average adjustment ratio was calculated for the EUL values of the sampled projects so as to enable extrapolating the results of the sample to all participants. The adjustment ratio was calculated using the following equation:

$$EUL\ Ratio = \frac{\sum Evaluated\ EUL_i \times Evaluated\ ES_i}{\sum Tracked\ EUL_i \times Evaluated\ ES_i}$$

Where *Evaluated ES* are evaluated energy savings and *i* represents each project included in the sample.

This calculation yielded an average adjustment ratio of 1.057, which, despite being close to unity, has a large margin of error of 17.3 percent. Because the margin of error did not meet the target of 10 percent, the Evaluator decided not to apply the adjustment ratio to the tracked value. Instead, a weighted average of evaluated EUL values in the sample was established at 13.6 years (with a margin of error of 0.6 years or 4.4%) and was applied to all projects. The fact that the average of the values had a much lower margin of error than the adjustment ratio shows that the generic EUL values by category were often a poor fit with individual projects. Most of the changes made were a result of having a more detailed set of EUL values that were based on the individual measures rather than the single overlying project category. For example, all of the projects categorized as compressed air were originally assigned an EUL of 4 years, whereas the Evaluator applied an EUL of 3 years to compressed-air leakage measures and an EUL of 15 years to compressor or variable frequency drive controls upgrades.

The Evaluator recommends that from now on, ENS select an EUL value specific to each project and the measures involved in it.

4.1.4 Revised Gross Savings

For those projects that claimed partial savings over the previous years and were completed in 2017, the Evaluator calculated a true-up adjustment ratio so that the sum of (1) the total adjusted gross savings or the total adjusted net savings claimed over the years and (2) the true-up amount is equivalent to the total tracked project savings multiplied by the adjustment ratio determined for the year of project completion.

The savings results are listed under three previously defined categories: (1) partial savings, (2) final savings for projects started and completed in the current year and (3) final savings for multi-year projects. The overall current-year adjustment ratio was established by calculating a weighted average of individual completed projects' adjustment ratios according to their respective total savings. This overall current year adjustment ratio was applied to all three categories, whereas true-up ratios were only applied to the final savings of multi-year projects.

Table 10 below shows an example of how the true-up ratio was applied to the gross energy savings of a multi-year project completed in 2017.

Table 10: Example of a True-up Adjustment

	2015	2016	2017	Total
Tracked Savings (kWh)	495,833.000	522,280.000	108,358.000	1,126,471.000
Year-specific Adjustment Ratio	1.002	1.038	0.995	
Revised Savings Prior to True-up (kWh)	496,824.666	542,126.640	107,816.210	1,146,767.516
Project Total Revised Savings with True-up (kWh)				1,120,838.65
True-up (kWh)				(25,928.87)

After the true-up adjustments were applied to the final savings of multi-year projects completed in 2017, the 2017 gross energy savings at the generator for Retrofit are estimated at 15.835 GWh and the total gross peak demand savings are estimated at 1.148 MW at the generator, as listed in Table 11 below. Gross lifetime energy savings for Retrofit were determined at 215.349 GWh.

Table 11: Revised Gross Energy and Peak Demand Savings for Retrofit

	Partial Savings	Final Savings for Projects Started and Completed in 2017	Final Savings for Multi-year Projects	Total
Number of Projects	18	39	7	64
Energy Savings				
Tracked Gross Energy Savings – at the Meter (GWh)	7.092	7.449	0.594	15.135
Adjustment Ratio for Energy Savings	0.995	0.995	0.995	-
Gross Energy Savings – at the Meter (GWh)	7.057	7.412	0.591	15.060
True-up Adjustment for Gross Energy Savings (GWh)	-	-	-0.082	-0.082
Adjusted Gross Energy Savings – at the Meter (GWh)	7.057	7.412	0.509	14.978
Line Loss Factor	1.057	1.058	1.053	-
Gross Energy Savings – at the Generator (GWh)	7.457	7.841	0.536	15.835
Effective Useful Life (years)	13.6	13.6	13.6	-
Gross Lifetime Energy Savings – at the Generator (GWh)	101.409	106.644	7.296	215.349
Peak Demand Savings				
Tracked Gross Peak Demand Savings – at the Meter (MW)	0.563	0.483	0.112	1.158
Adjustment Ratio for Peak Demand Savings	1.000	1.000	1.000	-
Gross Peak Demand Savings – at the Meter (MW)	0.563	0.483	0.112	1.158
True-up Adjustment for Gross Peak Demand Savings (MW)	-	-	-0.075	-0.075
Adjusted Gross Peak Demand Savings – at the Meter (MW)	0.563	0.483	0.037	1.083
Line Loss Factor	1.061	1.058	1.054	-
Gross Peak Demand Savings – at the Generator (MW)	0.597	0.511	0.039	1.148

4.2 Net-to-gross Ratio

The net-to-gross ratio (NTGR) determines the net savings, i.e., those savings that can be reliably attributed to a program component or service. More precisely, the NTGR includes effects, such as free-ridership and spillover, that positively or negatively affect the energy savings generated by a program component or service.

In the case of Retrofit, free-ridership has been quite stable over the previous years (10% in 2016; 8% in 2015; 10% in 2014; and 9% in both 2013 and 2012), despite the changes and variations occurring in the levels of participation and the types of projects submitted. For 2017, the free-ridership level has been established at 9 percent, based on the results of the last five years.

Since no other energy efficiency measures were implemented outside the service, as in 2015 and 2016, the spillover was established as nil.

4.2.1 NTGR Calculation

The NTGR was calculated using the following equation:

$$NTGR = (1 - \% \text{ free-ridership} + \% \text{ internal spillover})$$

Using the free-ridership and spillover levels established for Retrofit, the NTGR value was estimated at 0.91.

4.3 Net Savings

Net savings are defined as changes in energy use that are specifically attributable to Retrofit. Net Retrofit impacts are calculated by applying the NTGR value mentioned above to the gross Retrofit savings, as shown in the following equation:

$$Net\ Savings = Gross\ Evaluation\ Savings \times NTGR$$

Using an approach similar to the one used to adjust the gross savings, the Evaluator applied a true-up adjustment to the net energy savings of multi-year projects completed in 2017 so that the total revised net savings over the complete duration of the project are equivalent to the total revised gross project savings multiplied by the NTGR for 2017.

For 2017, Retrofit generated 14.418 GWh in net energy savings and 1.045 MW in net peak demand savings at the generator. The results obtained are listed in Table 12 below. Overall, using the Nova Scotia-specific factor¹¹ of greenhouse gas generated by electricity production, i.e., 0.6531 kg CO₂ eq/kWh, it was estimated that the net energy savings would translate to 9,415 tonnes of avoided CO₂ eq annually. Based on the average EUL of 13.6 years, the net lifetime energy savings were established at 196.090 GWh.

Table 12: Evaluated Net Energy and Peak Demand Savings for Retrofit

	Partial Savings	Final Savings for Projects Started and Completed in 2017	Final Savings for Multi-year Projects	Total
Energy Savings				
Revised Gross Energy Savings – at the Meter (GWh)	7.057	7.412	0.509	14.978
NTGR	0.91	0.91	0.91	-
Net Energy Savings – at the Meter (GWh)	6.422	6.745	0.463	13.630
True-up Adjustment for Net Energy Savings (GWh)	-	-	0.009	0.009
Adjusted Net Energy Savings – at the Meter (GWh)	6.422	6.745	0.472	13.638
Line Loss Factor	1.057	1.058	1.053	-
Net Energy Savings – at the Generator (GWh)	6.785	7.136	0.497	14.418
Effective Useful Life (years)	13.6	13.6	13.6	-
Net Lifetime Energy Savings – at the Generator (GWh)	92.282	97.046	6.762	196.090
Revised Gross Peak Demand Savings – at the Meter (MW)	0.563	0.483	0.037	1.083
NTGR	0.91	0.91	0.91	-
Net Peak Demand Savings – at the Meter (MW)	0.512	0.440	0.034	0.986
True-up Adjustment for Net Peak Demand Savings (MW)	-	-	0.001	0.001
Adjusted Net Peak Demand Savings – at the Meter (MW)	0.512	0.440	0.035	0.987
Line Loss Factor	1.061	1.058	1.054	-
Net Peak Demand Savings – at the Generator (MW)	0.544	0.465	0.037	1.045

¹¹ At the time of writing, 2017 data was not yet available. The Nova Scotia-specific factor was obtained from Nova Scotia Power's 2016 total system emissions data (7,079,268 CO₂ eq tonnes) and total electricity generation (10,839 GWh) was found in the following two sources:

Nova Scotia Power, *Total System Emissions*, <http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx>. (Last accessed December 17, 2017).

Emera Inc., *Management's Discussion & Analysis As at February 10, 2017*, <http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693> (Last accessed December 17, 2017).

5 NEW CONSTRUCTION MARKET EVALUATION

5.1 Participants' Perspectives

As part of the New Construction on-site visits, two participants were asked questions regarding their satisfaction with New Construction, any barriers they encountered and their improvement suggestions.

Satisfaction with New Construction

Overall satisfaction with New Construction was high among all participants, who gave an average rating of 8.0 on a 10-point scale (with 1 indicating “not at all satisfied” and 10, “completely satisfied”). Both interviewed participants were very satisfied with the smooth collaboration with ENS and the flexibility demonstrated by the staff, with one interviewee indicating that “staff is really flexible and easy to work with.”

Challenges and Barriers

Both interviewed participants cited the same challenge faced in their participation. They mentioned the difficulties encountered in understanding or obtaining technical information about the proposed energy-efficient measures.

Recommendations

One participant made suggestions on how to improve New Construction, and one did not since he was very satisfied and could not think of anything that should be improved. The participant who provided improvement suggestions indicated that it would be helpful for ENS to:

- › Better communicate technical information to participants; and
- › Share case studies and success stories featuring previous completed projects involving the proposed energy-efficiency measures.

6 NEW CONSTRUCTION IMPACT EVALUATION

The objective of the 2017 New Construction impact evaluation was to determine the service's gross and net electrical energy and peak demand savings. Like Retrofit, New Construction can claim three types of savings: (1) partial savings (projects to be completed in future years), (2) final savings of multi-year projects and (3) final savings of current year projects. In 2017, there were one project with partial savings, five final savings projects started and completed in 2016, and one multi-year project with final savings claimed in 2017.

6.1 Gross Savings

As with Retrofit, the Evaluator performed a detailed technical review of five of the six New Construction projects completed in 2017. Four projects were started in 2017 and their final savings claims were all made in 2017. The fifth project was a multi-year project.

6.1.1 Project Review Findings

In 2017, six projects were completed through the New Construction service. A detailed technical review was performed for five of the projects completed. An on-site visit was conducted for four of the five projects.

The site visits and project reviews determined that in all cases, energy efficiency measures were implemented as planned. However, all five projects saw their savings adjusted because errors were found in the energy models or in the subsequent savings calculations performed with the model output values.

The two projects where savings had the largest downward adjustment were adjusted for similar reasons. In both cases, the electricity consumption of the base case was reduced because it was calculated without properly taking into account the efficiency of the heating system. Indeed, the electricity consumption of the base case cannot be taken directly from the reference building energy model that was automatically generated by the simulation software (such as CanQUEST). This is because the reference building energy model uses the same heating system as in the efficient building (if the efficient building had natural gas boilers, then the reference model would use natural gas boilers as well.). For both projects, this did not represent what participants would have built in the absence of New Construction. As such, an adjustment was made by the participant's energy modeller to manually convert the natural gas consumption into the equivalent electricity consumption of electric baseboards.¹² For one of the projects, the conversion was performed using the nominal efficiency of the boilers, thus overestimating the savings. For the other project, the details of the calculations based on the simulation outputs were not provided by the participant's energy modeller. However, it appeared that savings had been overestimated, probably because the conversion from gas to electricity consumption was not

¹² This effectively means that electricity savings resulting from fuel-switching are considered under New Construction.

performed correctly. The Evaluator recommends that those calculations be added to the documentation requirements for New Construction projects. Another adjustment made to both projects included adding interactive effects for efficient appliances; the savings for this measure was calculated in an Excel file (outside of the energy simulation), so the impact of efficient appliances on the heating load was not considered. One of those projects also required an adjustment to the heating system's capacities, because, for 3,000 to 4,000 hours during the year, the heating load of some zones in the building was not met; this also had a downward impact on the evaluated savings. Those two projects' energy savings were decreased by 38 and 43 percent respectively.

The remaining three projects saw their savings reduced because of incorrect modelling of heat pump systems. For one project which consisted in the construction of a new ice skating rink, the base case refrigeration system of the arena was incorrectly modelled as an open centrifugal chiller with the coefficient of performance (COP) value rated at 44°F. This is not a reasonable reference because centrifugal chillers are extremely uncommon in arenas; typical systems are reciprocating chillers, so this type of chiller was used as a revised reference. Additionally, the COP of the chiller was entered for a temperature of 44°F, which is too high to be representative of the temperature at which the equipment runs to produce ice; the Evaluator adjusted the COP for a temperature of 20°F instead. Other minor adjustments were made to items such as fan run times and well water temperatures, resulting in an overall downward adjustment of 23 percent.

Another project was the retrofit of a live lobster tank facility, with a focus on the cooling system for sea water. In that case, the engineering calculations were based on an erroneous value for the flow rates of water to be chilled; the flow rates exceeded the capacity of the heat pump systems. It was found that the heat pump capacity was the correct value; so, the flow rates were adjusted downward to match that value. The COP value used initially was at standard operating conditions for air-conditioning purposes, which did not represent the conditions in which a sea water chilling system operates. The Evaluator used the specifications of the heat pump models of both the base case and the efficient case at a temperature of 2°C (corresponding to the actual temperature of the lobster tank water) to establish a more representative COP. Along with other minor adjustments, this resulted in a downward adjustment of 29 percent.

The last project for which heat pump models were adjusted was in a multi-unit residential building. For this project, the approach used to model the radiant in-floor heating and cooling system (a system that cannot be modelled directly in the software used, EE4), was not accurate. The Evaluator modified the model to be more representative of the actual operation of the system. Also, the air-source heat pumps were modelled as having a constant COP and capacity regardless of the outdoor conditions, which did not match the specifications provided for those heat pump models. This resulted in an over-estimation of the savings associated with the air-source heat pumps. The applicant provided monitoring data for the boiler and heat pumps and a yearly COP was obtained from the data and used to adjust the models. The revised energy savings were reduced by 25 percent in comparison to the tracked savings.

Overall, the revised energy savings for all five reviewed projects were 30 percent below the tracked value. As for peak demand savings, they were increased by a ratio of 3.41. To establish peak demand savings, the Evaluator used the difference in average peak demand consumption for December, January and February between the efficient and the base case buildings. It was not possible to explain exactly why the tracked values were so different from the revised values, since the methodology for calculating peak demand savings was not documented in New Construction.

The project reviews showed that for two projects, a large portion of the savings came from fuel-switching, namely, using natural gas to supply space heating and domestic hot water in place of the electrical systems that the participant would have installed in the absence of the program. Those savings are highly dependent on participants' declarations since the base case is not determined according to energy efficiency standards or building codes. The Evaluator also notes that greenhouse gas emission reductions for fuel-switching projects are lower than for projects where electricity consumption is reduced without additional fuel consumption. However, this was not taken into account in the avoided emissions calculated as part of this evaluation; avoided greenhouse gas emissions were quantified solely in terms of reduced electricity generation.

6.1.2 Interactive Effects

Because the savings for New Construction are based on the results of simulation models which encompass the total electricity consumption of both the proposed and reference buildings, the interactive effects are already included. No further interactive effects factor has thus been applied to savings.

6.1.3 Effective Useful Life

As part of the 2017 evaluation, the Evaluator reviewed the EUL values used by ENS in the calculations of energy savings that are expected to persist over time.

For New Construction, ENS assigned an EUL value to each measure based on its general measure category, using the same approach as for Retrofit. Based on the measure mix of all projects generating savings in 2017, the average tracked EUL value was established at 19.3 years.

The Evaluator conducted a literature review to establish the revised EUL values for individual measures implemented in the five projects reviewed. By basing this analysis on the reviewed projects only, the Evaluator was able to determine EUL values for specific measures rather than general categories, such as "HVAC". Table 13 lists the revised EUL values and their sources for the most common measures found among New Construction projects.

Table 13: Revised EUL Values for Common New Construction Measures

Measure	Revised EUL (years)	Reference
Household appliances	12	DEER 2008 ¹³
Heat pumps	18	GDS, 2007 ¹⁴
Insulation	25	GDS, 2007
Windows	20	DEER 2008
Motors and variable frequency drives	15	DEER 2008
Chillers	20	ERS 2005 ¹⁵

The revised energy savings were then used to obtain a weighted average EUL, which was established at 19.7 years.

6.1.4 Revised Gross Savings

The gross energy and peak demand savings calculated for 2017 New Construction are shown in Table 14. The line loss factor was calculated as a weighted average of each project's line loss based on savings at the meter. New Construction achieved gross energy savings at the generator of 5.751 GWh and gross demand savings at generator of 2.520 MW.

To establish the revised gross savings, one-time adjustments to the five reviewed projects' savings were made. A true-up adjustment was made to the multi-year project.

¹³ Database for Energy Efficiency Resources (DEER), *DEER 2008 EUL Table*, 2008.

¹⁴ GDS Associates. *Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures*, June 2007.

¹⁵ Energy & Resource Solutions. *Measure Life Study Report prepared for The Massachusetts Joint Utilities*, 2005.

Table 14: Revised Gross Energy and Peak Demand Savings for New Construction

	Partial Savings	Final Savings for Projects Started and Completed in 2017	Final Savings for Multi-year Projects	Total
Number of Projects	1	5	1	7
Energy Savings				
Tracked Gross Energy Savings – at Meter (GWh)	2.375	4.405	0.261	7.041
Adjustment Ratio for Energy Savings	1.000	0.758	0.571	-
Gross Energy Savings – at Meter (GWh)	2.375	3.339	0.149	5.862
True-up Adjustment for Gross Energy Savings (GWh)	-	-	-0.448	-0.448
Adjusted Gross Energy Savings – at Meter (GWh)	2.375	3.339	-0.299	5.415
Average Line Loss Factor	1.060	1.064	1.064	-
Gross Energy Savings – at Generator (GWh)	2.517	3.552	-0.318	5.751
Effective Useful Life (years)	19.7	19.7	19.7	-
Gross Lifetime Energy Savings – at the Generator (GWh)	49.588	69.966	-6.266	113.288
Peak Demand Savings				
Tracked Gross Demand Savings – at Meter (MW)	0.950	0.399	0.011	1.360
Adjustment Ratio for Demand Savings	1.000	2.814	6.371	-
Gross Demand Savings – at Meter (MW)	0.950	1.123	0.068	2.141
True-up Adjustment for Gross Demand Savings (MW)	-	-	0.231	0.231
Adjusted Gross Demand Savings – at Meter (MW)	0.950	1.123	0.300	2.372
Line Loss Factor	1.060	1.064	1.064	-
Gross Demand Savings – at Generator (MW)	1.007	1.194	0.319	2.520

6.2 Net-to-gross Ratio

Because New Construction bases its savings on the difference between a participant-specific baseline (the hypothetical building that would have been built in the absence of the program component) and the actual building built by the participant, the savings tracked by ENS are already considered as net of free-ridership. Furthermore, no spillover is considered since participants are unlikely to build other buildings within the same period and/or without participating again. Since free-ridership and spillover are intrinsic to gross savings, an NTGR of 1.00 was used to obtain net savings for New Construction.

6.3 Net Savings

Net savings are defined as changes in energy use that are specifically attributable to New Construction. Since the NTGR is assumed to be 1.00, net savings are equal to the gross savings presented in Table 14. For 2017, New Construction generated 5.751 GWh in net energy savings and 2.520 MW in net demand savings at the generator.

Overall, using the Nova Scotia-specific factor¹⁶ of greenhouse gas generated by electricity production, i.e., 0.6531 kg CO₂ eq/kWh, it was estimated that the net energy savings resulted in 3,755 tonnes of avoided CO₂ eq annually. Based on the average EUL of 19.7 years, the net lifetime energy savings were established at 113.288 GWh.

¹⁶ At the time of writing, 2017 data was not yet available. The Nova Scotia-specific factor was obtained from Nova Scotia Power's 2016 total system emissions data (7,079,268 CO₂ eq tonnes) and total electricity generation (10,839 GWh) was found in the following two sources:

Nova Scotia Power, *Total System Emissions*, <http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx>. (Last accessed December 17, 2017).

Emera Inc., *Management's Discussion & Analysis As at February 10, 2017*, <http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693> (Last accessed December 17, 2017).

7 BUILDING OPTIMIZATION MARKET EVALUATION

7.1 Participants' Perspectives

As part of the Building Optimization on-site visits, three participants were asked questions regarding their satisfaction with Building Optimization, any barriers they encountered and their improvement suggestions.

Satisfaction with Building Optimization

Overall satisfaction with Building Optimization was high among all participants, who gave an average rating of 8.3 on a 10-point scale (with 1 indicating “not at all satisfied” and 10, “completely satisfied”). Participants were very satisfied with the energy-efficiency improvement in their buildings and the associated cost savings achieved, with one interviewee indicating that “the Building Optimization program allowed us to resolve energy issues.”

Challenges and Barriers

Among the three interviewed participants, two ran into challenges during their participation in the Building Optimization service. One participant mentioned the difficulty of implementing energy-efficiency measures in a “live building” and coordinating with many third-party vendors. This frustration was exacerbated by the departure of a key ENS staff member midway through the participant's project. The other participant said that Building Optimization necessitated many “back-and-forth” discussions with ENS and third-party vendors and that the process was not always clear as to how to move the project forward.

Recommendations

The three interviewed participants made the following suggestions on how to improve Building Optimization:

- › Improve promotion;
- › Provide participants with more detailed information regarding the process, as well as technical support for implementing energy-efficiency measures; and
- › Ensure more stability in staffing to allow smooth collaboration.

8 BUILDING OPTIMIZATION IMPACT EVALUATION

The objective of the 2017 Building Optimization impact evaluation was to establish the service's gross and net electrical energy and peak demand savings. Building Optimization can also claim three types of savings: (1) partial savings, (2) final savings of multi-year projects and (3) final savings of current year projects. In 2017, six projects were started and completed, and they all had their final savings claimed in 2017. Only one project was listed with partial savings. As mentioned in Section 4.1, three projects were listed as Building Optimization projects, but they each had an overlap with Retrofit. These projects were consequently considered as Retrofit.

8.1 Gross Savings

The gross savings correspond to changes in energy consumption resulting from actions taken by Building Optimization participants, regardless of why they participated.¹⁷ This section describes the general adjustment methodology used for all Building Optimization projects and the adjustments made to specific projects.

8.1.1 Project Review Methodology

As with Retrofit and New Construction, the Evaluator performed a detailed technical review of four of the six Building Optimization projects completed in 2017, which were all the projects completed by the time this evaluation took place.

In preparation for the on-site visits, the Evaluator analyzed the project files and prepared a summary of the savings-generating measures. The Evaluator focused on key variables, such as baseline hours of operation, the existing control methods, equipment configuration and proposed schedule changes.

Upon completion of the documentation review, the Evaluator conducted on-site visits to validate the operation of individual projects. During the visits, the Evaluator interviewed the participants to determine the normal facility operating hours, confirm whether all the measures had been implemented, and review the revised building automation system schedules through the operator interface. The savings were then revised based on the information collected during the documentation review and the site visits.

¹⁷ Definition adapted from the National Renewable Energy Laboratory, "Chapter 23: Estimating Net Savings: Common Practices", *The Uniform Methods Project*, September 2014, p. 3, available at: http://energy.gov/sites/prod/files/2015/02/f19/UMPCchapter23-estimating-net-savings_0.pdf (Last accessed November 19, 2015).

8.1.2 Project Review Findings

Of the four Building Optimization projects reviewed in 2017, the Evaluator made downward adjustments to the energy savings for three of the projects and to the peak demand savings for two of the projects.

For two of the projects whose energy savings were adjusted, the reason for the adjustments was that incorrect engineering equations were used and those equations resulted in energy imbalance. This means that the loads for space-cooling or domestic hot water (DHW) were reduced, instead of improving the efficiency levels of the systems used to meet those loads. One project's baseline had a very high value for its cooling towers' hours of operation and this abnormal value would have resulted in water temperatures beyond a reasonable range. Therefore, the basecase hours of operation were reduced to 50 percent of the time for only the cooling season (6 months). This adjustment had a significant impact, reducing this project's energy savings by 37 percent.

The other project whose energy savings were adjusted included a measure aimed at optimizing the control of a DHW device which included heat pumps and electric boilers. The measurements showed that after the project, the electric boiler covered a higher portion of the DHW needs; it would be expected that the electricity consumption would have increased, since boilers are less efficient than heat pumps. Instead, the M&V report showed that energy savings were achieved because the DHW load in the proposed case was lower than in the basecase. The reduced DHW load was established based on lower measured runtimes for boilers and heat pumps in the reporting period. However, since hot water is recirculated in a loop, no heat is wasted (except through heat losses to the ambient air outside the heating season). So, it was impossible for this measure to have reduced the DHW load. The Evaluator noticed that the reporting period measurements were made in early fall, while the reference measurements were made in March. It is possible that the variation in the DHW load was due to seasonal variations. The removal of savings associated with this measure resulted in a 28 percent decrease in energy savings for this project.

For the last project that required an adjustment, the Evaluator reduced the amount of time per day during which fans were turned off, based on the information collected on site. This had a limited impact of 7 percent on this project. Overall, the adjustment ratio applied to the savings of sampled projects was 0.807.

Peak demand savings were tracked for two projects. Since the other two projects' savings occurred outside the peak demand period, their savings were nil. The Evaluator reduced the tracked peak demand savings to account for the fact that some measures occurred outside the peak demand period (such as the air-conditioning measures) and made a small adjustment to the PCF of one more measure. Overall, the adjustment ratio for peak demand savings was 0.526.

Because the sample size of four projects did not allow extrapolating the results of the review to all projects, the Evaluator only applied the adjustments to those four projects. Consequently, the adjustment ratio for non-reviewed projects was 1.0 and the average adjustment ratios for projects with final claims in 2017 were 0.845 and 0.526 for energy and peak demand savings, respectively.

The Evaluator found that the scope of projects reviewed in 2017 varied widely. While some projects included a scoping study which relied on advanced metering methods to identify deep savings potential, one project implemented in a school mainly involved fixing identified broken equipment, such as dampers rather than investigating energy-saving opportunities. While it is true that schools may not have enough budget to perform maintenance repairs as required and that savings occur from fixing equipment, this type of project does not benefit from the full potential of Building Optimization. Another project involved recommissioning a building finished less than a year before. This building had major problems in its mechanical systems operation because the builder did not deliver it in proper working condition. Some of these problems would have eventually resulted in equipment failure. That is why the Evaluator revised some of the basecase values to reflect more reasonable operating conditions and avoid overestimating savings. ENS should be careful in the future when reviewing the baseline case of such buildings to ensure that energy savings are based on real energy-efficiency measures. It should also be noted that this type of participant is more likely to be a free rider, since they have to conduct some equipment maintenance or partial recommissioning to maintain their buildings anyway.

8.1.3 Interactive Effects

Because interactive effects vary significantly from one Building Optimization project to another, they are generally taken into account in the project engineering calculations used to establish their initial gross savings. No other adjustment was made to the gross savings of these four projects reviewed.

8.1.4 Effective Useful Life

As part of the 2017 evaluation, the Evaluator reviewed the lifetime energy savings and corresponding EUL values used by ENS. The EUL of the measures implemented enabled calculating the energy savings achieved throughout a measure lifetime.

The EUL values of all the measures submitted through the service were reviewed based on the findings of the literature review.

ENS assigned an EUL value of 20 years to the HVAC measure category, which is the only one listed for Building Optimization projects. This value seems too high to be representative. Such an EUL value usually applies to very long-lasting measures, such as insulation installation or large mechanical upgrades, which are not part of the measures covered by Building Optimization.

A study by SBW Consulting on retrocommissioning projects¹⁸ found that the EUL values of recommissioning measures ranged from 3 years to 15 years. This study established EUL values for various measures: about 3 years for changes made to control parameters; 8 years for equipment repairs; about 12 years for new equipment installation. Since no new equipment was installed as part of the projects reviewed this year, the Evaluator therefore recommends applying the average of the values for changes to control parameters and equipment repairs to establish an average EUL value of 5.5 years for Building Optimization.

8.1.5 Revised Gross Savings

For Building Optimization, the gross savings at the generator were established at 0.836 GWh and 0.071 MW, respectively for energy and peak demand savings, as shown in Table 15. Gross lifetime energy savings for Building Optimization were determined at 4.599 GWh.

Table 15: Revised Gross Energy for Building Optimization

	Partial Savings	Final Savings for Projects Started and Completed in 2017	Total
Number of Projects	1	6	7
Energy Savings			
Tracked Gross Energy Savings – at the Meter (GWh)	0.176	0.722	0.898
Adjustment Ratio for Energy Savings	1.000	0.845	-
Gross Energy Savings – at the Meter (GWh)	0.176	0.610	0.786
Average Line Loss Factor	1.064	1.064	-
Gross Energy Savings – at the Generator (GWh)	0.187	0.649	0.836
Effective Useful Life (years)	5.5	5.5	-
Gross Lifetime Energy Savings – at the Generator (GWh)	1.029	3.571	4.599
Peak Demand Savings			
Tracked Gross Peak Demand Savings – at the Meter (MW)	0.049	0.034	0.083
Adjustment Ratio for Peak Demand Savings	1.000	0.526	-
Gross Peak Demand Savings – at the Meter (MW)	0.049	0.018	0.067
Line Loss Factor	1.064	1.064	-
Gross Peak Demand Savings – at the Generator (MW)	0.052	0.019	0.071

¹⁸ Roberts J. and Tso B. (SBW Consulting), *Do Savings from Retrocommissioning Last? Results from an Effective Useful Life Study*, ACEEE Summer Study on Energy Efficiency in Buildings, 2010.

8.2 Net-to-gross Ratio

For all the projects implemented through Building Optimization, an NTGR of 1.00 was applied since it was considered that free-ridership was likely to be very low, considering that the number of participants was still very low for this relatively new component. The validity of this assumption was supported by the results and findings of the interviews conducted with the participants during the on-site visits. Indeed, two of the three participants interviewed reported that, in the absence of the program component or service, they would not have implemented the energy-efficiency measures that they had implemented through this service. The other participant indicated he might have installed only a portion of the measures. Also, no participant had ever conducted any full commissioning project, except for one who did with the help of ENS, in another Building Optimization project.

8.3 Net Savings

Since the NTGR is assumed to be 1.00 for Building Optimization, its net savings are equal to the gross savings, as shown in Table 15. For 2017, Building Optimization generated 0.836 GWh in net energy savings and 0.071 MW in net peak demand savings at the generator. Overall, using the Nova Scotia-specific factor¹⁹ of greenhouse gas generated by electricity production, i.e., 0.6531 kg CO₂ eq/kWh, it was estimated that the net energy savings resulted in 546 tonnes of avoided CO₂ eq annually.

¹⁹ At the time of writing, 2017 data was not yet available. The Nova Scotia-specific factor was obtained from Nova Scotia Power's 2016 total system emissions data (7,079,268 CO₂ eq tonnes) and total electricity generation (10,839 GWh) was found in the following two sources:

Nova Scotia Power, *Total System Emissions*, <http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx>. (Last accessed December 17, 2017).

Emera Inc., *Management's Discussion & Analysis As at February 10, 2017*, <http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693> (Last accessed December 17, 2017).

9 OVERALL SAVINGS FOR CUSTOM

Table 16 below compares the total tracked and evaluated savings for the Custom program component, which includes savings from the Retrofit, New Construction and Building Optimization services.

Table 16: Comparison of Tracked and Evaluated Savings at the Generator for Custom

	Initial Gross Savings	Adjusted Gross Savings	NTGR*	Net Savings
Energy Savings				
Tracked Savings from ENS	24.437 GWh	24.437 GWh	0.93	22.836 GWh
Evaluation Results	24.437 GWh	22.421 GWh	0.94	21.005 GWh
Peak Peak Demand Savings				
Tracked Savings from ENS	2.757 MW	2.757 MW	0.96	2.635 MW
Evaluation Results	2.757 MW	3.739 MW	0.97	3.637 MW
* The NTGR was different for each component. The NTGRs listed in this table match the rounded averages obtained by dividing the net savings by the adjusted gross savings.				

The evaluated net savings for Custom are 8 percent below the tracked value. This reduction was mostly due to New Construction, which had its gross energy savings reduced by 27 percent this year. Retrofit, which accounted for 70 percent of Custom's gross savings, had only small adjustments made to its savings (about one percent). The reduction of 12 percent of Building Optimization's savings had a minimal impact on the overall difference between the tracked and the evaluated net savings. The 1 point of percentage increase in NTGR was only due to the difference in the weight of each service since the NTGR of each service remained the same in 2017 as in 2016.

There is a 38 percent positive difference between the evaluated and the tracked net peak demand savings for Custom. It is the adjustments made to New Construction's peak demand savings that explain most of this variation; those adjustments increased the evaluated savings by 1.012 MW for both the gross and the net savings.

10 EMIS OVERVIEW

The following sections present the Energy Management Information Systems (EMIS) evaluation results.

This section describes the EMIS program component, follows up on the 2016 evaluation recommendations and gives an overview of the participation history.

10.1 Description

EMIS offers incentives in the form of rebates or zero-percent on-bill financing to help facilities reduce their electricity consumption through the implementation of an energy management information system. First introduced in 2012 as a pilot, EMIS became a stand-alone program component of the Custom Incentives program in 2015.

EMIS's main goal is to assist industrial businesses and institutions in making real-time decisions about their processes using energy consumption data from metered systems. To achieve this goal, the EMIS program component provides participants with the funding required to audit their systems (EMIS audit), develop an energy management information system implementation plan (EMIS implementation plan) and install the metering and monitoring equipment (implementation of EMIS). This program component also provides training and organizational support to help convert energy-performance information into action. To be eligible, participants must possess the necessary resources to carry out all the aforementioned stages, demonstrate commitment to energy management and an adequate level of expertise, and agree to complete all the stages of an EMIS project. EMIS can encompass an entire facility, or just specific processes or departments within a facility.

Once approved, eligible participants must first enter into an agreement with ENS through a letter of intent before the EMIS audit is conducted. This letter of intent defines the anticipated costs and estimated incentives for each stage of participation, and the participant's overall required simple payback for the project. Then, participants have the audit conducted by a qualified professional to define the EMIS scope. ENS helps participants find qualified professionals by providing a list of the firms known to be able to meet the requirements of the different stages of an EMIS project. After reviewing the audit report, the participant has an implementation plan developed to detail the costs, potential savings, equipment to be installed, required training, etc. After ENS has reviewed and approved the implementation plan, the participant can start implementing its energy management information system. If necessary, ENS provides technical and organizational support to participants over a 12-month period after the energy management information system becomes fully operational to help them achieve their full potential savings.

EMIS aimed to achieve 4.0 GWh in net electricity savings and 0.1 MW in net peak demand savings in 2017.

10.2 Follow-up on 2016 Evaluation Report Recommendations

The EMIS component was evaluated in 2016 and recommendations were made by the Evaluator for its improvement. Table 17 below provides a brief summary of the implementation status of each recommendation presented in the executive summary section of the 2016 impact evaluation report.

Table 17: Implementation Status of the Recommendations in the 2016 Executive Summary

2016 Recommendations	Status
2016 EMIS-R1. Continue to support EMIS and identify potential new participants.	Implemented
2016 EMIS-R2. Continue encouraging EMIS participants to enroll in SEM and strengthen integration between the two program components.	Implemented
2016 EMIS-R3. Track incremental savings rather than cumulative savings.	Being implemented
2016 EMIS-R4. Investigate ways of using energy management information systems to their full potential.	Implemented
2016 EMIS-R5. Track major changes to facility operations and equipment and adjust energy baseline consumption as required.	Being implemented

Three of the 2016 EMIS recommendations were implemented in 2017. Regarding 2016 EMIS-R1 and 2016 EMIS-R2, ENS has promoted EMIS to new participants and has encouraged past SEM participants to participate in EMIS and continuing EMIS participants to participate in SEM.

To implement 2016 EMIS-R3, ENS is now tracking incremental savings rather than cumulative savings. The Evaluator considers this recommendation partially implemented in 2017, because for half of the projects, the incremental savings were estimated and not calculated. For the two projects for which an incremental baseline was created by the service provider, the Evaluator observed that the process for re-establishing the baseline was well understood and applied. ENS is currently working on building its capacity to re-establish the baseline models through internal staff training so as to be able to calculate the incremental savings for EMIS projects, if ENS decides to perform this task internally.

In the past year, ENS has worked with continuing participants to achieve higher incremental savings. So far, two of the four continuing participants have investigated ways to expand the use of their EMIS: additional measures are being implemented for one project; the other project is at the stage of analysis. Therefore, the Evaluator considers 2016 EMIS-R4 as implemented.

Regarding 2016 EMIS-R5, non-routine adjustments were mentioned in the annual reports, but crossover participation in other ENS program components (e.g., Custom Retrofit) was not. Also, no monthly log was added to each project's file to document all the changes that could explain changes in energy consumption or warrant making non-routine adjustments. ENS is aware of the need for monthly logs and is trying to find ways to encourage participants who already have contracts in place to provide this data to ENS. ENS has agreed to make future contract changes so that ENS is able to provide this data to the Evaluator for future participants. The Evaluator therefore considers this recommendation as partially implemented.

10.3 Participation History

Seven participants were originally selected by ENS to take part in EMIS in 2017: four were continuing participants from 2016 and 2015; and three were new participants. These last three participants were at various stages of assessment and implementation, which can take many months and in some cases years, and did not generate savings as of December 2017. Therefore, only four participants generated savings in 2017, and they were the same four participants that had generated savings in 2015 and 2016, as shown in Figure 8.

The distribution of gross energy savings between 2015 and 2017 presented in Figure 9 shows that incremental savings decreased over time.²⁰ This is explained by the fact that the measures implemented in the first year of EMIS participation (between 2014 and 2016 depending on participants) were maintained and optimized, but no new measure was implemented in subsequent years of participation. As for incremental peak demand savings, 2017's savings were higher than 2016's savings, because new data was available and more accurate calculation methods were used for two projects.

Figure 8: Summary of Participation in EMIS, 2015-2017

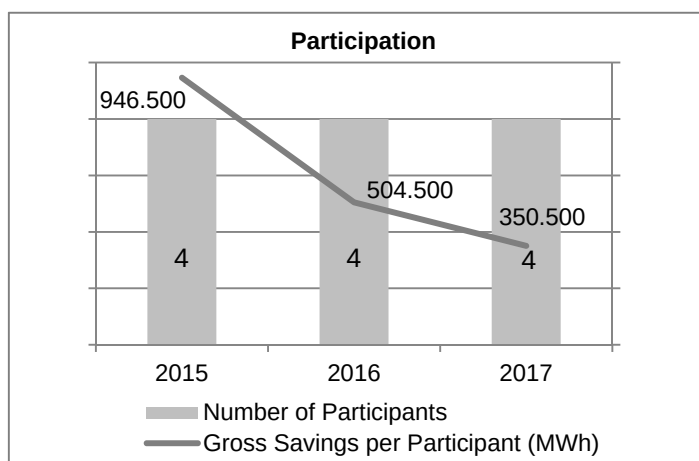
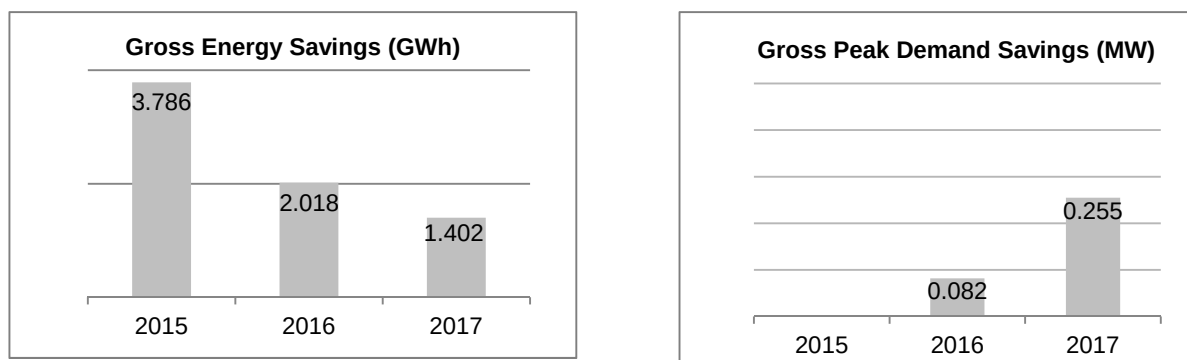


Figure 9: Summary of Gross Savings for EMIS, 2015-2017

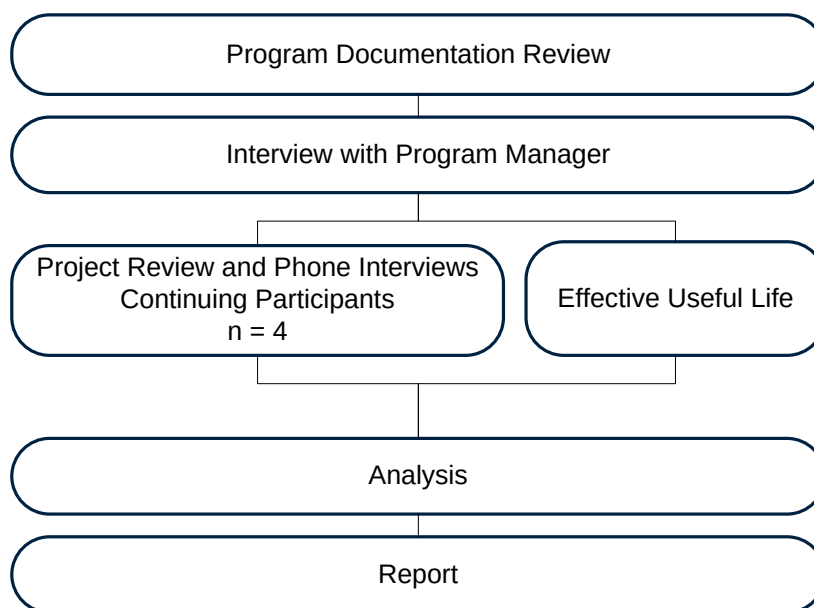


²⁰ Throughout this report, gross and net savings are incremental savings. Cumulative savings are presented for reference purposes but are not used as final evaluated results.

11 EMIS EVALUATION METHODOLOGY

Figure 10 below illustrates the research strategy employed and the data-collection activities carried out in the 2017 EMIS evaluation.

Figure 10: Methodological Model



The Evaluator first reviewed the EMIS program component documentation and then held a meeting with the program manager in August 2017 to verify the implementation status of the previous evaluation recommendations and learn about the main program component changes made.

These activities contributed to the Evaluator's overall understanding of EMIS and helped inform the development of the data-collection instruments. The specific evaluation activities were then undertaken, as described in the following subsections.

Project Review and Phone Interviews with EMIS Continuing Participants

For all four continuing EMIS projects from 2015 and 2016, the Evaluator reviewed their updated documentation to determine what had changed since the last evaluation. The Evaluator then conducted phone interviews to collect additional information on measures implemented or the changes made to the facilities in 2017. During the interviews, the Evaluator also asked participants questions about their satisfaction with this program component, as well as about savings persistence. The analysis of both EMIS's and SEM's savings persistence will be discussed in the 2018 evaluation report since this analysis is expected to be completed after the current evaluation cycle. The Evaluator then reviewed the baseline and the incremental baseline to ensure that the 2017 cumulative and incremental savings were valid.

The information gathered from continuing participants during the 2015 on-site visits was used again this year to confirm the assumption that free-ridership is nil. Econoler relied on the 2015 results since the participants interviewed in 2015 for the free-ridership assessment were the same four participants who generated savings in 2017.

The project review protocol and interview guide are provided in Appendix X.

Effective Useful Life Review

As part of the 2017 evaluation, to examine the EUL values used by ENS to calculate lifetime energy savings, the Evaluator conducted a thorough literature review by consulting TRMs, evaluation reports and relevant studies.

12 EMIS MARKET EVALUATION

This section describes participants' perspectives on EMIS.

12.1 Participants' Perspectives

As part of the EMIS phone interviews, the four participants were asked questions regarding their satisfaction with EMIS, any barriers they encountered and their improvement suggestions.

Satisfaction with EMIS

Overall satisfaction with EMIS was high among all participants, who gave an average rating of 8.3 on a 10-point scale (with 1 indicating "not at all satisfied" and 10, "completely satisfied"). Participants were most satisfied with the energy management information system itself. They mentioned that the system provides useful data to target energy consumption by plant area and allows them to make informed decisions. Participants also appreciated the support they received by their service providers throughout the discovery and implementation phases.

"Really good support and follow-up with respect to finding other initiatives."

Challenges and Barriers

Among the interviewed participants, one participant experienced challenges when implementing the energy management information system as it was difficult to install the hardware and teach staff how to use it properly.

Another participant experienced challenges when managing the system after installation, specifically with respect to measuring steam and refrigeration-related energy consumption. The participant felt the sensors could be improved to perform better.

The other two participants found no significant issue or barrier. One participant felt that the process was a bit long, yet straightforward from the audit to implementation.

Recommendations

Three participants made suggestions on how to improve EMIS, and one did not (due to being very satisfied and unable to think of anything that should be improved). The participants made the following suggestions:

- › Help develop a growth and sustainability plan to engage all employees in the EMIS process and foster continuous improvement over the years.
- › Involve maintenance staff so that they know how things run and how to troubleshoot.
- › Accelerate the installation process by providing more support and manpower.

13 EMIS IMPACT EVALUATION

The objective of the 2017 EMIS projects' impact evaluation is to determine their gross and net electrical energy and peak demand savings.

13.1 Impact Definitions

Table 18 defines various EMIS-related terms to provide the reader with a better understanding of the vocabulary and concepts used in the impact evaluation section of the report.

Table 18: Definition of EMIS-related Terms

Term	Definition
Baseline	Referring to the systems, time period, energy use, or conditions that provide a reference to which later performance of an energy conservation measure can be compared.*
Baseline Period	Defined period of time chosen to represent the operation of the facility or system before the implementation of an energy conservation measure.*
Baseline Regression	A mathematical model correlating energy use to one or more independent variables during the baseline period.
Cumulative Savings	The annual savings achieved with respect to the baseline situation prior to the implementation of the EMIS.
Incremental Baseline	Referring to the systems, time period, energy use, or conditions that provide a reference to which later performance of an energy conservation measure can be compared to obtain incremental savings.
Incremental Savings	The additional annual savings not measured in previous years. Incremental savings result from new measures implemented during the evaluation year or from recent improvements to energy efficiency measures that were initiated in previous evaluation years. These savings are calculated by using the previous year's situation as the baseline.
Independent Variable	Parameter that is expected to change routinely and have a measurable impact on energy consumption and/or demand of a system or facility.*
Reporting Period	Defined period of time chosen for the purposes of verifying savings after implementation of an energy conservation measure.*

*The definitions marked with an asterisk are taken from the International Performance Measurement and Verification Protocol.²¹

13.2 Gross Savings

This section describes the methodology used to review the four EMIS projects that generated savings in 2017 and summarizes the review findings. The interactive effects and the revised gross savings are also assessed.

²¹ Efficiency Valuation Organization, *Core Concepts, International Performance Measurement and Verification Protocol*, October 2016.

13.2.1 Project Review Methodology

In 2016, the Evaluator made a distinction between the cumulative energy savings tracked by ENS and incremental energy savings, and recommended that ENS track incremental savings rather than cumulative savings. Both incremental and cumulative savings were tracked in 2017. The incremental savings were the focus of the evaluation and the evaluated incremental savings correspond to the impact results reported for this program component.

The Evaluator also reviewed the cumulative savings for all projects even though they were not used for impact evaluation; cumulative savings are only presented as valuable information to participants. For the two projects with the estimated incremental savings reported in the tracking sheet, the estimated reported savings were based on the difference between 2017 cumulative savings and 2016 cumulative savings. The Evaluator calculated the actual incremental savings based on the project documentation available and additional information gathered during the phone interview.

Peak demand savings were assessed using the annual M&V reports and year-end EMIS calculation workbooks, which were compared to the peak demand savings estimated by the service providers. To do so, the Evaluator used information on the operating modes usually occurring in the defined peak period and the demand data, if available, from the energy management information system.

13.2.2 Project Review Findings

Documentation Review

In preparation for the phone interviews, the Evaluator analyzed the project documentation to thoroughly understand each facility's goals and operations, to learn about its project baseline and implemented energy efficiency measures, and understand how the tracked savings were calculated. Key documents consulted included: (1) the EMIS tracking sheet, (2) the annual savings reports, and (3) the savings calculation workbooks.

The Evaluator first reviewed the contents of the tracking sheet. This spreadsheet contains every project's monthly tracked cumulative and incremental energy savings. Peak demand savings were not documented in the tracking sheet.

For three of the four projects, ENS provided the Evaluator with annual savings reports and corresponding EMIS savings calculation workbooks prepared by the service provider. As for the project for which no annual report was provided, its virtual private network broke down in early July 2017, which has since led to continuous complete communication failure; the project owner had not made any arrangements with the service provider for virtual private network connection repair (a service not covered by the original contract). For this project, ENS provided monthly Excel workbooks summarizing the energy savings results, and the Evaluator compiled results for the first two quarters of 2017. The documentation for this particular project did not include annual peak demand savings calculations although peak demand savings were generated in 2017. The Evaluator therefore calculated annual peak demand savings based on the monthly data provided.

The savings calculation workbooks prepared by the service provider were used by the Evaluator as the primary source of information for verifying the energy savings presented in the annual reports. One improvement over 2016 was the addition of incremental savings analysis for two projects. It allowed the Evaluator to easily understand the work that had been carried out to establish the adjusted baselines. As for the remaining two projects, the Evaluator relied on both last year's and this year's savings calculation workbooks to calculate actual incremental savings.

While reviewing the project documentation, the Evaluator found several discrepancies between the savings figures reported in the final tracking sheet and the savings figures documented in the annual savings reports. Also, two of the four projects did claim annual peak demand savings in the annual reports; however, apparently this information was not tracked by ENS in the tracking sheet. The Evaluator used the annual report savings as the final tracked values. The Evaluator suggests that, from now on, the final tracking sheet should be updated with the final values documented in the annual reports.

Savings Review

Table 19 provides a summary of all four EMIS projects reviewed, including the measures implemented and non-routine adjustments made.

Table 19: Summary of EMIS Projects Reviewed

Project Number	Energy Efficiency Measure			Non-routine Adjustment	
	Measure Number	Description	Implementation Date	Type	Period
1	1.1	Reducing electricity consumption during the non-production mode	January 2016	None	N/A
	1.2	Controlling electricity consumption in the partial production mode	January 2016	None	N/A
	1.3	Reducing electricity consumption during shift change	January 2016	None	N/A
	1.4	Turning off unnecessary equipment during breaks	January 2016	None	N/A
	1.5	Controlling the residual system's energy consumption during cleaning	January 2016	None	N/A
	1.6	Reducing electricity consumption during production downtimes	January 2016	None	N/A
2	2.1	Reducing electricity consumption in one of the plants during the zero activity mode	April 2014	None	N/A
	2.2	Controlling electricity consumption during the sanitation-maintenance mode according to specific kilowatt targets	April 2014	None	N/A
	2.3	Reducing unnecessary electricity load (such as hydraulic power packs, air-handling units, and air compressors) during the production mode	April 2014	None	N/A
3	3.1	Turning off air compressors on weekends when there is no production	April 2015	Custom Retrofit projects: addition of new air compressor and air leakage repairs	March 2016 - Now
	3.2	Turning off air-handling units on weekends when there is no production	April 2015	None	N/A
	3.3	Turning off lights on weekends when no production is taking place	April 2015	None	N/A
4	4.1	Operational control of the heating elements for the each production lines using EMIS information	April 2014	Change in raw material freeness	May 2015 - Now
				Change in freeness due to freeness-analyzer malfunctioning	May-June 2017

What follows is a discussion of the adjustments made to the tracked cumulative savings and then the adjustments made to the tracked incremental savings.

The Adjustments Made to the Tracked Cumulative Savings

As part of the savings verification process, the Evaluator searched on the DSMDS for incentivized energy-efficiency projects already claimed through other ENS program components in 2017 for each of the four EMIS participants. The findings about the implementation of other energy-efficiency projects were subsequently used in the interview process to determine whether any of the participant models would require baseline adjustments. The results of the interviews revealed that no projects affected the EMIS measurement boundaries, and therefore, no new baseline adjustments were required.

In 2017, the Evaluator adjusted the reported cumulative savings of one of the four projects (Project 3). The adjustment was a result of updating the baseline consumption for a compressed air measure (Measure 3.1) that had undergone some equipment upgrades as part of two Custom Retrofit projects in 2016. In the first Retrofit project, a new 50 kW air compressor was installed to service the plant's compressed-air base load and the original 250 kW compressor was kept to supply the autoclave equipment. The same participant conducted a compressed-air audit and made some repairs to improve the plant's leakage factor. Since both Retrofit projects had affected the performance of the compressed-air system in the plant, the Evaluator had recommended adjusting the baseline in 2016; however, not enough information was available to allow for accurately performing the calculations at the time of the 2016 evaluation.

This year, ENS and the service provider did not adjust the cumulative baseline for Measure 3.1 and did not provide the Evaluator with compressor baseline data for the Custom Retrofit projects. Without such data, the Evaluator made a non-routine adjustment to the average baseline consumption based on the difference between the compressor's energy consumption levels over a 3-month period before and after the installation of the new 50 kW air compressor (Retrofit project). This approach was not ideal because energy performance probably kept improving over both the pre-installation and the post-installation periods and this continuous improvement in energy performance could undermine the precision of the non-routine adjustment. However, making no adjustment resulted in overestimating the savings since the EMIS's savings included the energy savings achieved by the compressor upgrade (and these savings were already captured under the Retrofit project). As for the other Retrofit project, air leakages were not repaired on a specific date, but over an unspecified period in 2016. Since the Evaluator did not notice any fluctuation in the compressor data associated with this project, no adjustment was made to account for the implementation of this Retrofit project. Additionally, the Evaluator also established separate baseline compressor consumption for compressor shut-down on Saturdays and Sundays since the shut-down period was longer on Sundays than on Saturdays. In fact, when this measure was implemented back in early 2015, it was only in effect on non-production days, i.e., on Sundays. At the end of 2015, the compressed-air measure was extended to Saturdays at the end of the production shift. By establishing separate baselines for Saturdays and Sundays, the original baseline consumption of

3,146 kWh was increased to 3,508 kWh for Sundays and decreased to 1,543 kWh for Saturdays. These adjustments have led to a cumulative energy savings adjustment ratio of 0.89 for this project.

It should also be noted that, during the interview with the Evaluator, the participant stated that the production hours increased on weekends in 2017 due to overtime, affecting the compressor, air-handling units and lighting consumption levels. Since this downtime decrease can reduce the energy-savings potential for all measures²², this reduced potential should be accounted for by applying a routine adjustment, namely by adjusting the baseline consumption based on weekend production levels. The Evaluator strongly suggests that from now on, production data should be tracked for this project and used as an independent variable for the baseline regression.

No other adjustments were made to the energy savings values for the other three projects. Overall, the tracked savings calculated by the service provider were accurately documented and reflected the normal operation of the other three facilities.

As for cumulative peak demand savings, one of the four EMIS projects (Project 4) had peak demand savings reported in the annual report. As part of the technical review, the Evaluator determined that two other projects (Projects 1 and 2) were also generating peak demand savings. For the first adjustment (Project 2's Measure 2.3), the Evaluator used the measured demand for 69 data points that occurred within the peak demand period, which is defined as 5 p.m. to 7 p.m. from December through February on a non-holiday weekday. The cumulative savings were calculated by finding the difference between the 2017 production demand and the baseline demand at 2017 production levels and the peak demand savings were established at 91.5 kW at the meter.

A second peak demand savings adjustment was made to another project (Project 1) based on recommendations made as part of the 2016 evaluation, where the Evaluator discovered that the project's shift-change operating mode (Measure 1.3) had the potential of generating peak demand savings since it occurred between 4:30 and 6:00 p.m. Since the energy conservation measures for this mode were not implemented until almost the end of 2016, the annual results showed a small increase in energy consumption for this operating mode, yet no demand reduction in 2016. This year, the Evaluator also assessed the results of this operating mode in 2017 and calculated the cumulative peak demand savings by determining the difference in historical consumption data between 2015 (the baseline year) and 2017. A peak coincidence factor of 0.5 was applied to account for the shift-change mode, which only coincides with the peak demand period between 5:00 and 6:00 p.m., and a positive peak demand savings value was established at 16.6 kW.

Overall, the cumulative savings tracked by the EMIS were sufficiently documented and easy to verify in 2017. All four reviewed projects generated cumulative energy savings and three generated peak demand savings. As recommended in 2016's evaluation, the Evaluator still suggests that ENS require each facility to keep a monthly log and prepare a custom report indicating any crossover participation in other ENS programs or program components (e.g., Custom). ENS is aware of the need for monthly logs

²² Negative incremental savings were generated by Measures 3.2 (-223,846 kWh) and 3.3 (-1,280 kWh) in 2017.

and is trying to find ways to encourage participants who already have contracts in place to provide this data to ENS. ENS has agreed to make future contract changes so that ENS is able to provide this data to the Evaluator for future participants. This recommendation, if properly implemented, will improve the results and facilitate identifying major equipment changes made between any two reporting dates.

The Adjustments Made to Tracked Incremental Savings

Incremental energy savings were tracked for all four EMIS projects. The adjustments were made by the Evaluator for two (Projects 2 and 3) of the four tracked energy savings values. The two projects (Projects 1 and 4) for which the service provider calculated the incremental savings did not require any adjustment, thus indicating that the service provider understood the participants' processes.

For the other two projects (Projects 2 and 3), the Evaluator recalculated the incremental savings to assess the accuracy of the tracked incremental savings reported by ENS. One of the two projects (Project 2) required a minor revision to address the difference between the calculation methods: ENS had determined the incremental savings by finding the difference between the 2016 and 2017 cumulative results, while the Evaluator calculated the incremental savings by using the 2016 data as the baseline instead of the 2014 data used for cumulative savings. This adjustment resulted in an energy adjustment ratio of 0.89.

The second adjustment made to incremental energy savings had a bigger effect, resulting in an adjustment ratio of -2.29. For this project (Project 3), ENS had overestimated the incremental savings by finding the difference between 2016 and 2017 cumulative energy savings, rather than adjusting the baseline period used for cumulative savings. For two of the measures involving shutting down equipment over weekends (Measures 3.2 and 3.3), the Evaluator adjusted their baselines by using the average consumption during the corresponding weekend day in 2016 rather than the average weekly consumption of the corresponding week in 2017. For the third measure (Measure 3.1), the Evaluator calculated the incremental savings using 2016 metered compressor data from the EMIS after the implementation of the Retrofit projects. As with the revision of the cumulative savings, the Evaluator established separate consumption baselines for Saturdays and Sundays. This baseline adjustment resulted in negative incremental savings. A factor causing the negative savings was the increase in production levels on weekends in 2017 compared to 2016. As previously mentioned, the production levels were not taken into account as an independent variable for this project. Therefore, the energy performance level in 2017 was below that of 2016, thus resulting in negative incremental savings.

Overall, incremental energy savings accounted for 24 percent of the total cumulative energy savings in 2017. One project's incremental energy savings corresponded to 0 percent of its cumulative savings due to the revised compressor baseline changes made by the Evaluator. The incremental energy savings of the other three projects ranged from 23 percent to 58 percent of their cumulative energy savings respectively.

Incremental peak demand savings were calculated by the service provider for one project (Project 4) and by the Evaluator for two projects (Projects 1 and 2). The Evaluator calculated incremental peak

demand savings for Measures 1.3 and 2.3 using the same methodology as that for cumulative savings, by using the historical consumption data from 2016 as baseline consumption. Those adjustments resulted in a positive increase of 113 kW in incremental peak demand savings.

Overall, the total incremental peak demand savings accounted for 45 percent of the total cumulative peak demand savings. The incremental savings of the three projects which generated peak demand savings ranged between 30 and 249 percent of their cumulative peak demand savings.

In general, the procedures for tracking incremental savings can be improved by adopting a standardized approach or methodology. As indicated by the results, the difference in cumulative energy savings between one year to another alone does not accurately reflect incremental savings achieved by large manufacturing facilities. Therefore, the Evaluator suggests that ENS adopt an incremental baseline based on 2017 energy consumption data to establish 2018's incremental savings results.

Summary of Adjustments Made to Tracked Savings

Table 20 and Table 21 below summarize the adjustments made to tracked cumulative and incremental savings of each EMIS project reviewed.

Table 20: Summary of Adjustments Made to Gross Tracked Cumulative Savings

Project	Cumulative Savings									
	Energy Savings					Peak Demand Savings				
	Tracked Savings (kWh)	Revised Savings (kWh)	Adjustment Ratio	Adjustment Type	Cause	Tracked Savings (kW)	Revised Savings (kW)	Ratio	Adjustment Type	Cause
1	1,110,807	1,110,807	1.00	NA	NA	0.0	16.6	-	Addition of savings for one measure	Savings had not been calculated
2	595,559	595,559	1.00	NA	NA	0.0	91.5	-	Addition of savings for one measure	Savings had not been calculated
3	555,931	491,745	0.56	Non-routine adjustment for one measure	Custom Retrofit projects impacting baseline	0.0	0.0	1.00	NA	NA
4	3,513,784	3,513,784	1.00	NA	NA	438.2	438.2	1.00	NA	NA

Table 21: Summary of Adjustments Made to Gross Tracked Incremental Savings

Project	Incremental Savings									
	Energy Savings					Peak Demand Savings				
	Tracked Savings (kWh)	Revised Savings (kWh)	Adjustment Ratio	Adjustment Type	Cause	Tracked Savings (kW)	Revised Savings (kW)	Adjustment Ratio	Adjustment Type	Cause
1	253,498	253,498	1.00	NA	NA	0.0	41.3	-	Addition of savings for one measure	Savings had not been calculated
2	389,594	346,472	0.90	Re-establish the baseline for all measures	Savings estimated rather than calculated	0.0	71.5	-	Re-establish the baseline and addition of savings for all measures	Savings had not been calculated
3	87,615	-200,472	-2.29	Re-establish the baseline for all measures	Savings estimated rather than calculated	0.0	0.0	1.00	NA	NA
4	943,798	943,798	1.00	NA	NA	131.0	131.0	1.00	NA	NA

13.2.3 Interactive Effects

The savings associated with EMIS are established based on the results of metered electrical energy consumption within a defined measurement boundary encompassing specific industrial processes. Like in previous years, one participant had an M&V boundary that included the facility's HVAC systems. However, since this measure's savings were determined based on measured weekly data, the interactive effects were already included in the metered savings. The other three participants had process-related energy consumption that could impact the HVAC equipment's consumption, but none of these facilities had electrical heating systems or air-conditioning systems. So, no interactive effects were considered. Other process loads were considered for these three facilities. However, the Evaluator determined that all these loads were outside the measurement boundary and had no impact on EMIS's tracked cumulative or incremental savings.

13.2.4 Effective Useful Life

The persistence of incremental savings in EMIS has not been established based on measured values in the literature. The Evaluator therefore analyzed the available data to suggest a conservative yet realistic approach.

Based on the 2017 evaluation results, the Evaluator concluded that all EMIS participants obtained incremental savings in 2015, 2016 and 2017. Participant 3 is an exception; because their production on weekends increased and production level was not tracked as an independent variable, their incremental savings were negative. This was however most likely because the model was underspecified and was not because their energy performance decreased. Consequently, the energy performance of the continuing participants was sustained and kept increasing. This was observed at the individual measure level as well. Since savings for every measure increased, it means that incremental savings did not result from only new measures generating new savings and overcompensating for the decreased performance of the older measures; the incremental savings also resulted from individual measures' continuous increase in performance.

From these observations, it is concluded that as long as participants remain in EMIS, their incremental savings from previous years persist. Two scenarios could explain this persistence:

- › **Savings persist because of ENS involvement.** This means that there is "avoided decay" (e.g. energy savings are being maintained because of ENS support), which could be considered as a form of incremental savings (i.e., savings that would not occur in the absence of new intervention).
- › **Savings persist because the EMIS itself supports savings.** This means that persisting savings are the results of a nil decay rate and that no additional avoided decay savings can be claimed due to support provided by ENS.

The Evaluator, in collaboration with ENS, decided to estimate savings conservatively by not claiming additional incremental savings as a result of avoided decay for two reasons. First, it is difficult to estimate

the avoided decay without any measured data for those participants who have ended their participation in the program component; so, reporting avoided decay savings as evaluated results would result in higher uncertainty. Second, incremental savings resulting from avoided decay are not exactly the same as first-year incremental savings reported for other program components; they were not savings that occurred for the first time in this evaluation year. To avoid summing different types of savings, only improvement in energy performance over the previous year (first-year incremental savings) are considered as incremental savings. Consequently, persisting savings and avoided decay are accounted for through their effect on the EUL.

To estimate the EUL to be applied to savings, two elements were considered:

- › **The remaining time in the program component:** Since full persistence of savings (i.e., a nil decay rate) has been demonstrated only for participants who are still EMIS participants, the number of years during which 100 percent of savings will persist is a function of how many years are left in program component participation. The Evaluator made the assumption that on average, participants will be active in EMIS (i.e., receiving support from ENS and their service provider) for four years, based on the current participation trends. Therefore, the first portion of EUL can be calculated as four minus the number of years (excluding the current year) over which the energy management information system has generated savings.
- › **The decay rate of savings after participation ends:** This value is unknown at this point, since no measured data is available. The Evaluator performed a sensitivity analysis to calculate the lifetime energy savings (and corresponding EUL value) after the end of program component participation as a function of the decay rate, as illustrated by the simplified example in Table 22. This example assumes an equipment life of 10 years for the software and hardware of the energy management information system; this is the same equipment life as that for a building automation system.²³ This assumption has been made to determine after how many years savings will be nil, independently of the decay rate.

²³ Illinois Energy Efficiency Stakeholder Advisory Group, *Illinois Statewide Technical Reference Manual for Energy Efficiency Version 6.0, Volume 2: Commercial and Industrial Measures*, February 8, 2017, p. 226.

Table 22: Example of Persisting Savings Depending on the Decay Rate

Year	Cumulative Savings (kWh)	Incremental Savings (kWh)	Persisting Savings (kWh) Depending on Decay Rate		
			50%	25%	10%
1	1,000	1,000	-	-	-
2	1,500	500	-	-	-
3	1,750	250	-	-	-
4	2,000	250	-	-	-
5	0	0	1,000	1,500	1,800
6	0	0	500	1,125	1,620
7	0	0	250	844	1,458
8	0	0	125	633	1,312
9	0	0	63	475	1,181
10	0	0	31	356	1,063
TOTAL	6,250	2,000	1,969	4,932	8,434
EUL after end of participation	-	-	0.98	2.47	4.22

In this analysis, no decay rate above 50 percent is considered. The Evaluator considered that values above that would have been too pessimistic, based on the results of the interviews conducted with participants. Indeed, when asked to rate the usefulness of the energy management information system in maintaining savings, all four participants gave ratings of more than 8 out of 10 (with 0 indicating “not useful at all” and 10, “extremely useful”). The same participants were asked to rate the probability that they will maintain their savings once they are no longer supported by their service provider, and all participants gave ratings between 8 and 10 for all their measures. Table 23 below summarizes the answers given by participants to those questions during their interviews.

Table 23: Participants’ Ratings for the Usefulness of EMIS Main Elements and the Probability of Maintaining Savings

Participant	Usefulness of EMIS in Maintaining Savings	Usefulness of Service Provider Support in Maintaining Savings	Probability of Maintaining Savings after Program Support Ends
1	9	9.5	10
2	9	9	10
3	8.5	8.5	8 or 9*
4	9	7	10
* The interviewed participants rated the likelihood of maintaining savings for each implemented measure after program support ends. So this participant gave different ratings for different measures.			

The results show that lifetime savings after the end of participation will correspond to 0.98 of the preceding year's cumulative savings if the decay rate is 50 percent (in other words, if half of the previous year's savings persist each year). If the decay rate is 10 percent, savings will occur 4.22 times; so the EUL for savings occurring after the end of participation would be 4.22 years in this example.

The EUL of savings during participation are then added to the EUL of savings after participation. For savings occurring in a third year of participation, the EUL would therefore be 2 years plus 1 to 4 years (depending on the decay rate), reaching a total of 3 to 6 years.

Even though the decay rate is currently unknown, the Evaluator recommends applying a conservative estimate of this decay rate to the calculation of lifetime energy savings. By applying the most conservative decay rate value, the EUL corresponds to the number of years left in program component participation, added to 1 year after the end of participation. The Evaluator therefore applied a different EUL to each participant. One participant ended their EMIS participation in 2017, so an EUL of two years was applied. Two participants were in their fourth years of participation but are known to continue with EMIS in 2018, so an EUL of three years was applied to both. Finally, a participant completed their second year of participation in 2017 so an EUL of four years was used.

13.2.5 Revised Gross Savings

EMIS's 2017 gross energy and peak demand savings at the generator are listed in Table 24 below for both cumulative and incremental savings. The final evaluated savings correspond to the incremental savings associated with EMIS and the following subsections focus on the latter.

The average line loss factors were obtained as the division between total gross savings at the generator and total gross savings at the meter for both energy and peak demand savings. The gross incremental energy savings at the generator are 1.402 GWh, which translates to 4.112 GWh in lifetime energy savings, based on an EUL value of 2.9 years. The gross incremental peak demand savings at the generator are 0.255 MW. Total incremental energy savings represent about 24 percent of the total cumulative savings of 5.983 GWh, and total incremental peak demand savings represent about 45 percent of the total cumulative savings of 0.571 MW.

Table 24: 2017 EMIS Revised Gross Energy and Peak Demand Savings

	Cumulative Savings	Incremental Savings
Number of Projects		4
Energy Savings		
Tracked Gross Energy Savings – at the Meter (GWh)	5.776	1.675
Adjustment Ratio for Energy Savings	0.989	0.802
Gross Energy Savings – at the Meter (GWh)	5.712	1.343
Line Loss Factor	1.048	1.044
Gross Energy Savings – at the Generator (GWh)	5.983	1.402
Equivalent Effective Useful Life (years) ²⁴	-	2.93
Gross Lifetime Energy Savings – at the Generator (GWh)	-	4.112
Peak Demand Savings		
Tracked Gross Peak Demand Savings – at the Meter (MW)	0.438	0.131
Adjustment Ratio for Peak Demand Savings	1.247	1.861
Gross Peak Demand Savings – at the Meter (MW)	0.546	0.244
Line Loss Factor	1.044	1.046
Gross Peak Demand Savings – at the Generator (MW)	0.571	0.255

13.3 Net-to-gross Ratio

The NTGR allows for determining the net savings, i.e., the energy savings that can be reliably attributed to a program or program component. More precisely, the NTGR represents the positive or negative impact of spillover and free-ridership effects on the gross savings.

Last year, since the free-ridership and spillover effects were considered to be nil, a NTGR of 1.00 was applied. The Evaluator believed that the limited number of participants and the limited penetration of energy management information systems among industrial and institutional facilities justify the decision of not applying any factor associated with free-ridership. An interview was conducted during the 2015 on-site visits with each of the participants to validate this assumption and understand the level of knowledge they had about energy management information systems prior to participating in the program component, and whether they intended to implement such a system in the absence of the program component.

²⁴ The equivalent EUL for EMIS represents the life of the incremental savings which occur in the current year.

Since all four 2017 participants have been continuing since 2015 or 2016, the conclusion that free-ridership is nil is still valid.

The internal spillover effects were expected to be negligible because energy management information systems measure savings at the facility level, which means that little potential savings would occur outside the system measurement boundaries.

13.4 Net Savings

Net savings are defined as the changes in energy use that are specifically attributable to EMIS. Since the spillover and free-ridership effects were considered to be nil, the net program component impacts are equal to the gross program component savings, as summarized in Section 13.2.4. Using the Nova Scotia-specific factor²⁵ for greenhouse gas emissions generated by electricity production, 0.6531 kg CO₂ eq/kWh, it was estimated that the net energy savings resulted in 916 tonnes of avoided CO₂ eq annually.

Table 25 below compares EMIS's total tracked savings and evaluated savings.

Table 25: Comparison of EMIS Tracked and Evaluated Savings at the Generator

	Initial Gross Savings	Adjusted Gross Savings	NTGR	Net Savings
Energy Savings				
ENS Tracked Savings	1.752 GWh	1.752 GWh	1.00	1.752 GWh
Evaluation Results	1.752 GWh	1.402 GWh	1.00	1.402 GWh
Peak Demand Savings				
ENS Tracked Savings	0.137 MW	0.137 MW	1.00	0.137 MW
Evaluation Results	0.137 MW	0.255 MW	1.00	0.255 MW

In 2017, the Evaluator did not adjust the incremental savings of the two projects for which a proper incremental baseline approach was used by the service provider, but only adjusted the incremental savings for the two other projects (for which incremental savings were simply estimated as the difference between 2017 and 2016 cumulative savings). Overall, the change in the approach used to obtain energy savings for the two projects for which incremental savings were estimated rather than calculated resulted in a 20 percent reduction between evaluated and tracked energy savings.

²⁵ At the time of writing, 2017 data was not available. The Nova Scotia-specific factor was obtained from Nova Scotia Power's 2016 total system emissions data (7,079,268 CO₂ eq tonnes) and total electricity generation (10,839 GWh), from the following two sources:

Nova Scotia Power, *Total System Emissions*, <http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx>. (Last accessed December 17, 2017).

Emera Inc., *Management's Discussion & Analysis As at February 10, 2017*, <http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693> (Last accessed December 17, 2017).

The large increase in peak demand savings (86%) is attributable to the addition of peak demand savings to two projects that had not reported any. The NTGR used by ENS remained unchanged.

14 OVERALL SAVINGS FOR THE CUSTOM INCENTIVES PROGRAM

Table 26 presents the number of participants and gross and net savings for each Custom Incentives program component as well as those for the program as a whole for 2017.

Table 26: 2017 Overall Participation and Savings for Custom Incentives²⁶

	Participation Level	Gross Savings	NTGR	Net Savings
Custom				
Energy Savings	58 projects completed	22.421 GWh	0.94	21.005 GWh
Lifetime Energy Savings		333.236 GWh	0.94	313.977 GWh
Peak Demand Savings		3.739 MW	0.97	3.637 MW
EMIS				
Energy Savings	4 participants	1.402 GWh	1.00	1.402 GWh
Lifetime Energy Savings		4.112 GWh	1.00	4.112 GWh
Peak Demand Savings		0.255 MW	1.00	0.255 MW
Total				
Energy Savings		23.823 GWh		22.407 GWh
Lifetime Energy Savings		337.348 GWh		318.089 GWh
Peak Demand Savings		3.994 MW		3.892 MW

²⁶ No SEM participants generated savings in 2017, therefore the SEM program component was excluded from this table.

CONCLUSION

The Custom Incentives program is comprised of one well-established program component (Custom) and two relatively new program components (EMIS and SEM). The Custom Incentives program aimed to achieve 24.8 GWh in net energy savings and 1.9 MW in net peak demand savings at the generator in 2017. The program achieved 22.407 GWh in net energy savings and 3.892 MW in net peak demand savings at the generator in 2017, resulting in 14,635 tonnes of avoided CO₂ eq annually. The total net lifetime energy savings amount to 318.089 GWh. The program thus achieved its planned peak demand savings value, but fell short of its planned energy savings value. In fact, none of the three program components achieved their planned energy savings.

The following subsections summarize the main findings for the Custom and EMIS program components of the Custom Incentives program. Since no SEM project generated savings in 2017, this program component is not discussed below.

Custom

The Custom program component is comprised of the Retrofit, New Construction and Building Optimization services. Altogether, these services generated 21.005 GWh in net energy savings and 3.637 MW in net peak demand savings at the generator in 2017, with 78 projects generating savings and 58 projects completed.

The 2017 evaluation has included a technical review of project documentation and on-site visits for each Custom service. The efforts made by ENS to implement the 2016 evaluation recommendations have resulted in overall improvement in the availability and quality of Retrofit project documentation. As a result of this improvement, the adjustment ratio for the Retrofit service was closer to unity than last year, especially for peak demand savings. The Evaluator nonetheless identified four projects where insufficient M&V activities prevented the adjustment of gross savings. The project review done for the New Construction and Building Optimization services resulted in more substantial adjustments than for the Retrofit service. These adjustments were mostly due to inappropriate energy models, and missing elements or wrong assumptions in the savings calculations. Overall, the adjustments made by the Evaluator to the gross energy savings for all the services diminished ENS's tracked value by 9 percent.

As part of the 2017 evaluation, the Evaluator conducted a process evaluation of the Retrofit service by interviewing 10 Retrofit consultants and 15 Retrofit participants. These consultants and participants provided positive feedback about the Retrofit service. Among the Retrofit service successes, it is worth mentioning the high satisfaction level among the consultants and participants, as well as BDM's role in promoting the service, supporting the participants throughout their application process and extending participation to new industries.

Energy Management Information Systems

Seven participants were originally selected by ENS to take part in EMIS in 2017: four were continuing participants from 2016 and 2015; and three were new participants. The three new participant projects were at different stages of EMIS and had not yet generated savings by the end of 2017, therefore, only four participants reported savings in 2017.

Last year, the Evaluator made a distinction between the cumulative energy savings²⁷ tracked by ENS and the incremental energy savings.²⁸ This year, ENS tracked incremental savings. Only incremental savings were considered as evaluated savings, and so they were the focus of this evaluation. The 2017 evaluation revealed that EMIS achieved 1.402 GWh in net energy savings and 0.255 MW in net peak demand savings at the generator.

Overall, the savings were well documented, allowing the Evaluator to easily assess how savings were established. One improvement over last year was the addition of an incremental savings analysis for two projects. The savings review revealed that the process for re-establishing the baseline was well understood and applied to those two projects, thus requiring only a small adjustment to one project's peak demand savings. Evaluated savings were 20 percent below the tracked value; this was mainly due to the change in the approach used to obtain energy savings for the two other projects for which incremental savings were simply estimated as a difference between 2017 and 2016 cumulative savings rather than calculated through a process for re-establishing the baseline. As indicated by the results, the difference in cumulative energy savings between one year to another alone does not accurately reflect incremental savings achieved by large manufacturing facilities. ENS is aware of this issue and plans on increasing internal knowledge to be able to perform calculations for re-establishing the baseline. Lastly, the savings review revealed that there is room for improvement in the tracking of results and changes occurring at participating facilities.

The interviews conducted with the participants revealed they were very satisfied with their experience with EMIS. Participants felt that the system provided useful data about energy consumption and allowed them to make informed decisions, indicating that EMIS reached its main goal of assisting its participants in making real-time decisions about their processes using energy consumption data from metered systems.

²⁷ The annual savings achieved with respect to the baseline situation prior to the implementation of the EMIS.

²⁸ The additional annual savings not measured in previous years. Incremental savings result from new measures implemented during the evaluation year or from recent improvements to energy efficiency measures that were initiated in previous evaluation years. These savings are calculated by using the previous year's situation as the baseline.

LIST OF APPENDICES

The following are presented in the Custom Incentives Program – Appendices.

Custom

Appendix I - Custom: 2017 Recommendations

Appendix II - Custom: Retrofit Interview Guide with Consultants

Appendix III - Custom: Retrofit Interview Guide with Participants

Appendix IV - Custom: Retrofit On-site Visit Protocol

Appendix V - Custom: New Construction On-site Visit Protocol

Appendix VI - Custom: Building Optimization On-site Visit Protocol

Appendix VII - Custom: New Construction Methodology

Appendix VIII - Custom: Retrofit Calculation Example

EMIS

Appendix IX - EMIS: 2017 Recommendations

Appendix X - EMIS: Project Review Protocol and Phone Interview Guide



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CUSTOM INCENTIVES PROGRAM

2017 DSM EVALUATION

EFFICIENCY NOVA SCOTIA

Appendix Report

March 15, 2018



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Appendix I

CUSTOM: 2017 RECOMMENDATIONS

This appendix summarizes all the recommendations made by the Evaluator as part of the 2017 evaluation, as well as all 2016 evaluation recommendations that were not fully implemented.

Sections	Recommendations
Executive Summary	1 Continue relying on BDMs to assist participants and find new markets. The 2017 evaluation showed that many participants heard about Retrofit from a BDM and those who worked with a BDM were satisfied with their interactions. This support included providing answers to the participants' inquiries, especially about eligibility requirements, and informing about the latest service changes. In some cases, these relationships also resulted in identifying additional projects. The BDMs have successfully brought in numerous participants from the aquaculture industry and are looking for new markets to replicate this success. To maintain a high level of participation in Custom, the Evaluator recommends that ENS continue to expand outreach efforts via BDM contacts with specific business groups in the industrial and agricultural sectors
	2 Continue conducting an in-depth review of energy models as part of the evaluation and improve ENS staff's capacity to identify discrepancies in energy models. The more in-depth review of energy models conducted during the 2017 evaluation identified discrepancies in all five projects and resulted in significant downward adjustments to savings. Modelling of heat pump systems and manual calculations to adjust baselines were most problematic. This showed that a systematic review should be conducted, even if energy models are prepared by experienced consultants. The Evaluator also recommends that ENS provide tools and training to their staff so that they are better able to conduct technical reviews of energy models. Those tools could include checklists of parameters to validate for certain types of projects or building systems
	3 Establish clear objectives for Building Optimization. The Building Optimization projects reviewed this year differed widely in scope. Some projects involved detailed investigative work to tap into deep energy savings, while others were limited to replacing known broken equipment or repairing recently installed mechanical systems that had never worked as intended. While all projects generated savings and all participants benefited from Building Optimization, the participants' needs were quite different from one another. The Evaluator believes that clearly establishing the objectives of the

	service would result in providing the right level of support to each participant and maximizing the added value of ENS support, that is, involving specialized consultants in retrocommissioning only when detailed investigation of energy-saving opportunities is a project's objective. Better defining objectives and eligibility criteria would also clarify how the basecase should be established. For example, the project whose mechanical systems had never worked as intended had a basecase with such a high number of hours of use that the cooling towers would have provided far too much cooling to the building. An analysis of what should qualify as an acceptable Building Optimization project would allow for distinguishing between the ordinary repairs that a building owner needs to make his or her building function normally and the real energy-saving opportunities for improving energy performance above a minimum level. Better objective-setting would allow for allocating Building Optimization's financial and technical resources to those projects that will most benefit from them
	4 Better document the basecase conditions for Building Optimization projects. The Evaluator observed that the basecase conditions were sometimes not measured or documented (using photos, for instance). Since these conditions cannot be verified because they no longer exist after project implementation, the Evaluator recommends that ENS gather more information about the pre-implementation conditions to support savings evaluation afterwards.
2016 Recommendations (Not fully implemented at the time of evaluation)	5 Identify the root causes of New Construction's low participation. Recommendation 2016 Custom-R2 was meant to discover the real reasons for New Construction's low participation. Although changes were made to New Construction in 2017, whether these changes have had a positive impact on participation will not be observed until at least 2018. These changes included: (1) the requirement of holding a kick-off meeting with the entire design team and ENS before the project starts; (2) an incentive of up to \$10,000 for modelling and design work that has not been removed from the overall incentive mechanism; (3) a standard incentive amount per kWh; and (4) a baseline that conforms with the 2015 National Energy Code of Canada for Buildings (NECB). ENS will be following up with consultants and participants in Q1 2018, and monitoring any changes in New Construction participation.
Retrofit Project Review Findings	6 In some instances, there were changes to the project scope that were observed on site but had not been identified in the project documentation provided by ENS. The Evaluator recommends that ENS implement a

	change-tracking document to allow the project manager to track and update the demand-side management data system (DSMDS) accordingly.
Retrofit Effective Useful Life	7 Currently, the measure category specific EUL values are not shown for each project in the Custom tracking report. The Evaluator recommends that from now on, ENS select an EUL value specific to each project and the measures involved in it and that it be included in the tracking report.
New Construction Project Review Findings	8 The electricity consumption of the base case building cannot be taken directly from the reference building energy model that is automatically generated by the simulation software (such as CanQUEST). Consequently, adjustments are made to manually to convert the natural gas consumption into the equivalent electricity consumption of electric baseboards. The Evaluator recommends that those calculations be added to the documentation requirements for New Construction projects.

Appendix II

CUSTOM: RETROFIT INTERVIEW GUIDE WITH CONSULTANTS

Instrument Information

Table 1: Research Objectives and Associated Questions

Research Objective	Associated Questions
Assess program outreach	Q6, Q7, Q8, Q9, Q10, Q22
Assess program delivery	Q11, Q12, Q13, Q14, Q15, Q16, Q20, Q21, Q22, Q25, Q26, Q29
Identify barriers to customer participation and possible solutions	Q17, Q18, Q19
Identify barriers to consultant participation and possible solutions	Q24, Q25
Identify program successes and challenges	Q30, Q31, Q32, Q33
Assess consultant satisfaction with program including M&V procedures and tools	Q20, Q21, Q22, Q23, Q27, Q28, Q29
Inquire about possible ways to increase # of projects and possible ways to increase savings	Q8, Q10, Q32
Address interactions of BDMs with consultants	Q6c, Q20, Q21, Q22, Q23

Programmer Information

Programming note style conventions in this document:

- › **[PROGRAMMING]** Programming instructions are in bracketed CAPS.
- › *[Interviewer notes]* Onscreen interviewer instructions are bracketed in *italics*.
- › **[Piped value]** Database inputs are in **bold**.

Program Description

The Custom – Retrofit program provides incentives and help commercial and industrial customers (including non-profits) reduce electrical consumption and demand. The program provides support for energy audits and the implementation of efficient measures. This program is designed to cover a wide array of measures not covered by the prescriptive program measures and serves to build awareness of all ENS program offerings available to C&I customers.

The Custom program is broken into a suite of five offerings, of which two cover retrofit measures. Retrofit Track 1 covers small scale (simple) custom projects and Retrofit Track 2 covers larger more complicated projects. Most projects are in track 2 and the smaller scale track 1 projects typically wind up in the SBES program. The other program elements, new construction, compressed air leak audits, and building optimization are not being included in this round of evaluation.

Instrument

Introduction

Name: Response

Company: Response

Date: Response

Interviewer: Response

Script for Initial Phone Call or Voicemail

Hi, this is _____ from Research Into Action.

I am on an evaluation team for Efficiency Nova Scotia's Custom-Retrofit program and I understand you have worked on some Custom projects for your customers. I would like to speak with you about your perspectives on how things are going with the program. Our conversation should take about 30 minutes.

Here are some times that are available for a call; please let me know if one of these works for you.

[INSERT DATES/TIMES; NOTE PROGRAM STAFF ARE ON ATLANTIC TIME.]

Thank you very much. I look forward to speaking with you.

Introduction

Thanks for taking the time to talk today. I work for Research Into Action, part of the Econoler evaluation team, and we have been asked by Efficiency Nova Scotia, or ENS, to conduct the process evaluation for the Custom - Retrofit program. As part of that, we are talking with people who are involved with the program so we can make sure we understand how it is working.

Our talk will take about 30 minutes.

I'll be audio recording this interview, to insure the accuracy of my note taking. [If asked whether the audio will be provided to Efficiency Nova Scotia say: We do not identify any respondent in our reporting, and it is research best practices not to provide the audio or notes to Efficiency Nova Scotia, unless legally required to do so.] Is it ok that I record the interview?

Do you have any questions before we get started?

Roles and Responsibilities

- Q1. Let's start with a bit about you. Can you please tell me your title and briefly describe your role with your company?
- Q2. What is the principal type of work your firm does? [PROBE: Lighting, HVAC, motors, etc.]
- Q3. How long have you worked with ENS's Custom program?

- Q4. How did you first become aware of the Custom program?
- Q5. I understand you have completed [# of CUSTOM-RETROFIT PROJECTS HERE] in 2017, as of October. Does that sound right? If not, how many have you done?

Program Outreach and Sales

- Q6. How often do you identify custom retrofit projects using each of the following sources:
- Working with your existing customers (either you propose projects or they call you)?
 - Cold calls to potential customers?
 - Referrals or leads from ENS' Business Development Managers (BDMs)?
 - Some other way? (describe)
- Q7. How often do customers ask you about participating in the Custom program instead of you telling them about it? When customers bring up the program, what do they say interests them or what do they want to know about it? [if needed: energy savings, electricity cost savings, improvements in production, comfort, etc.]
- Q8. What information or benefits about the Custom program do you emphasize in your sales process? [PROBES: Do you discuss savings, non-energy benefits of participating, etc.?
- Q9. What materials, if any, does your firm use to reach out or inform customers about opportunities with the Custom program? If not mentioned: Do you use any materials from ENS in talking with customers about the program? What do you use and how do you use them?
- Q10. How do you handle a situation where a customer wants one type of custom project – say a prescriptive lighting project – but you notice other projects – say an HVAC upgrade?

Program Services

- Q11. In general, a Custom project has five phases. Please describe how you are typically involved in each phase. Let's start with the first phase...
- Confirming eligibility
 - Scoping study
 - Feasibility study
 - Implementation
 - Measurement and Verification (M&V)

For each phase, I'd now like to know what is working well and what could use improvement – both for you as the consultant and for your customers.

- Q12. Let's start with the first phase, confirming eligibility for your customers.
- What problems or issues, if any, have you faced?
 - What has worked well for you?
 - What problems or issues, if any, have your customers faced?

4 What has worked well for your customers?

Q13. How about the scoping study?

- 1 What problems or issues, if any, have you faced?
- 2 What has worked well for you?
- 3 What problems or issues, if any, have your customers faced?
- 4 What has worked well for your customers?

Q14. How about the feasibility study?

- 1 What problems or issues, if any, have you faced?
- 2 What has worked well for you?
- 3 What problems or issues, if any, have your customers faced?
- 4 What has worked well for your customers?

Q15. How about the implementation (installation) phase?

- 1 What problems or issues, if any, have you faced?
- 2 What has worked well for you?
- 3 What problems or issues, if any, have your customers faced?
- 4 What has worked well for your customers?

Q16. How about the M&V phase?

- 1 What problems or issues, if any, have you faced with M&V procedures?
- 2 What has worked well for you with the existing M&V process?
- 3 What problems or issues, if any, have your customers faced with M&V procedures?
- 4 What has worked well for your customers?
- 5 How satisfied are you with the M&V tools provided by ENS? What makes you satisfied or dissatisfied with the tools? What could be improved? What should not be changed?

Q17. What reasons do customers most often give when they decide to a lesser project? [Probe if needed: What other reasons (besides money)?]

Q18. What reasons do customers give when they decide not to go forward and complete a project? Is there a typical phase when developing a project at which customers opt out?

Q19. What approaches or strategies you use that encourage customers to complete a Custom project when they get stopped in the process?

Support from ENS

Q20. I want to understand more about your working relationship with Efficiency Nova Scotia. How often do you communicate with someone from Efficiency Nova Scotia about the Custom program? For what reasons? How, if at all, could those interactions be improved?

Q21. [If they said they get referrals from BDMs] You mentioned you sometimes get referrals or leads to Custom projects from ENS Business Development Managers (BDMs).

1 How does the referral process from BDMs work? Would you suggest any improvements for the referral process?

Q22. Do you (also/ever) work with BDMs during the sales process? [If needed: By sales process I mean when you first interact with the customer and discuss possible project elements] How does working with BDMs affect selling a project to customers? Would you suggest any improvements for coordinating with BDMs during the sales process?

Q23. How about working with a BDM during the project development process – do you do that? [If needed: By project development I mean when you are scoping out project details and doing a feasibility analysis]. How does that work? Would you suggest any improvements for coordinating with BDMs on the project development process?

Q24. What services or support, if any, have you received from ENS during the installation of Custom projects?

1 [Do you also work/Have you worked] with BDMs to get Custom projects installed? What support does the BDM provide?

2 In what ways could BDM support for installing projects be improved?

Q25. What additional services or support, if any, would you like to see from Efficiency Nova Scotia to help you complete more Custom projects?

Q26. Are there any additional measures that ENS should make eligible for Custom projects?

Consultant Satisfaction

Q27. Has the Custom program helped you get projects you may not have otherwise gotten? How so? [Probe for influence of BDMs]

Q28. How satisfied have you been with the program in terms of the requirements asked of you?

Q29. Successes Overall, how satisfied have you been with Efficiency Nova Scotia in terms of providing you with the service and support you need to deliver Custom rebated projects to your customers? What improvements would you like to see in ENS support?

Successes, Challenges, and Opportunities

Q30. How, if at all, has the Custom-Retrofit program benefited your firm?

Q31. How, if at all, has the Custom-Retrofit program created challenges for your firm?

Q32. Other than increase incentives, what could Efficiency Nova Scotia do to make the Custom - Retrofit program more effective?

Q33. Is there anything else about the program that we have not discussed that you would like to mention?

Appendix III

CUSTOM: RETROFIT INTERVIEW GUIDE WITH PARTICIPANTS

Instrument Information

Table 2: Research Objectives and Associated Questions

Research Objective	Associated Questions
Assess program outreach	Q4, Q7, Q6, Q7
Assess program delivery	Q8, Q9, Q17, Q22, Q23, Q24, Q25, Q26
Identify barriers to customer participation and possible solutions	Q8, Q10, Q25, Q28
Identify program successes and challenges	Q10, Q29, Q31, Q32, Q32
Inquire about possible ways to increase # of projects	Q27, Q28, Q32
Inquire about possible ways to increase savings	Q27, Q28

Programmer Information

Programming note style conventions in this document:

- › [PROGRAMMING] Programming instructions are in bracketed CAPS.
- › [*Interviewer notes*] Onscreen interviewer instructions are bracketed in *italics*.
- › [Piped value] Database inputs are in **bold**.

Program Description

The Custom – Retrofit program provides incentives and help commercial and industrial customers (including non-profits) reduce electrical consumption and demand. The program provides support for energy audits and the implementation of efficient measures. This program is designed to cover a wide array of measures not covered by the prescriptive program measures and serves to build awareness of all ENS program offerings available to C&I customers.

The Custom program is broken into a suite of five offerings, of which two cover retrofit measures. Retrofit Track 1 covers small scale (simple) custom projects and Retrofit Track 2 covers larger more complicated projects. The other program elements, new construction, compressed air leak audits, and building optimization are not being included in this round of evaluation.

Instrument

Introduction

Name: Response

Company: Response

Date: Response

Interviewer: Response

Script for Initial Phone Call or Voicemail

Hi, this is _____ from Research Into Action.

As you may know, we are part of the evaluation team for Efficiency Nova Scotia's (ENS) Custom - Retrofit program. I would like to speak with you about your experience participating in the Custom program as part of this evaluation. Learning from folks like you will help ENS design programs that will best serve the needs of customers such as yourself. Here are some times that are available for a call; please let me know if one of these works for you.

[INSERT DATES/TIMES; NOTE PROGRAM STAFF ARE ON ATLANTIC TIME.]

Thank you very much. I look forward to speaking with you.

Introduction

Thanks for taking the time to talk today. I work for Research Into Action, part of the Econoler evaluation team, and we have been asked by Efficiency Nova Scotia to conduct the process evaluation for the Custom - Retrofit program. As part of that, we are talking with people who are involved with the program so we can make sure we understand how it is working.

Our talk will take about 30 minutes.

I'll be audio recording this interview, to insure the accuracy of my note take. [If asked whether the audio will be provided to Efficiency Nova Scotia say: We do not identify any respondent in our reporting, and it is research best practices not to provide the audio or notes to Efficiency Nova Scotia, unless legally required to do so.] Is it ok that I record the interview?

Response

If you want to refer me to specific documents to answer any of my questions, that's great – I'm happy to look things up if I know where to get the information.

Do you have any questions before we get started?

Roles and Responsibilities

- Q1. Let's start with a bit about you. Can you please tell me your title and briefly describe your role with your company?
- Q2. What is the principal type of work your firm does? [PROBE: Food service, Industrial, etc.]
- Q3. Approximately how many square feet is your facility? [If needed: I am just looking for a rough way to understand the size of facilities that participate in the custom program].

Program Outreach

- Q4. How did you learn about the Custom program? [If needed: Was it through a consultant, experience with ENS programs, seeing ads, or experience with a Business Development Manager?]
- Q5. [If Q4 = Through a consultant] Was this a consultant you had worked with previously?
- Q6. What was your motivation to complete the Custom project [Measures included ____, ____, and ____]? Were you primarily interested in saving energy long-term, fixing a problem such as poor ventilation, meeting corporate energy saving goals, something else?
- Q7. When you were preparing to start this project, did you have an idea of how extensive it would be? For example, you may have started out wanting to do a lighting project and then opted to complete other measures such as HVAC.

Program Services

In general, there are five key phases of a Custom project. They are....

- 1 Confirming eligibility
 - 2 Scoping study
 - 3 Feasibility study
 - 4 Implementation
 - 5 Approval (including any verification of savings) and receiving your incentive
- Q8. What problems or issues, if any did you or your firm face with each phase? Let's start with the first phase...
- 1 Confirming eligibility
 - 2 Scoping study
 - 3 Feasibility study
 - 4 Implementation
 - 5 Approval (including any verification of savings) and receiving your incentive

Q9. What worked well for you, if anything, during each phase? Let's start with the first phase...

- 1) Confirming eligibility
- 2) Scoping study
- 3) Feasibility study
- 4) Implementation
- 5) Approval (including any verification of savings) and receiving your incentive

Q10. What suggestions, if any, do you have for improving each phase?

- 1 Confirming eligibility
- 2 Scoping study
- 3 Feasibility study
- 4 Implementation
- 5 Approval (including any verification of savings) and receiving your incentive

Support from Consultant

Q11. How often did you communicate with your consultant about your participation in the Custom program?

Q12. What did you communicate with your consultant about?

Q13. Was there one phase of the project where you interacted with your consultant more often than the others? Which phase was that and why was their more interactions?

Q14. Was there any service or support you would have liked to see from your consultant that you did not receive? What support was needed?

Q15. Overall, how satisfied were you with the following aspects of your consultant?

- 1 The service you received throughout the process
- 2 The information you received about the installed products
- 3 The quality of the final installation

Q16. Did the consultant identify additional energy saving projects than what you initially intended to complete? For example, perhaps you intended to upgrade some motors and when providing the bid, the consultant suggested upgrading lighting, or some other device. If so, did you undertake the additional work the consultant suggested? Why?

Support from ENS

Q17. How often, if at all, did you communicate with someone from Efficiency Nova Scotia about your participation in the Custom program?

Q18. How often, if at all, do you work with ENS Business Development Managers (BDMS)? [If needed: A BDM is someone from ENS that works with large customers in a specific market sector. For example, there is a BDM that focuses on hospitals and health care]

- Q19. [IF they work with BDMS] What do you typically work on with the BDMS? [If needed: Billing questions, efficiency projects, etc.]]
- Q20. [IF they work with BDMS] Do you ever work with BDMS and consultants to discuss technical aspects of a project you are interested in? How does that typically occur?
- Q21. [IF they work with BDMS] Overall, how satisfied are you with your interactions with BDMS? Is there any service or assistance that you would like to see BDMS offer firms such as yours? What are those services and why would they be helpful?
- Q22. [If communicated with ENS] What did you communicate with ENS about staff and were you able to get your questions answered well and in a timely manner?
- Q23. What service or support, if any, did you receive from ENS to help you complete your project?
- Q24. What service or support, if any, would you like to see from Efficiency Nova Scotia to help you complete Custom projects in the future? Why?
- Q25. Are there certain measures or services ENS should provide for Custom projects that are not currently supported?
- Q26. Overall, how satisfied have you been with Efficiency Nova Scotia in terms of providing you with the service and support you needed to complete your Custom project? Why?

Opportunities, Successes, and Challenges

- Q27. Do you have any plans to do additional Custom program projects in the coming year or two? If so, what projects are you considering and why are you considering the projects?
- Q28. Are there other potential Custom program projects you would like to do in the coming year or two but don't have the time money or other resources to do? What are those projects and what are the specific barriers to doing those?

Before we end this call, I have just a couple overarching questions about your participation.

- Q29. How, if at all, has your participation in the Custom-Retrofit program been a success for your firm?
- Q30. How, if at all, has your participation in the Custom-Retrofit program been a challenge for your firm?
- Q31. Other than increased incentives, what could Efficiency Nova Scotia do to make the Custom-Retrofit program more effective, if anything?
- Q32. Is there anything else about the program that we have not discussed that you feel should be mentioned?

Appendix IV

CUSTOM: RETROFIT ON-SITE VISIT PROTOCOL

This appendix describes the protocol used as part of the Retrofit on-site visits.

On-site Visit Protocol

After reviewing the 2016 Retrofit protocol, the Evaluator considered it still appropriate for the 2017 site visits.

The on-site protocol form was used by the Evaluator to collect technical data and summarize information, such as project details, a building's heating and cooling systems, key parameters to review during the site visit, and previous M&V activities. Other technical information collected could include, but is not limited to, the equipment's operating schedules, the equipment's specifications, quantities, baseline conditions, typical equipment loading, and changes that occurred since M&V had been conducted.

Prior to conducting the on-site visits, the Evaluator reviewed documents stored in the DSMDS. The documents reviewed included, but were not limited to, the following: Scoping and/or Feasibility studies, Energy Efficiency Measure (EEM) savings calculations, Project Development Agreements, M&V reports, and email correspondence.

On-site Visit Data Collection Form for Retrofit Projects



1. General Information

Site Visit Date:		EQ Team:		Contact Name:	
Project ID:				Contact Title:	
Project Type:				Contact Phone:	
Company Name:				E mail:	
Address:					
List of people met during the visit:					
Type of building:	☐ Commercial/institutional ☐ Municipal	☐ Industrial/manufacturing ☐ Other (specify)	Specify:		

2. Facility Operation Schedules

Facility Description: *Outline a quick description of the facility and its primary operation/purpose.*
 NOTE: PC Users "Alt+Enter" for new line in cell. MAC Users "CMD+Option+Enter".

Facility Annual Schedule:

Fill the table below for each occupancy schedule reported by the site contact as occupancy could vary for each section of the facility. Use additional sheets if necessary.

Description	1 - Normal Schedule		2 - Specify:		3 - Specify:	
	Weekdays	Weekends	Weekdays	Weekends	Weekdays	Weekends
Number of day with regular schedule per year						
Number of day with regular holidays schedule per year						
Number of days with no occupancy per year (For example: seasonal closure)						
Total number of day per year	0	0	0	0	0	0

Total=261 Total=104

Facility Daily Schedule:

Fill the table below for each occupancy schedule reported by the site contact as occupancy could vary for each section of the facility. Use additional sheets if necessary.

Schedules		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Holidays
Schedule 1: Normal	Time of use (e.g. 8:00 am to 5:00 pm)								
	Hours per day								
Schedule 2 (specified above)	Time of use								
	Hours per day								
Schedule 3 (specified above)	Time of use								
	Hours per day								

3. Interactive Effects

Interactive Effects?

YES

☐

NO

☐

If YES the fill in the table below for each heating system at the site

Briefly describe interactive effects for the project.

4. Building Heating/Cooling System Description
Heating Systems

Fill the table below for each heating system at the site.

Description	Heating System 1	Heating System 2	Heating System 3	Heating System 4
Energy Source				
Heating System Type				
Nominal Capacity				
Efficiency or COP				
Percent of Load (Declaration)				
If any, changes in building set points (occ/ unocc. temp., % hum)				

Cooling Systems

Fill the table below for each cooling system at the site.

Description	Cooling System 1	Cooling System 2	Cooling System 3	Cooling System 4
Energy Source				
Cooling System Type				
Nominal Capacity				
SEER or COP				
Percent of Load (Declaration)				
If any, changes in building set points (occ/ unocc. temp., % hum)				

5. Pre-Visit Assessment of the Project

Indicate the key variables & observations from all available reports. These notes will serve on site to guide the visit and identify the main information to collect and/or verify.

6. On-Site Observations and Findings

Report the on-site visit and indicate the key observations and findings made on site.

7. M&V Post Implementation Results

Were any baseline measurements taken ?

(Y/N)

Are electrical savings based on measurements? (Y/N)

Are demand savings based on measurements? (Y/N)

IF so summarize measurement plan, and measurement type.

Report the on-site visit and indicate the key observations and findings made on site.

Seasonal Load Profile? (Y/N)

Summer Load Variations? (Y/N)

Predicted Results (MWh)	M&V Results	Percent of Expected (%)	M&V Start Date	M&V Finish Date	Days in Period	Notes

Notes: Insert Comments from M&V Reports

8. Energy and Demand Savings Adjustments

Energy Savings from Tracking Sheet:		kWh/yr
Demand Savings from Tracking Sheet:		kW
Diversity Factor Used by ENSC:		

Adjustment from the Evaluator

Adjusted Energy Savings:	
Adjusted Demand Savings:	
Adjusted Demand Savings with PCF:	
Diversity Factor Used by Econoler:	

Adjustments made to energy savings? (Y/N)

Project Estimated Finish Month:	
Notes on Project Status:	

Final Project Impacts at the Generator

Evaluated Energy Savings:		0.0 kWh/yr
Evaluated Demand Savings with PCF:		0.0 kW

Percent of Tracked Savings

Adjustments made to demand savings?		(Y/N)	Client Rate Code
Adjustments made to PCF?		(Y/N)	Line Loss Factor Used

9. Summarize Project Adjustments and Final Savings Values

IF any adjustments were made to the energy savings, demand savings or PCF, describe the rationale and provide calculations.

Appendix V

CUSTOM: NEW CONSTRUCTION ON-SITE VISIT PROTOCOL

This appendix describes the protocol used as part of the New Construction on-site visits and simulation model review.

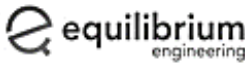
On-site Visit Protocol

After reviewing the 2016 New Construction protocol, the Evaluator considered it still appropriate for the 2017 evaluation. However, questions were added to evaluate the participant satisfaction and suggestions for improvement.

Prior to conducting any site visits, the Evaluator reviewed ENS's entire project documentation archived in the DSMDS to identify relevant questions and/or concerns. The files reviewed included, but were not limited to, a summary report of the model and findings, the energy model, the drawings and equipment specifications, the project development agreement, and the email correspondence.

On-site Visit Data Collection Form for New Construction Projects





**BNI New Construction Program
Efficiency Nova Scotia
On-Site Visit Protocol**

1. General Information

Site Visit Date: Staff: Contact Name:
 Project ID: Contact Title:
 Project Type: Contact Phone:
 Project Status: Email:
 Project Name:
 Address:

List of people met during the visit:

Efficiency Measures	
Building Envelope	Fans
HVAC	Lighting
Refrigeration	Domestic Hot Water
Pumps	Other (specify)

Specify:

Energy Model Received Prior to Visit? (Y/N)

2. Facility Operation Schedules

Facility Description: *Outline a quick description of the facility and its primary operation/purpose.*
NOTE: PC Users "Alt+Enter" for new line in cell. MAC Users "CMD+Option+Enter".

Facility Annual Schedule: *Fill the table below for each occupancy schedule reported by the site contact as occupancy could vary for each section of the facility. Use additional sheets if necessary.*

Description	1 - Normal Schedule		2 - Specify:		3 - Specify:	
	Weekdays	Weekends	Weekdays	Weekends	Weekdays	Weekends
Number of day with regular schedule per year						
Number of day with regular holidays schedule per year						
Number of days with no occupancy per year (For example: seasonal closure)						
Total number of day per year	0	0	0	0	0	0

Total=261 Total=104

Facility Daily Schedule: *Fill the table below for each occupancy schedule reported by the site contact as occupancy could vary for each section of the facility. Use additional sheets if necessary.*

Schedules		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Holidays
Schedule 1: Normal	Time of use (eg. 8:00 am to 5:00 pm)								
	Hrs per day								
Schedule 2 (specified above)	Time of use								
	Hrs per day								
Schedule 3	Time of use								

(specified above)	Hours per day						

3. Building Heating/Cooling System Description

Heating Systems

Fill the table below for each heating system at the site.

Description	Heating System 1	Heating System 2	Heating System 3	Heating System 4
Energy Source				
Heating System Type				
Nominal Capacity				
Efficiency or COP				
If any, changes in building set points (occ./ unocc. temp., % hum)				

Cooling Systems

Fill the table below for each cooling system at the site.

Description	Cooling System 1	Cooling System 2	Cooling System 3	Cooling System 4
Energy Source				
Cooling System Type				
Nominal Capacity				
SEER or COP				
If any, changes in building set points (occ./ unocc. temp., % hum)				

Domestic Hot Water

Fill the table below for each heating system at the site.

Description	Heating System 1	Heating System 2	Heating System 3	Heating System 4
Energy Source				
Heating System Type				
Nominal Capacity				
Efficiency or COP				
If any, changes in building set points (occ./ unocc. temp., % hum)				

4. Electricity Consumption

Was billing data made available? IF YES fill out table below. IF multiple years of data are available copy and paste this table.

Electric company: _____

kWh Rate: _____

kW Rate: _____

Month	Number of Days	Energy (kWh)	Peak Demand (kW)	Total Cost (\$)
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				

5. Pre-Visit Assessment of the Project

SOFTWARE USED:

BASELINE USED:

IF CUSTOM BASELINE EXPLAIN:

Indicate the equipment that should have been installed as per the energy model. Validate size/efficiency/operational hours. These notes will serve on site to guide the visit and identify the main information to collect and/or verify.

NOTES

7. On-Site Observations and Findings

Report the on-site visit and indicate the key observations and findings made on site.

8. Energy and Demand Savings Adjustments

Energy Savings from Tracking Sheet:		kWh/yr	Project Estimated Finish Month:	
Demand Savings from Tracking Sheet:		kW	Notes on Project Status:	
Diversity Factor Used by ENSC:				

Adjustment from the Evaluator		Final Project Impacts at the Generator	
Adjusted Energy Savings:		Evaluated Energy Savings:	0.0 kWh/yr
Adjusted Demand Savings:		Evaluated Demand Savings with PCF:	0.0 kW
Adjusted Demand Savings with PCF:			
Diversity Factor Used by Econoler:			

Adjustments made to energy savings?		(Y/N)	Percent of Tracked Savings	
Adjustments made to demand savings?		(Y/N)	Client Rate Code	
Adjustments made to PCF?		(Y/N)	Line Loss Factor Used	

9. Summarize Adjustments to Energy, Demand & Diversity Factor

Total Project Savings:

Baseline Validation Questions

New Construction 2017 Evaluation Baseline Validation Questions

B1a. At which point in your design and construction process did you contact ENS?

B1b. Does your company have a corporate policy with respect to new bldg energy efficiency? If so, please describe the policy.

B2. Before you knew about the amount of the incentive, had you decided to include energy efficiency measures in your building? If so, which type of [system/technology] were you considering?

[IF B1b=yes OR B2=YES, ASK B3 TO B5 FOR EACH TECHNOLOGY MENTIONED and FILL OUT THE TABLE BELOW]

B3. If you had not benefited from ENS's financial and technical assistance, is this the [system/technology] that would've most likely been installed in your facility?

[IF B3=NO]

B4. What would you say is the [system/technology] that you would most likely have installed?

[IF system/technology declared ≠ system/technology modeled as your baseline, ASK:]

B5a. Project documentation states that [insert technology/system in baseline] would have been installed in the absence of the program. Can you explain why the [system/technology] was modeled as your baseline?

B5b. Is this [system/technology] what you would have really done in the absence of the program (investigate costs and timeline issues)?

	System/Technology 1	System/Technology 2	System/Technology 3	System/Technology 4	System/Technology 5	System/Technology 6	System/Technology 7	System/Technology 8
Baseline as mentioned in the project documentation								
Efficient measure mentioned in project doc								
B3.								
B4.								
B5a.								
B5b.								

Participant Market Questions

S1. Using a scale from 1 to 10 where 1 is “not at all satisfied” and 10 is “completely satisfied” how would you rate your satisfaction with the program overall?

S2. **[IF S1<8]** What was the most important reason you were not more satisfied with the program overall?

S3. **[IF S1>8]** What was the most important reason you were satisfied with the program overall?

S4. Did you face any challenges or barriers when implementing your New Construction project through the program?

S5. **[IF S4 = YES, then ask:]** What was the most important challenge or barrier?

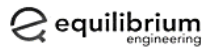
S6. Do you have any suggestions on how to improve the New Construction Program?

Consider all aspects of the program: Participation process, program forms, marketing, interactions with ENS staff or contractors, etc.

Simulation Model Review Protocol

The energy models were used to compare the modelled features with the on-site findings and construction documents.

Energy Model Review Data-collection Form for New Construction Projects



**New Construction
Efficiency Nova Scotia
Energy Simulation Review Protocol**

1. General Information

Date Reviewed:		Staff:		Simulator Name:	
				Company:	
Project Details					
ID:		000		Contact Phone:	
Project Name:		0		Email:	
Building Type:					
Development Status:					
Address:		0			
Efficiency Measures:					
Building Envelope		0	Fans		0
HVAC		0	Lighting		0
Refrigeration		0	Domestic Hot Water		0
Pumps		0	Other (specify)		0
					Specify:
Modelling Software & Version:					
Modelled Baseline (Describe if custom):					

2. Construction & EE Modeling Documents

		Documents Available	
		Y/N	Notes:
Architectural Drawings			
Includes:			
Wall Assemblies			
Roof Assemblies			
Foundation Insulation			
Mechanical Drawings			
Includes:			
HVAC distribution layouts			
Mechanical schedule of equipment			
HVAC Control layout for proposed energy saving measures			
HVAC occ. schedules for all proposed energy saving measures			
Shop Drawings of modeled components			
Electrical Drawings			
Includes:			
Lighting layouts			
Lighting schedules for all proposed energy saving measures			
Lighting Control layout for proposed energy saving measures			
Shop Drawings of modeled components			
Zoning Diagrams			
Takeoffs/Side Calculations			
Final Summary Report			
Includes:			
Brief energy model description			
Modelling workaround description(s)			
Brief description of building (size, function and operating)			
Brief electrical design description			
Brief mechanical design description			
Electronic simulation files, base case and design case			
Electronic simulation output files (i.e. compliance report, .SIM file)			

Additional Notes:

3. Energy Model Review

	Y/N	Notes:
Weather file used equivalent to actual or nearest location		
Total floor area of proposed and baseline model equivalent to as-built drawings		
Shell design of proposed and baseline model equivalent in area and orientation		
R-value of all wall assemblies modelled match drawings/site conditions		
R-value of all wall assemblies modelled includes thermal bridging		
R-value of all roof assemblies modelled match drawings/site conditions		
R-value of all roof assemblies modelled to includes thermal bridging		
U-value of all windows modelled match drawings/site conditions		
U-value of all windows modelled includes framing		
All modelled lighting takes into account lighting ballast factor		
Modelled lighting equivalent in either quantity and wattage or energy intensity footprint as indicated in proposed drawing set and is consistent with site conditions		
Controls are modelled as indicated in proposed drawing set & consistent with site conditions		
Equipment operating schedules selected correctly based on building type or space function & consistent with site conditions		
Proposed space heating/cooling equipment modelled according to proposed drawing set & consistent with site conditions		
Proposed ventilation flow rates and control strategies modelled according to proposed drawing set & consistent with site conditions		
Proposed DHW equipment modelled according to proposed drawing set & consistent with site conditions		
Modelling workarounds appropriately selected for each situation		
Modelling workarounds executed properly		
Assumptions used to model baseline and proposed process equipment are reasonable (i.e. runtime, efficiency, etc.)		

	Approx. percentage of total heating supplied annually
Primary baseline space heating fuel source:	0%
Secondary baseline space heating fuel source:	0%
Approx. percentage of total heating supplied annually	
Primary baseline DHW heating fuel source:	0%
Secondary baseline DHW heating fuel source:	0%

	Y/N	Notes:
Is electricity the primary source of space heating in the baseline model?		
Is electricity the primary source of DHW heating in the baseline model?		

Additional Notes:

Appendix VI

CUSTOM: BUILDING OPTIMIZATION ON-SITE VISIT PROTOCOL

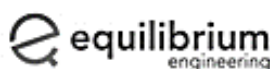
This appendix describes the protocol used as part of the Building Optimization on-site visits.

On-site Visit Protocol

The protocol included a pre-visit assessment section, which allowed the Evaluator to review all the project documents from the DSMDS and highlight those questions and/or concerns regarding the project prior to arriving on site. ENS's files included, but were not limited to, the M&V reports, the project development agreement, and email correspondence.

The Evaluator reviewed such information as the quantity and type of systems commissioned, the equipment and facility operation schedules, and the changes made to the control methods and set points. If a building automation system (BAS) was installed, the Evaluator also reviewed screenshots of the data monitored.

On-site Visit Data Collection Form for Building Optimization Projects


BOpt Program
Efficiency Nova Scotia Corporation
On-Site Visit Protocol

1. General Information

Site Visit Date:		CW		Contact Name:	
Project ID:		Team		Contact Title:	
Project Type:				Contact Phone:	
Company Name:				Email:	
Address:					
List of people met during the visit:					
Type of building:	Commercial/institutional	☐	Industrial/manufacturing	☐	
	Municipal	☐	Other (specify)		Specify:

2. Facility Operation Schedules

Facility Description: *Outline a quick description of the facility and its primary operation/purpose.*
NOTE: PC Users "Alt+Enter" for new line in cell. MAC Users "CMD+Option+Enter".

Facility Annual Schedule: *Fill the table below for each occupancy schedule reported by the site contact as occupancy could vary for each section of the facility. Use additional sheets if necessary.*

Description	1 - Normal Schedule		2 - Specify:		3 - Specify:	
	Weekdays	Weekends	Weekdays	Weekends	Weekdays	Weekends
Number of day with regular schedule per year						
Number of day with regular holidays schedule per year						
Number of days with no occupancy per year (For example: seasonal closure)						
Total number of day per year	0	0	0	0	0	0

Total=261 Total=104

Facility Daily Schedule: *Fill the table below for each occupancy schedule reported by the site contact as occupancy could vary for each section of the facility. Use additional sheets if necessary.*

Schedules		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Holidays
Schedule 1: Normal	Time of use (e.g. 8:00 am to 5:00 pm)								
	Hours per day								
Schedule 2 (specified above)	Time of use								
	Hours per day								
Schedule 3 (specified above)	Time of use								
	Hours per day								

3. Interactive Effects

Interactive Effects?

YES

NO

If YES the fill in the table below for each heating system at the site

Briefly describe interactive effects for the project.

4. Building Heating/Cooling System Description

Heating Systems

Fill the table below for each heating system at the site.

Description	Heating System 1	Heating System 2	Heating System 3	Heating System 4
Energy Source				
Heating System Type				
Nominal Capacity				
Efficiency or COP				
Percent of Load (Declaration)				
If any, changes in building set points (occ / unocc. temp., % hum)				

Cooling Systems

Fill the table below for each cooling system at the site.

Description	Cooling System 1	Cooling System 2	Cooling System 3	Cooling System 4
Energy Source				
Cooling System Type				
Nominal Capacity				
SEER or COP				
Percent of Load (Declaration)				
If any, changes in building set points (occ / unocc. temp., % hum)				

5. Pre-Visit Assessment of the Project

Indicate the key observations from the feasibility study and M&V report analysis. These notes will serve on site to guide the visit and identify the main information to collect and/or verify.

6. Systems Affected by Cx Process (Populate Prior to Visit)

		Notes:
Number of Systems Commissioned in Project		
Building Equipped with Central Automation System:		
New Controls Added?		
Functional Test Reports Available?		

Equipment Type	Location	Controller Upgrade?	Schedule Change?	Setpoint Change?	Change Validated?
Electric Baseboard					
Notes:					
Notes:					
Notes:					

7. Peak Demand Savings

For each energy efficiency measure, determine if it operates during peak hours (between 5pm and 7pm in the months of December to February on a non-holiday weekday) and its corresponding peak coincidence factor.

Energy Efficiency Measure	Savings	During or outside peak?	Peak coincidence factor	Calculations

8. On-Site Observations and Findings

Report the on-site visit and indicate the key observations and findings made on site.

9. Questionnaires

Market Information Questionnaire
Completed?

 (Y/N)

Free Ridership Questionnaire Completed?

 (Y/N)

10. M&V Post Implementation Results

Are electrical Savings based on measurements? (Y/N)

Are demand savings based on measurements? (Y/N)

Were any measurements taken? (Y/N)

If so summarize measurement plan, and measurement type.

Report the on-site visit and indicate the key observations and findings made on site.

Seasonal Load Profile? (Y/N)

Summer Load Variations? (Y/N)

Predicted Results (MWh)	M&V Results	Percent of Expected (%)	M&V Start Date	M&V Finish Date	Days in Period	Notes

Notes: Insert Comments from M&V Reports

11. Energy and Demand Savings Adjustments

Energy Savings from Tracking Sheet		kWh/yr
Demand Savings from Tracking Sheet		kW
Diversity Factor Used by ENSO:		

Adjustment from the Evaluator

Adjusted Energy Savings:	
Adjusted Demand Savings:	
Adjusted Demand Savings with PCF:	
Diversity Factor Used by Econoler:	

Adjustments made to energy savings? (Y/N)

Project Estimated Finish Month:	
Notes on Project Status:	

Final Project Impacts at the Generator

Evaluated Energy Savings:		0.0 kWh/yr
Evaluated Demand Savings with PCF:		0.0 kW

Percent of Tracked Savings #DIV/0!

Adjustments made to demand savings? (Y/N)

Adjustments made to PCF? (Y/N)

12. Summarize Project Adjustments and Final Savings Values

Final Adjusted Total Project Savings:

Energy Savings (kWh)

Demand Savings (kW) =

Free Ridership Questions

- FR1. Before taking part in the BOPT program, had you ever conducted commissioning on your building?
- FR2. Before taking part in the BOPT program, were you aware of what an existing building commissioning project was?
- FR3. Of all the energy efficiency measures implemented through your participation in the BOPT program, which proportion do you think you would have implemented even if you had not participated in the BOPT program?

Participant Market Questions

- S1. Using a scale from 1 to 10 where 1 is “not at all satisfied” and 10 is “completely satisfied” how would you rate your satisfaction with the program overall?
- _____
- S2. **[IF S1<8]** What was the most important reason you were not more satisfied with the program overall?
- _____

S3. [IF S1>8] What was the most important reason you were satisfied with the program overall?

S4. Did you face any challenges or barriers when implementing your Building Optimization project through the program?

S5. [IF S4 = YES, then ask:] What was the most important challenge or barrier?

S6. Do you have any suggestions on how to improve the BOpt program?

Consider all aspects of the program: Participation process, program forms, marketing, interactions with ENS staff or contractors, etc.

Appendix VII

CUSTOM: NEW CONSTRUCTION METHODOLOGY

This appendix describes the subtasks carried out by the Evaluator to establish the gross savings of the New Construction projects.

Review of the Project Simulation Reports

As part of the submission package to ENS, energy simulators were required to provide the following documentation:

- › A summary report of the energy model and energy-efficiency measure findings;
- › Construction drawings and specifications;
- › The energy model and all side calculations; and
- › PDA and a Feasibility Study Summary containing a breakdown of energy-efficiency measure savings and incremental costs.

Prior to the site visits, the Evaluator collected and reviewed all the documentation found in the DSMDS. The documentation was then used to compile an on-site visit protocol to enable the Evaluator to identify the purposes served by the building's design and operations. The compilation involved summarizing the proposed energy-efficiency measures and the associated baseline used for each measure.

On-site Validation of the Measures Implemented in the Building

For the 2017 New Construction review, the Evaluator carried out on-site validation for four of the five projects. The purpose of the visits was to confirm that the proposed energy efficiency measures documented in the PDA had been installed and were operational. The Evaluator also evaluated the participant satisfaction and suggestions for improvement during the site-visits.

During the on-site visits the Evaluator discussed the occupancy rates, and documented the buildings' normal operating schedules. Upon completion of the interviews, the Evaluator requested that the participant give a tour of the building and review the efficiency measures implemented in order to validate the PDA information. The major focus was usually placed on, but not limited to, verifying whether the proposed building envelope components were present, the HVAC equipment's sizes and efficiencies, lighting power densities, occupancy types and the operating schedules. Any discrepancies discovered during the on-site review were used to calculate the adjustments to be made to project-specific savings in both the annual energy consumption and demand savings.

For one of the projects, the site visit was not conducted because the project was completed at the end of the year. Instead, the Evaluator performed a desk review made possible since mechanical zoning diagrams, drawings and pictures of the installed equipment, and simulation files were obtained from the

DSMDS. Sufficient information was made available to confirm that the measures were installed and verify the savings.

Verification of Participant-specific Baseline

In 2017, the Evaluator continued implementing the approach to calculating net savings that was first used in 2014. This implies that for each participant, savings were calculated as the difference between the energy consumption of the hypothetical building that would have been built in the absence of the program and the more efficient building that was constructed as part of the program.

When conducting the site visits and phone interviews, the Evaluator used a standard questionnaire to validate that the baseline defined by ENS truly corresponded to the design intention of that specific participant. The baseline for each energy efficiency measure mentioned in the project documentation was investigated. The questionnaire can be found in Appendix V. As mentioned above, a site visit could not be conducted for one of the projects. Therefore, the baseline questionnaire could not be answered by the participating customer.

Review of Simulation Models

The Evaluator used a checklist review for the protocol, stating whether the submission package contained architectural, mechanical and electrical drawings, specifications, modelling files and whether the final report contained specific project and energy-efficiency measure descriptors. Furthermore, the protocol provided the Evaluator with a list of modelled parameters for comparison with construction documents as well as data collected through the on-site visits.

The review of this year's New Construction projects showed all the projects used whole-building simulation software to calculate energy savings.

Adjustment of Energy Savings

The last step in the New Construction evaluation involved comparing on-site findings with the energy model inputs and construction documents. Adjustments were made to gross energy and demand savings if discrepancies were found between the modelled parameters and those discovered through the on-site review.

If adjustments were needed, the Evaluator modified the energy model according to the parameters affected by the discrepancy, and chose to modify the input file or the output results, depending on the specific situation and the complexity of the change (i.e., the number of variables affected, interactive effects, etc.).

Appendix VIII

CUSTOM: RETROFIT CALCULATION EXAMPLE

This appendix provides a sample of the calculations used to adjust the energy savings results for one of the projects reviewed as part of the 2017 Custom Retrofit impact evaluation. The algorithms described below show the adjustments made to a tank insulation project based on information collected during a site visit by the Evaluator.

The equations used for calculating the savings are presented first, followed by the tracked savings claimed by ENS. Revised savings are then calculated using information collected during the on-site visit and a subsequent analysis of the documentation found on the DSMDs. A project-specific adjustment ratio was established as a result of the evaluation.

Savings Equations

This project involved insulating an LLDPE (linear low-density polyethylene) tank used during the scheduled cleaning of six ultra-membrane filters at a water treatment plant. The documentation of the energy savings calculations consisted of an email thread and an Excel workbook containing a calculation formula from an unsourced TRM. The key variables required for the calculation were contained in the emails provided. The savings calculations were based on a comparison of the steady state heat loss from the tank with the insulation installed and without it.

In the Excel workbook, the following calculation was used to determine the annual energy savings value at the meter. No demand savings calculations were made for the project.

$$\Delta kWh/yr = \frac{(U_{base}A_{base} - U_{insul}A_{insul}) \times (T_{setpoint} - T_{ambient})}{3412 \times \eta_{Elec}} \times HOU$$

Tracked Savings Calculation

ENS adopted the annual savings calculation provided by the Embedded Energy Manager for the tracked savings. Values for the tank dimensions, temperatures and material were provided by the water treatment facility staff while the insulation specifications were provided by the insulation contractor. The calculation variables applied are listed in Table 3 below.

Table 3: Tank Insulation Variables and Tracked Savings Values

Variable	Unit	Value
A_{base} <i>Surface area of the storage tank prior to adding the tank wrap</i>	ft ²	292
A_{insul} <i>Surface area of the storage tank after addition of the tank wrap</i>	ft ²	314
U_{base} <i>Overall heat transfer coefficient of the water heater prior to adding the tank wrap</i>	Btu/h.°F.ft ²	4.65
U_{insul} <i>Overall heat transfer coefficient of the water heater after addition of the tank wrap</i>	Btu/h.°F.ft ²	0.12
$T_{setpoint}$ <i>Temperature of hot water in the tank</i>	°F	96.8
$T_{ambient}$ <i>Temperature of ambient air</i>	°F	64.4
η_{Elec} <i>Thermal efficiency of the electric heater element</i>	None	0.98
HOU <i>Annual hours of use of the water heater tank</i>	Hours	8,760
Energy savings	kWh	62,261
Peak demand savings	kW	0

Revised Savings Calculation

Adjustments to the energy savings were made based on data found by the Evaluator during the on-site visit. A temperature sensor attached to the tank displayed 24.4°C at the time of the site visit while the tracked savings were based on a tank temperature of 36°C. The Evaluator reviewed the original email documentation, which stated the temperature fluctuated between a minimum value of 3°C and a maximum of 36°C. The Project Support Questionnaire also stated: “This tank is used during the scheduled cleaning of the six ultra membrane filters [...]. Water is heated to 35°C for the cleaning process which is 10 hours long. During this 10-hour period, considerable heat is lost to ambient air in the process area of the plant.” The Evaluator contacted the treatment plant supervisor to confirm the cleaning process and tank temperatures. The operator indicated that tanks were on continuously but that the average tank temperature was 24°C as measured by the process automation system at the facility.

The energy and demand savings were recalculated by the Evaluator using the equations shown below and the variables listed in Table 4. The main difference between the energy savings equation below and that used by ENS is that the area of the tank remains the same before and after insulation is added.

The revised equations are also slightly different because metric units were used and so, the conversion factors were changed. As for the tracked savings, the tank surface area was calculated using the formula for the surface area of a cylinder, which includes the cylinder walls and the two circular ends. This calculation was revised since the tank was only insulated on the top end.

$$\text{Energy Savings} = \frac{(A_{\text{tank}}/R_{\text{base}} - R_{\text{insul}}) \times (T_{\text{tank}} - T_{\text{ambient}})}{\eta_{\text{Elec}}} \times \text{HOU} \div 1000 \frac{W}{kW}$$

$$\text{Peak Demand Savings} = \frac{\text{Energy Savings}}{\text{HOU}} \times \text{PCF}$$

Table 4: Revised Tank Insulation Variables

Variable	Unit	Revised Value
Tank Radius	m	1.041
Tank Height	m	2.921
Thermal Conductivity of LLPDE	W/mK	0.33
R _{base} (RSI of LLPDE 1/2")	m²K/W	0.0385
R _{insul} (RSI of mineral fiber wrap)	m²K/W	1.4088
A _{top}	m²	3.406
A _{walls}	m²	19.111
A _{tank}	m²	22.517
T _{ambient}	°C	18
T _{tank}	°C	24
Delta T (T _{tank} -T _{amb})	°C	6
η _{Elec}	%	98
HOU	h/year	8,760
PCF	none	1.0
Energy Savings	kWh	30,510
Demand Savings	kW	3.483

Based on the calculations made above, the revised annual savings were decreased by 31,751 kWh/year and the demand savings were increased by 3.483 kW.

Table 5: Revised Gross Savings Values

	Energy (kWh)	Demand (kW)
Tracked Gross Savings	62,261	0
Revised Gross Savings	30,510	3.483
Percent of Tracked Savings	49%	-

Appendix IX

EMIS: 2017 RECOMMENDATIONS

This appendix summarizes all the recommendations made by the Evaluator as part of the 2017 evaluation, as well as all 2016 evaluation recommendations that were not fully implemented.

Sections	Recommendations
Executive Summary	1 Ensure that the tracking sheet is complete and accurate. While reviewing the project documentation, the Evaluator found several discrepancies between the savings figures reported in the final tracking sheet and the savings figures documented in the annual savings reports. Also, two of the four projects claimed peak demand savings in their annual reports; however, this information was not tracked by ENS in the tracking sheet. The Evaluator recommends that, from now on, the final tracking sheet be updated with the final values documented in the annual reports and that annual peak demand savings be tracked.
	2 Design baseline regressions and plan M&V activities to ensure accurate savings calculations even when changes occur in the facility. This year, the Evaluator discovered that one project had an increase in the weekend production time, which impacted potential energy savings for the measures implemented through EMIS. Since the production level variable was not documented, the Evaluator could not adjust the savings accordingly. To avoid such an issue, the Evaluator suggests that ENS and the service provider proactively identify and track independent variables so that the baseline remains relevant even when changes in operations occur. The Evaluator also recommends that M&V activities and non-routine adjustments be planned as needed. In the case of the Custom Retrofit compressed-air projects implemented after the baseline period for instance, ENS and the service provider could have planned on the implementation of those Custom Retrofit projects by gathering the baseline data before their implementation and made the necessary baseline adjustments afterwards.
2016 Recommendations (Not fully implemented at the time of evaluation)	3 Track incremental savings rather than cumulative savings. For continuing participants in 2016, the Evaluator modified the methodology used to establish savings so that they correspond to incremental first-year savings. Indeed, savings were tracked with respect to a baseline period that spanned approximately one year prior to the beginning of EMIS activities. When participants continued taking part in EMIS for a second year, their tracked savings were the result of the sum of actions taken since the beginning of their participation and not only the additional actions taken since 2015. This

	was considered standard industry practice. Since ENS established all of its program component savings targets as incremental savings, the evaluated savings were modified to correspond to that definition. Energy savings that persist year over year only as a result of on-going support or intervention from ENS could also be classified as incremental savings and are not captured under the methodology used in this evaluation because no data on the rate at which savings would decrease in the absence of on-going support is available in the technical literature. As new research is conducted on the impact evaluation of programs similar to EMIS, this methodology might be refined to capture all incremental savings. 4 Track major changes to facility operations and equipment and adjust energy baseline consumption as required. The Evaluator identified one project for which the compressed air system had been replaced as part of a Custom Retrofit project in 2016. This modified the baseline energy consumption of the plant and resulted in double-counting savings. The Evaluator made this adjustment, but did not have sufficient data to update the baseline regression; new data should be gathered to update this baseline energy regression in 2017. To avoid this in the future, systematic reviews of facility operational and equipment changes should be implemented by ENS to ensure the accuracy of reported savings.

Appendix X

EMIS: PROJECT REVIEW PROTOCOL AND INTERVIEW GUIDE

The 2017 EMIS impact evaluation involved conducting four project reviews of continuing projects from 2015 and 2016 and phone interviews with participants to collect additional information on measures implemented or changes made to the facilities in 2017. During the interviews, the Evaluator also asked questions to participants about their satisfaction with this program component, as well as about savings persistence. This appendix describes the project review protocol used to conduct the reviews and the participant interviews.

Project Review Protocol and Participant Interview Guide

The Evaluator adapted the 2016 evaluation protocol, distinguishing sections to be completed with the information gathered in previous years (2015 and 2016) from sections to be completed with the information gathered in 2017. The information previously collected during the 2015 on-site visits were also included in this protocol. The Evaluator used the information provided in the updated annual reports, the savings calculation workbooks, and the information gathered during phone interviews to complete the remaining sections of the protocol on interactive effects, energy and demand savings adjustments, and final savings values. The project review protocol also includes a series of questions on persistency of savings and participant satisfaction that were asked during the phone interviews with participants.

 ECONOLER	 equilibrium engineering	Energy Management Information System Efficiency Nova Scotia Corporation Project Review Protocol						
1. General Information								
Interview Date: EQ Team: Project ID: EMIS Provider: Company Name: Address: List of people interviewed: <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%; height: 20px;"></td> <td style="width: 33%; height: 20px;"></td> <td style="width: 33%; height: 20px;"></td> </tr> <tr> <td style="height: 20px;"></td> <td style="height: 20px;"></td> <td style="height: 20px;"></td> </tr> </table>							Contact Name: Contact Title: Contact Phone: Email:	
2. General Description of Facility/Products Manufactured								
Identify/list primary purpose of the facility and all major products and/or processes NOTE: PC Users "Alt+Enter" for newline in cell. MAC Users "CMD+Option+Enter". Notes from previous years (2015 and 2016 protocols):								
Notes from this year (2017 interview): Are there any changes in the facility main purpose, major projects and processes?								
3. Facility Operation Schedules								
Facility Description: <i>Outline/describe the normal schedules for processes, office space etc. Obtain shutdown/PM</i> NOTE: PC Users "Alt+Enter" for newline in cell. MAC Users "CMD+Option+Enter". Notes from previous years (2015 and 2016 protocols):								

Notes from this year (2017 interview): Are there any changes in facility operating schedules?

4. Major Consumers Identified During the EMIS Audit

List all major consumers and percent of total loads below

Item #/Description/Energy Source/% of Total

Notes from previous years (2015 and 2016 protocols):

Notes from this year (2017 interview): Are there any changes in major consumers?

5. Sensor List

List all sensors identified in the implementation plan, and all major system components (i.e. historian, server etc)

Notes from previous years (2015 and 2016 protocols):

Notes from this year (2017 interview): Are there any changes in the sensors location and major system components?

6. Pre-Visit Assessment of the Project (from Previous Years)

Indicate the key observations from the feasibility study and M&V report analysis. These notes will serve on site to guide the visit and identify the main information to collect and/or verify. Specifically look at how the adjusted baseline is established, and give consideration to any discrepancies or missing information.

Notes from previous years (2015 and 2016 protocols):

7. On-Site Observations and Findings (from Previous Years)

Report the on-site visit and indicate the key observations and findings made on site.

Notes from previous years (2015 and 2016 protocols):

8. Participant Questions (from Previous Years)

Notes from previous years (2015 and 2016 protocols):

Q1. How often are you reviewing the data/reports generated by the EMIS? Are there more than one user group for these reports?

Q2. Were any automatic feedback controls implemented to automate your production process?

Q3. Does the EMIS have alarm notifications when the energy consumption exceeds or falls below the baseline target?

Q4. If so who is responsible for taking action to correct or document the running conditions?

Q5. Can you explain your process of identifying and implementing production/operational changes that impact your energy consumption? How and where do you document these changes?

Q6. How do you manage/track changes in equipment and/or production that may impact the existing baseline? (i.e. addition of new equipment)

Q7. Can you describe seasonal variations in your production? What are the key variables that impact your energy consumption (ie. Weather, raw material characteristics, etc.)?

9. Persistency Questions

Notes from this year: Follow-up questions to be asked during the interview

P1. First of all, I would like to validate that my list of energy conservation measures implemented at your facility is complete.

For each measure, could you please confirm its beginning and end date, and if it is still ongoing?

Is there anything that I didn't mention?

Table 1: Measures Implemented under EMIS

	Description of measure (from documentation)	Year of implementation (from documentation)	P1. Beginning and end date	P1. Still ongoing?
Measure 1				
Measure 2				
Measure 3				
Measure 4				
Measure 5				
Measure 6				
Measure 7				
Measure 8				
Measure 9				
Measure 10				

P2. In 2017, have you implemented any other energy conservation measures outside of the EMIS program (for example: Custom projects) or have you made any modifications to your production equipment that could impact the energy consumption of your facility?

Description of measures
implemented outside of the
EMIS program

Now, we would like you to answer some questions regarding the energy conservation measures implemented and the support provided by your EMIS service provider.

P3. We have looked at your incremental savings for 2015, 2016 and 2017. Those savings represent savings with respect to the previous year, so savings that would be the result of new initiative undertaken in that year. In 2015 and 2016, your incremental savings were of ...

Could you give us more information on the variation of savings from one year to another?

Table 2: Energy savings evolution

	Year	Incremental Savings (kWh)	Explanation of variation in savings
Year 1	2015		
Year 2	2016		
Year 3	2017 (up to end of		

For the next questions, we'd like you to think about the usefulness of the EMIS system in itself versus the support given by the service provider.

P4. Thinking specifically about the EMIS that is implemented in your facility and the information it provided you...

a) Can you describe how the EMIS system itself was helpful in maintaining the energy conservation measures put in place in previous years?

b) Using a scale from 1 to 10 where 1 is "not helpful at all" and 10 is "very helpful" how would you rate the helpfulness of the EMIS system itself in maintaining the energy conservation measures put in place in previous years?

Rate

c) Was the EMIS system more helpful in maintaining some measures than others? If so, what type of measures?

YES NO

*Types of measures easier to
maintain through the EMIS*

P5. Now thinking specifically about the support given by the service provider...

a) Can you describe how the service provider was helpful in maintaining the energy conservation measures put in place in previous years?

b) Using a scale from 1 to 10 where 1 is "not helpful at all" and 10 is "very helpful" how would you rate the helpfulness of the service provider in maintaining the energy conservation measures put in place in previous years?

Rate

c) Was the service provider more helpful in maintaining some measures than others? If so, what type of measures?

YES NO

*Types of measures easier to
maintain with the service
provider*

P6. When you will no longer receive support from the service provider, how likely are you to maintain the measures implemented under the program? Please answer on a scale from 1 to 10 where 1 means "not likely at all" and 10 means "very likely".
(Ask this question for each measure identified in Table 3).

Table 3: Measures validated

	Description of measure	Year of implementation	P6.
Measure 1			
Measure 2			
Measure 3			
Measure 4			
Measure 5			
Measure 6			
Measure 7			
Measure 8			
Measure 9			
Measure 10			

10. Interactive Effects & Variables Impacting Total Energy Consumption

Notes from this year:

Interactive Effects? YES NO

Seasonal Variables? YES NO

Production Variables? YES NO

Briefly describe interactive effects for the project, and identify if there are seasonal impacts that modify the normal energy baseline.

11. Energy and Demand Savings Adjustments

Notes from this year:

	Cumulative Savings		Incremental Savings	
Energy Savings from Tracking Sheet:		kWh/yr		kWh/yr
Demand Savings from Tracking Sheet:		kW		kW
Evaluated Energy Savings:		kWh/yr		kWh/yr
Evaluated Demand Savings:		kW		kW
Adjustment - M&V Energy Savings:				
Adjustment - M&V Demand Savings:				

12. Summarize Project Adjustments and Final Savings Values

Notes from this year: Including both peak demand savings and energy savings

13 EMIS Satisfaction and Barriers

Notes from this year: Questions to be asked during the interview

S1. Using a scale from 1 to 10 where 1 is “not at all satisfied” and 10 is “completely satisfied” how would you rate your satisfaction with the EMIS program overall?

Rate:

S2. [IF S1<8] What is the most important reason you are not more satisfied with the program overall?

S3. [IF S1>8] What is the most important reason you are satisfied with the program overall?

S4. Did you face any challenges or barriers when implementing the energy management information system in your company, or when managing the system after its implementation?

YES NO

S5. [IF S4 = YES, then ask:] What were these challenges or barriers?

S6. Do you have any suggestions on how to improve the EMIS program?

Consider all aspects of the program: Participation process, program forms, marketing, interactions with ENS staff or contractors, etc.



ECONOLER

DIRECT INSTALLATION PROGRAM

2017 DSM EVALUATION

EFFICIENCY NOVA SCOTIA

Final Report

March 15, 2018



ABBREVIATIONS

BER	Business Energy Rebates
CRA	Corporate Research Associates
DIY	Do-it-yourself
DSM	Demand-side management
ENS	Efficiency Nova Scotia
ETN	Efficiency Trade Network
EUL	Effective useful life
GHG	Greenhouse gas
HID	High-intensity discharge
HOU	Hours of use
HVAC	Heating, ventilation and air conditioning
LED	Light-emitting diode
NTGR	Net-to-gross ratio
PCF	Peak coincidence factor
SBEA	Small Business Energy Auditor
SBES	Small Business Energy Solutions
SOP	Standard operating procedure
TRM	Technical reference manual

DEFINITIONS

Accuracy	Reflects the proximity of measurements to the true value.
Adjustment ratio	The ratio of evaluated results to tracked results. This ratio expresses the adjustment made to tracked savings or other tracked values such as effective useful life.
Base case	To determine gross savings, a base case is established providing detailed information about the reference (e.g. pre-existing or standard) measure or equipment chosen to be compared with the efficient measure or equipment. For the reference measure or equipment, the base case may include such information as the hours of operation, wattage and the base consumption.
Bias	Systematic deviations of measurements from the true value.
Billing calibration	An activity that consists of adjusting the expected energy savings based on the relative difference between the results of the energy simulations and the actual energy consumption of the building or system.
Confidence interval	The estimated range of values which is likely to include the unknown population parameters.
Displaced wattage	The displaced wattage is defined as the difference between the wattage values of the baseline equipment or product and the efficient equipment or product.
EnerGuide rating	An EnerGuide (official brand of Natural Resources Canada) rating is a standard measure of the home's energy performance. It is a measure of the efficiency of the building only and does not take into account occupant behaviour. It shows how energy efficient the home is through modelled heat losses of the home, based on several factors including building envelope characteristics, heated volume, heating systems and air leakage.
Effective useful life	The period a measure is expected to be in service and provide both energy and peak demand savings. This value combines the equipment life and the measure persistence, which includes factors such as business turnover or early retirement.
Equipment life	The number of years installed equipment will operate before it fails.
Equivalent CO ₂	A unit of measurement indicating the amount of carbon dioxide to which various kinds of emitted greenhouse gases are equivalent in terms of warming effects. In this report, the gases' global-warming potential is estimated over a timescale of 100 years.
Equivalent effective useful life	The number of years by which the first-year savings estimate is multiplied to obtain lifetime energy savings. This value takes into account variations in annual energy savings throughout the effective useful life due to increased baselines.

Evaluated savings	Gross and net savings calculated by the Evaluator using the parameters (unitary savings values, installation rates, interactive effects, net-to-gross ratio, etc.) validated or measured during the evaluation process. Unless otherwise specified, the evaluated savings are the first-year savings.
Evaluation plan	The evaluation plan summarizes the program description, objectives, base cases, documentation, evaluation methodology, budget and schedule.
First-year savings	The first full year of energy savings generated by an energy efficiency measure.
Free-ridership	Percentage of gross savings attributable to participants who would have implemented the same or similar energy efficiency measures, with no change in timing, in the absence of the program.
Gross energy savings	Energy savings generated by energy efficiency measures, before applying the net-to-gross ratio.
Induced consumption	Energy consumption of appliances that would have been unplugged and not replaced by participants in the absence of the program.
Interactive effects	Effects on the energy consumption of other systems in the building (such as heating and cooling) due to the installation of an energy efficiency measure.
Internal spillover	Savings attributable to participants who continue to implement the energy efficiency measure introduced by a program after participating in it once, without participating in the program a second time.
In-service rate	The proportion of incentivized products that are installed and operating. This rate is usually applied to programs through which rebates are offered in-store and products are likely to be stored for a certain period before being installed, such as LED bulbs.
Lifetime energy savings	The energy savings that occur over the lifetime of an energy efficiency measure. Lifetime energy savings account for a measure's effective useful life and any increase in the baseline efficiency level (which reduces attributable annual savings) over its lifetime.
Line loss factor	The multiplier to convert savings at the customer meter to savings at the utility generator. It accounts for the electrical losses of the transmission and distribution system.
Margin of error	The amount of random sampling error.
Market effects	The impact of the program on the market (such as increased product availability, practices, and prices) that extends beyond changing the program participants' behaviour. This includes spillover among non-participants.
Net energy savings	Energy savings that can be reliably attributed to a program. This includes effects, such as free-ridership and spillover, that negatively or positively affect the energy savings attributable to a program.
Net-to-gross ratio	The ratio of net energy savings to gross energy savings.

Non-sampling error	Errors arising during the course of all survey activities other than sampling. Non-sampling errors tend to lead to bias in measurements and are very difficult to quantify.
Peak coincidence factor	The percentage of measure demand savings that coincide in time with the annual peak demand of the entire electricity system.
Peak demand savings	The demand savings that coincide in time with the expected annual peak demand period of the entire electricity system.
Precision	The extent to which repeated measurements agree with one another.
Random sampling error	The error in measurement due to the fact that measurements are taken from a subset of the population and not the entire population.
Sample size	The number of observations or replicates included in a statistical sample.
Secondary market impacts	Energy consumption of appliances that would have been transferred to the secondary market if said appliances had not been retired.
Tracked savings	Gross and net savings calculated by ENS in the tracking system, based on various parameters such as number of participants, unitary savings values, installation rates, interactive effects, and the net-to-gross ratio.
Unitary savings	Energy or peak demand savings established on a unitary basis. This unit can either be a product (e.g., an 8 W LED lamp), a capacity (e.g., one-ton capacity of an air-source heat pump) or a participant (e.g., one participant taking part in a behaviour-based program).

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EXECUTIVE SUMMARY

This report presents the results of the 2017 demand-side management (DSM) evaluation of the Direct Installation program, which is comprised of only one program component, namely Small Business Energy Solutions (SBES). SBES offers Nova Scotia's small businesses incentives and resources to make smart energy-efficient upgrades at their facilities by participating in the audit path or the do-it-yourself (DIY) path.

As part of the 2017 evaluation, the Evaluator interviewed the SBES program manager, surveyed 70 participants, conducted 50 project reviews and on-site visits, and four on-site visits with Small Business Energy Auditors (SBEAs) during the energy audits.

Table 1 below summarizes the participation level, gross savings and net savings for the audit and the DIY paths of SBES.

Table 1: SBES Overall Participation and Savings in 2017

	Participation Level	Gross Savings	NTGR	Net Savings
Audit Path				
Energy Savings	50 projects	1.519 GWh	0.93	1.415 GWh
Lifetime Energy Savings		20.178 GWh	0.93	18.796 GWh
Peak Demand Savings		0.266 MW	0.93	0.247 MW
DIY Path				
Energy Savings	367 projects	7.401 GWh	0.87	6.472 GWh
Lifetime Energy Savings		93.748 GWh	0.87	82.058 GWh
Peak Demand Savings		1.273 MW	0.87	1.116 MW
TOTAL				
Energy Savings		8.920 GWh	0.88	7.887 GWh
Lifetime Energy Savings ¹		113.926 GWh	0.88	100.854 GWh
Peak Demand Savings		1.538 MW	0.89	1.363 MW

¹ In this report, energy savings always refer to first-year energy savings rather than lifetime energy savings, unless otherwise specified.

Small Business Energy Solutions

SBES offers incentives and resources to Nova Scotia's small businesses to encourage them to make smart energy-efficient upgrades at their facilities. To be eligible, businesses must use less than 350,000 kWh annually.

Applicants are required to complete a business profile before participating in SBES. This profile indicates their annual energy usage and helps Efficiency Nova Scotia (ENS) determine whether a business is qualified for an energy audit (audit path). The audit path provides a free-of-charge energy audit conducted by a Small Business Energy Auditor (SBEA), who is randomly selected for each participant. SBEAs are assigned to service territories and there are multiple SBEAs in each territory. Participants who are not approved for an audit may choose to have an audit conducted at their own expense with no funding from ENS.

Those businesses that are not offered the audit and those that decline it can follow the DIY path. Participants following the DIY path are provided with quotes and invoice guidelines, product worksheets and a referral to the Efficiency Trade Network (ETN). Participants can select the measures to be implemented, or contact a contractor to help them make that decision.

In 2017, two participants completed projects through the Affordable Multifamily Housing Pilot, which offers measures similar to other SBES projects, but bases its eligibility criterion on affordable housing rather than an energy consumption requirement.

SBES Key Findings

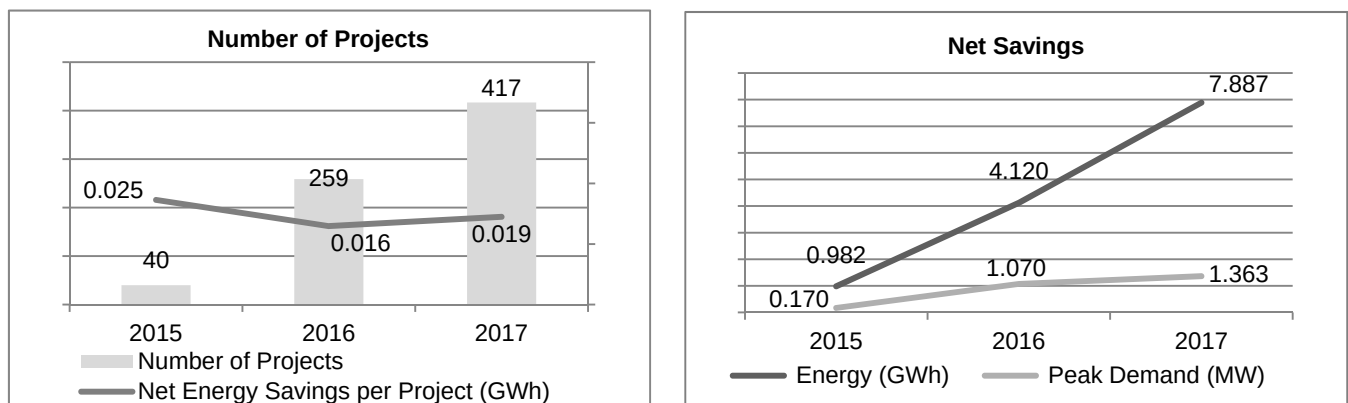
SBES Performance

SBES aimed to achieve net electricity savings of 8.8 GWh and net peak demand savings of 1.9 MW at the generator in 2017. The Evaluator has determined that SBES achieved 7.887 GWh in net energy savings and 1.363 MW in net peak demand savings at the generator. These savings represent 5,151 tonnes of CO₂ eq in avoided greenhouse gas (GHG) emissions annually. Based on a weighted average effective useful life (EUL) value of 12.8 years, SBES's net lifetime energy savings are 100.854 GWh.

In 2017, among the 417 projects completed through SBES, 367 were implemented by following the DIY path and 50 were implemented by following the audit path. Those projects included 10 projects completed by two Affordable Multifamily Housing Pilot participants. In 2017, the DIY projects accounted for 87 percent of all the implemented projects and 80 percent of the total net savings achieved through SBES.

Figure 1 below provides an overview of SBES's participation level, net energy and peak demand savings since its inception in 2015,² and clearly illustrates SBES's steady increase in participation level and the associated savings.

Figure 1: Overview of SBES Performance, 2015-2017



Market Evaluation Highlights

Overall, participants were very satisfied with SBES again this year. They reported a high level of satisfaction with the equipment installed in their businesses. Except for two participants who were less satisfied with their contractors, most participants were very satisfied with the services received from their contractors and the ease of finding one. Audit recipients were also largely satisfied with various aspects of the audit, such as professionalism of the auditor and usefulness of the audit. The other few participants who were less satisfied indicated dissatisfaction with the amount of the incentive (n=2) and the energy savings achieved (n=2).

When asked to rate the predetermined factors as barriers to installing energy-efficiency upgrades, participants did not rate any one factor as being a major barrier. Financial challenges and a lack of knowledge about incentives and equipment are the main barriers cited by the participants surveyed.

While two-thirds of the participants made no recommendation on how to improve SBES, a small number suggested better promoting the program component (11%), improving communication (10%), increasing the rebate amount (9%), speeding up the process for receiving the rebate (6%), simplifying the program component (6%), and improving contractors' quality of work (6%).

² It should be noted that SBES only ran over five months in 2015.

SBES Energy Savings

The Evaluator reviewed ENS's gross savings estimates by conducting a desk review using the information contained in the tracking system, the CIRx Screening Tool and the findings from the on-site visits. The results of this review were similar to the previous evaluations, with some minor improvements observed compared to the 2016 evaluation results. Most of the discrepancies found were related to the operating conditions found on site, which did not match those assumed in the tracked savings calculations. Based on the site visits' results, there were four most commonly adjusted parameters: the baseline wattage, the efficient wattage, the hours of use (HOU) and the peak coincidence factors for lighting projects. Given the sampling methodology used and the less-than-statistically-significant difference between the adjustment ratios of the audit and DIY paths, one single overall adjustment ratio was calculated for all the measures implemented via the two paths. For energy savings, the adjustment ratio was found to be equal to 0.889 and 0.744 for peak demand savings.

To establish the appropriate net-to-gross ratio (NTGR) to be applied, the Evaluator assessed the free-ridership and internal spillover effects associated with SBES by conducting a telephone survey and on-site visits with participants. The survey results revealed a free-ridership level of 7 percent for the audit path and 13 percent for the DIY path, and the spillover was found to be nil. Table 2 below presents the NTGR values calculated as part of this evaluation.

Table 2: Net-to-gross Ratio

	Audit Path	DIY Path	Overall Value
Free-ridership Level	7%	13%	12%
Spillover Level	0%	0%	0%
Net-to-gross Ratio	0.93	0.87	0.88

In 2017, the total net energy and peak demand savings at the generator for the audit path were established at 1.415 GWh and 0.247 MW respectively. Those for the DIY path were 6.472 GWh and 1.116 MW respectively. Table 3 below provides a comparison of the tracked and evaluated savings for SBES.

Table 3: Comparison of Tracked and Evaluated Savings at the Generator

	Initial Gross Savings	Adjusted Gross Savings	NTGR	Net Savings
Energy Savings				
ENS Tracked Savings	10.036 GWh	10.036 GWh	0.87	8.757GWh
Evaluation Results	10.036 GWh	8.920 GWh	0.88	7.887 GWh
Peak Demand Savings				
ENS Tracked Savings	2.068 MW	2.068 MW	0.87	1.804 MW
Evaluation Results	2.068 MW	1.538 MW	0.89	1.363 MW

The evaluated net energy savings are 10 percent below the corresponding tracked figure. This is mainly due to the adjustment made to the gross savings, since the 2017 evaluated NTGR was slightly higher than the tracked one. As explained in Section 4.2.1, these adjustments mostly affected lighting measures, for which discrepancies in HOU values and baseline and efficient wattages were detected during the site visits.

The evaluated net peak demand savings are 24 percent lower than the tracked value. Again, this downward adjustment is mainly due to the adjustments made to the peak demand savings of lighting measures, for which the peak coincidence factors had to be revised to zero for many cases where the lamps did not operate during the system peak hours.

SBES Recommendations

Although 2017 was only SBES's second full year of operation, this program component performed well during this year and showed some very encouraging signs, such as increased participation and high satisfaction among participants from both the audit and DIY paths. In order for SBES to keep moving forward on the right track and further improve its performance and effectiveness, the Evaluator has the following recommendations to make. These recommendations can also be found in Appendix I.

2017 SBES-R1. Implement an internal procedure to identify and thoroughly review the most complex custom projects to ensure savings calculation accuracy. During the projects review, the Evaluator found one large custom project which was based on an incorrect energy model and that could not be revised with the limited information available. Modelling software or complex engineering equations are often used to estimate custom projects' savings. Validating their savings requires specialized technical knowledge and a more in-depth review procedure, unlike other more typical SBES projects. Since custom measures often represent the ones with the largest savings, ENS should review in greater detail the savings calculations for these custom measures. To that end, it may be advisable for the SBES team to seek assistance from the Custom Incentive Program's personnel, who already have the skills and expertise needed for reviewing this type of project.

2017 SBES-R2. Closely monitor the new lighting application forms' effectiveness to confirm that they are achieving their intended goals. Following last year's recommendations, ENS developed new lighting application forms to better document on-site operating conditions, thereby enabling more accurate savings estimates. Since these forms were not put in use until January 2018, the Evaluator could not judge the impact these new forms had with respect to their intended goals. Nonetheless, the similarities between this year and last year in the adjustments made to lighting projects suggest that these new forms, if properly used, could indeed help improve savings calculation accuracy. ENS should carefully monitor how participants complete these forms and how the collected information is used to calculate the savings. Special attention should be paid to the peak coincidence factor used to calculate the peak demand savings to ensure that the daily operating schedule coincides with the system peak demand period, since the Evaluator found multiple cases where adjustments were required.

2017 SBES-R3. Investigate new ways to encourage the implementation of non-lighting measures to increase their share of savings and ultimately increase SBES's total savings. Although SBES offers a wide variety of measures, lighting retrofits accounted for 80 percent of SBES's total gross savings in 2017. This predominance is not surprising among DIY participants, because lighting upgrades are energy-saving opportunities which are easy to identify. Surveyed participants mentioned that a lack of knowledge about equipment is one main barrier to installing energy-efficiency upgrades; so this is consistent with the small number of projects that include technologies that are more complex than lighting. With SBES gaining in maturity and as the market for energy efficient lighting becomes saturated, the Evaluator believes that ENS would benefit from exploring various options to favor a wider variety of measures among the DIY participants to ensure SBES's continued strong performance. Such options could include the development of new marketing and educational materials to better promote non-lighting measures and educate DIY participants with respect to dormant energy-saving opportunities, other than lighting, in their facilities. Project analyses under in the audit path can be used to identify sector-specific opportunities and provide content for the development of success stories on non-lighting measures. Another option would be to provide additional support to participants who do not complete the audit path, for instance by having an ENS staff member follow up to help them consider non-lighting measures if the facility includes other large energy-consuming equipment.

INTRODUCTION

Efficiency Nova Scotia (ENS) is a franchise held by EfficiencyOne³ and is responsible for helping Nova Scotians improve the energy efficiency of their homes and workplaces. ENS designs, markets and delivers energy efficiency and conservation programs for various segments of the population. ENS receives funding for its activities from Nova Scotia Power (NSP) and the Province of Nova Scotia. The funds received from NSP cover the costs of activities designed to help reduce electricity consumption, whereas funds from the Province of Nova Scotia are primarily used for activities designed to help reduce the use of other fuels by households with lower incomes.

Econoler was commissioned to evaluate ENS's 2017 demand-side management (DSM) program portfolio comprised of six electricity efficiency programs and assess the impact of energy efficiency codes and standards introduced in Nova Scotia. To carry out this assignment, Econoler collaborated with Research Into Action, Equilibrium Engineering and Corporate Research Associates (CRA).

Econoler served as team leader in the 2017 evaluation and was involved in every aspect of the evaluation. Specifically, Econoler was in charge of coordinating and supervising all activities, conducting final reviews of all data collection instruments, performing impact evaluation calculations, as well as preparing and reviewing the evaluation reports. Research Into Action carried out the process evaluations, while Equilibrium Engineering conducted the on-site visits and contributed to some impact evaluation analyses. CRA conducted the interviews and surveys with participants and partners, as well as analyzed and reported on the data collected from these activities. Throughout this report, this team is referred to as the Evaluator.

For each program, the Evaluator prepared a DSM evaluation report presenting the general findings, electrical first-year and lifetime energy savings, peak demand savings and avoided greenhouse gas (GHG) emissions.

Table 4 below lists the various programs assessed as part of the 2017 evaluation and indicates their respective components and the types of evaluations conducted. In this table, "C" means a complete evaluation, and "R" indicates that reduced evaluation activities were performed, as compared to 2016. The main difference between the 2016 and 2017 evaluation scopes was that the process evaluation was not done in 2017. Section 1 of the DSM Programs Evaluation Executive Summary presents the scope of work in further detail, along with the rationale for the types of evaluation performed for each program component.

³ On January 1, 2015, ENS became a franchise owned by the Province of Nova Scotia and was licensed to the new not-for-profit organization EfficiencyOne.

Table 4: Types of Evaluations Conducted for Each Program Component

Program	Program Component	2016			2017		
		Process	Market	Impact	Process	Market	Impact
Residential Efficient Product Rebates Program	Appliance Retirement		C	C			R
	Instant Savings		C	C		R	R
Existing Residential Program	Home Energy Assessment		C	C		C	C
	Green Heat		C	C	C	C	C
	Efficient Product Installation		C	C		C	C
New Residential Program	New Home Construction		C	C		C	C
Efficient Product Rebates Program	Business Energy Rebates		C	C		C	R
Custom Incentives Program	Custom		C	C	C*	C	R
	Energy Management Information Systems	C	C	C		C	C
	Strategic Energy Management**	C	C	C			
Direct Installation Program	Small Business Energy Solutions	C	C	C		C	C
*The process evaluation specifically targets the Retrofit service of the Custom program component. ** Due to the start date of the latest Strategic Energy Management (SEM) cohort, SEM did not have any participants who achieved savings in 2017; therefore, no evaluation was conducted for 2017.							

This evaluation report is for the Direct Installation program, which is comprised of one component: Small Business Energy Solutions (SBES). The program component description, evaluation methodology and main evaluation findings are presented in the following sections.

1 SBES OVERVIEW

This section describes the SBES program component, follows up on the 2016 evaluation recommendations and gives an overview of its participation history.

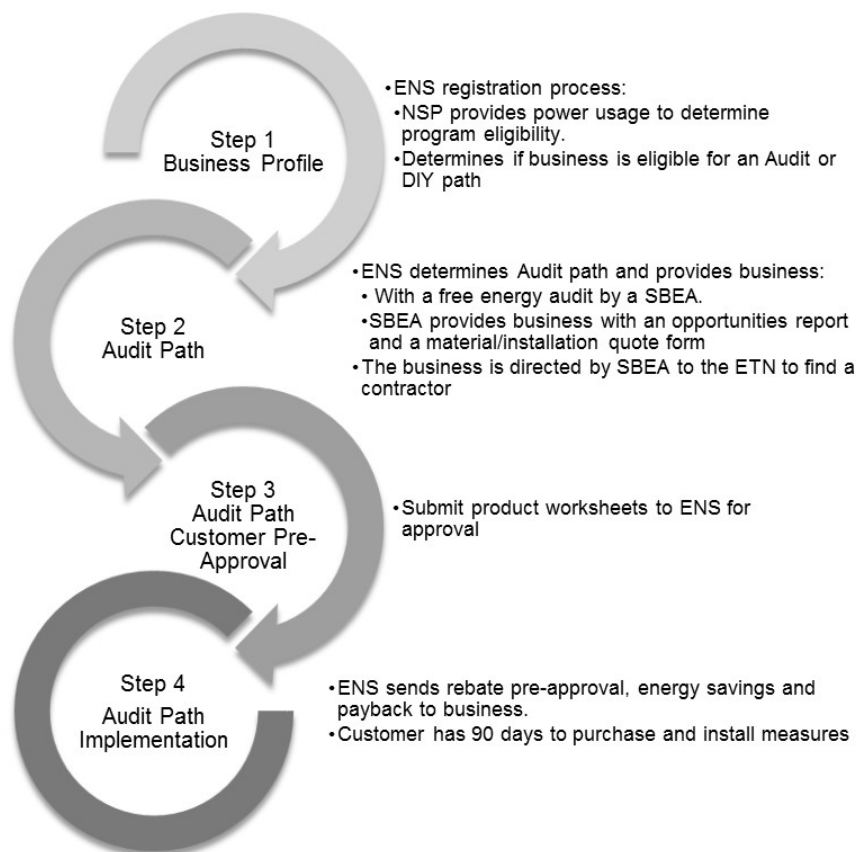
1.1 Description

SBES offers incentives and resources to Nova Scotia's small businesses to encourage them to make smart energy-efficient upgrades at their facilities. To be eligible, businesses must use less than 350,000 kWh annually. Businesses with annual electricity consumption higher than this limit are directed towards ENS's Custom or Business Energy Rebates (BER) program components.

All SBES participants must first complete a business profile as part of their registration process with this program component. ENS uses the information in this profile and the business's power usage history from NSP to determine first whether it is eligible for SBES and, if yes, then whether it is eligible for an audit to help identify potential energy-saving upgrades (audit path). Those businesses that are not offered the audit and those that decline it follow the do-it-yourself (DIY) path.

The audit path provides a free-of-charge energy audit conducted by a Small Business Energy Auditor (SBEA), who is randomly selected for each participant. SBEAs are assigned to service territories and there are multiple SBEAs in each territory. Participants who are not approved for an audit may choose to have an audit conducted at their own expense, with no funding from ENS. After the energy audit is done, the SBEA provides participants of the audit path with: (1) an opportunities report; and (2) relevant material and installation quote forms. The opportunities report outlines energy opportunities and is not product-specific. The SBEAs refer the audit-path participants to the ENS's Efficiency Trade Network (ETN) to find a contractor to complete the upgrades they choose to implement. Participants can select their own contractors outside the ETN if they prefer. Before implementing any upgrades, the participant and/or the contractor selected by the participant need to submit the product worksheets to ENS for approval. Figure 2 below presents the audit path participation process.

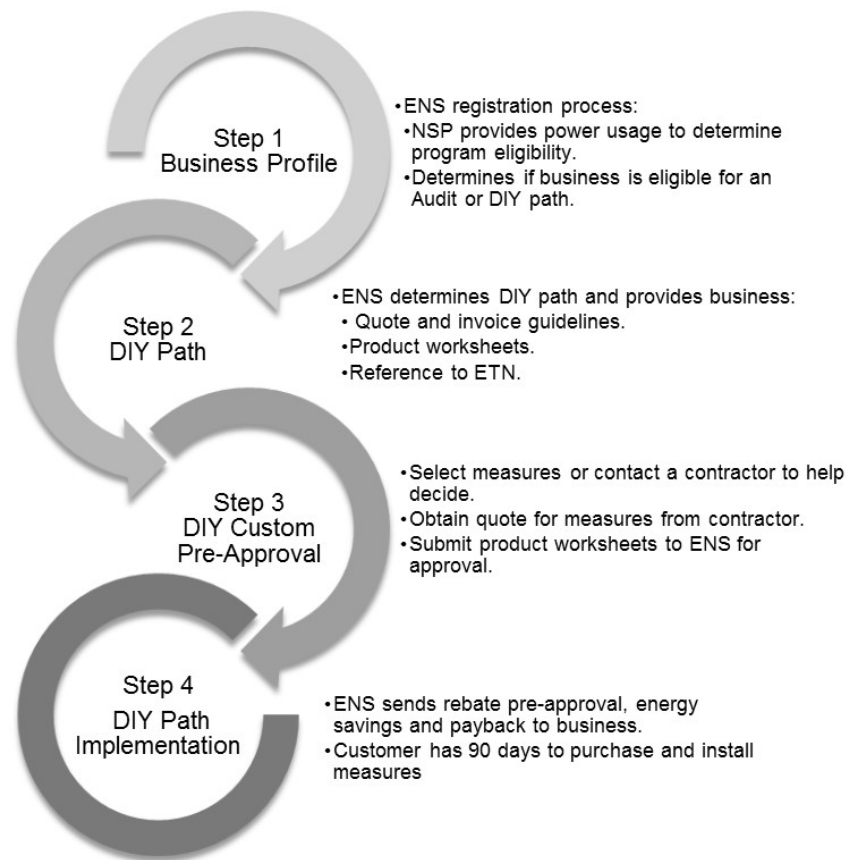
Figure 2: Audit Path Participation Process



Participants of the DIY path are provided with quote and invoice guidelines, product worksheets and a reference to the ETN. Participants can select the measures to be implemented, or contact a contractor to help them make that decision. Before implementing any upgrades, the participant is to obtain a quote from the contractor they are working with and submit the product worksheets and specification sheets to ENS for approval.

After receiving participant documentation for approval, ENS sends back to the participant a rebate pre-approval document to indicate the products approved for rebates, as well as the associated energy savings and payback. Once participants receive their rebate pre-approval, they have 90 days to purchase and install the approved products. Rebates vary according to internal program component unit cost (\$/kWh) and various factors related to a specific technology, including its ratio of the rebate versus its total and incremental costs, its rate of adoption, and its strategic importance to SBES and ENS. Figure 3 below presents the DIY path participation process.

Figure 3: DIY Path Participation Process



SBES aimed to achieve net electricity savings of 8.8 GWh and net peak demand savings of 1.9 MW at the generator in 2017.

Affordable Multifamily Housing Pilot

Launched in 2016, the Affordable Multifamily Housing Pilot provides affordable-housing owners with incentives for building-wide energy retrofit projects with the intent to enable Nova Scotia's affordable housing to reduce its electricity consumption. The delivery of this pilot uses the same framework as the SBES delivery model and proposes similar measures, but its eligibility criterion is based on affordable housing rather than an energy consumption requirement. The pilot achieved the targeted level of participation by the end of 2016 with 17 participants undergoing an energy audit to identify energy-efficient upgrade opportunities. Each participant received an upgrade report detailing the recommended energy-efficiency upgrades for their buildings. Participant feedback in 2017 indicated that additional time is needed to make decisions on the energy-efficient upgrades recommended in the upgrade reports and that pilot participants did not have sufficient capital available even with the levels of incentive being offered. In 2017, SBES continued to work with pilot participants to support them in implementing the

recommended changes and as a result, 10 projects were completed for two pilot participants and more projects could be completed in 2018.

1.2 Follow-up on 2016 Evaluation Report Recommendations

SBES was evaluated in 2016 and recommendations were made by the Evaluator for its improvement. Table 5 provides a brief summary of the implementation status of each recommendation presented in the executive summary section of the 2016 evaluation report.

Table 5: Implementation Status of Recommendations in the 2016 Executive Summary

2016 Recommendations	Status
2016 SBES-R1. Assist participants throughout the participation process, from enrollment to completion, to minimize the number of participants who do not complete projects and encourage equipment installation.	Implemented
2016 SBES-R2. Engage, support, and provide resources to help contractors promote SBES among potential participants.	Implemented
2016 SBES-R3. Consider working with auditors to make the process of developing cost estimates less burdensome for auditors, contractors, and distributors.	Being implemented
2016 SBES-R4. Improve the application forms and the internal review procedure to ensure the accuracy of savings calculations for DIY projects.	Implemented
2016 SBES-R5. Identify those SBEAs who are qualified to conduct audits at industrial facilities.	Implemented

All five 2016 recommendations made for SBES have either been implemented or are in the process of being implemented. In accordance with Recommendation 2016 SBES-R1, ENS made several improvements to the Opportunities Report given to participants following the audits to enhance the participant experience and encourage project completion. These improvements mainly included the addition of new information, such as simple payback values, a link to the ETN, the type of contractor required for each measure, and financing possibilities. In addition, ENS also began doing direct follow-up with participants when projects get close to their expiry dates in order to minimize the number of lapsed participants.

To implement Recommendation 2016 SBES-R2, ENS also offers supporting contractors with sales training and provides them with marketing materials, such as business rack cards to help them promote SBES among potential participants and act as ambassadors of this program component. Moreover, to fully implement this recommendation, ENS also provides all new contractors involved in the program component with a step-by-step guide outlining the SBES process.

Other improvements and modifications were also brought to this program component this year in order to facilitate the auditors' work and better align their qualifications with the facilities they are assigned to visit. Indeed, as suggested by Recommendation 2016 SBES-R3, ENS developed a list of cost estimates by measure based on the information from BER. To date, only a partial list covering some lighting measures has been shared with the auditors to facilitate the process of developing cost estimates. A complete and exhaustive list is currently being developed; once finalized, it will be shared with the auditors. Additionally, to implement Recommendation 2016 SBES-R5, auditors are now categorized into tiers according to their capacity and experience as described in Section 4.1. As a result, ENS now only attributes industrial audits to qualified Tier 3 auditors. This recommendation was fully implemented when the new contracts with the auditors were signed in October 2017.

Finally, ENS has also implemented Recommendation 2016 SBES-R4 to improve the application forms and ensure the accuracy of savings calculation for DIY projects. SBES documents were reviewed and the worksheets were revised in late 2017 to better capture actual runtime hours and room location for each measure as from 2018. The Evaluator expects the impact of this change to show in the 2018 impact evaluation, since new forms had not yet been made available to the participants visited as part of the 2017 evaluation.

1.3 Participation History

SBES was initially launched in August of 2015, and has seen an increase in its level of participation and gross energy savings. Between 2016 (SBES's first full year of operation) and 2017, the gross energy savings increased by 79 percent and the number of projects increased by 61 percent, as highlighted in Figure 4 and Figure 5 below. Through SBES, a total of 417 projects were completed in 2017 (50 audit-path projects and 367 DIY-path projects). Both audit and DIY paths' participation levels increased, with the audit-path projects accounting for about 12 percent of the total number of projects this year.

Figure 4: Overview of Participation in SBES, 2015-2017

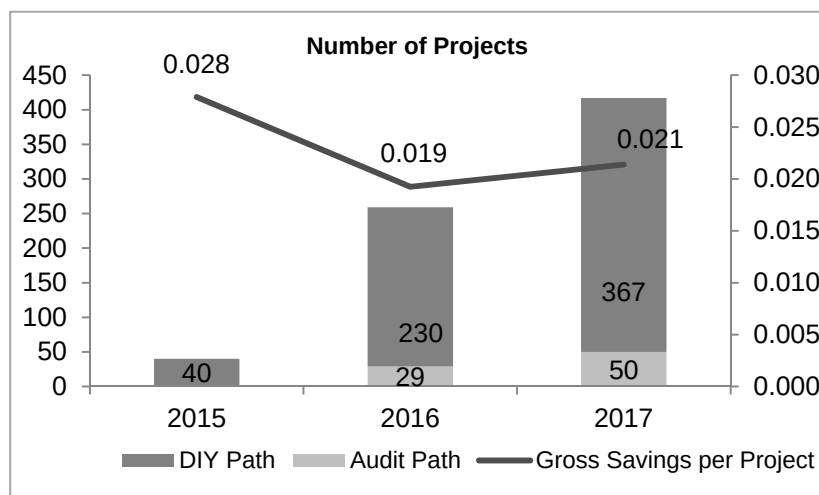
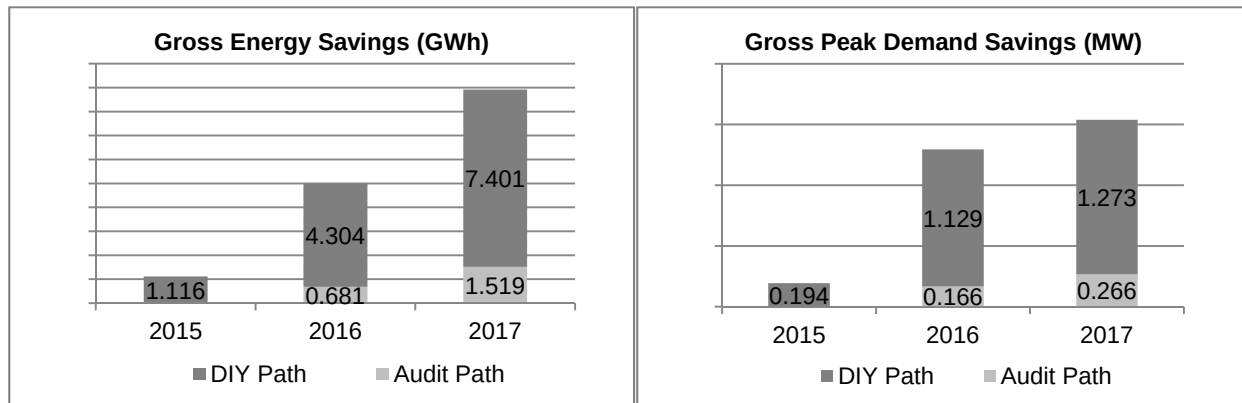


Figure 5: Summary of Gross Savings for SBES, 2015-2017

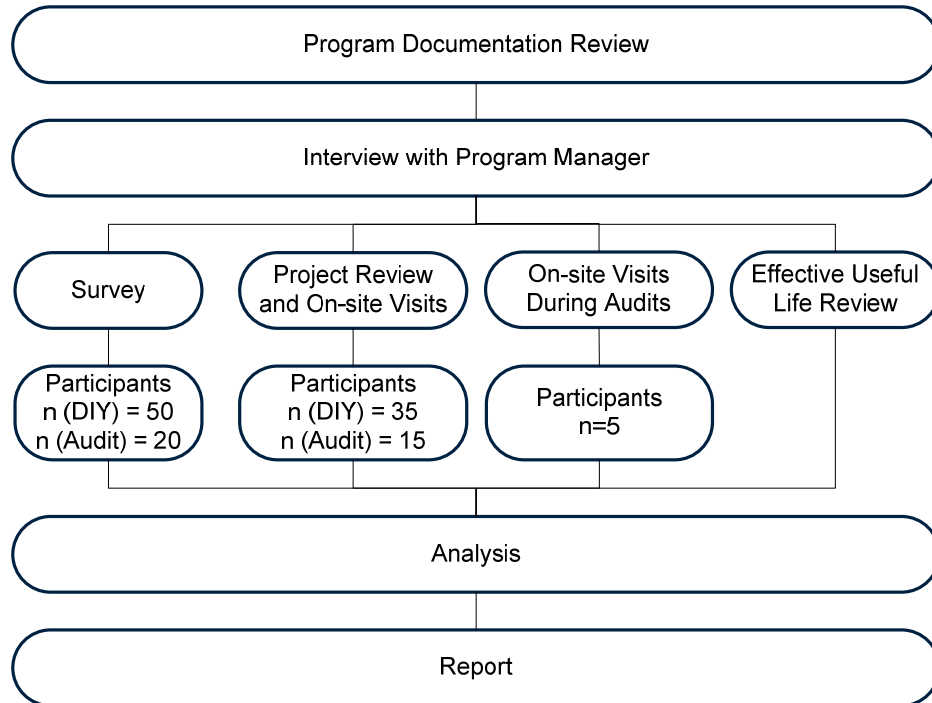


Among all the measure categories, lighting projects were the most common in SBES and accounted for about 80 percent of the total gross savings. In 2016, the most common measure category was also lighting projects. While the percentage of total gross savings generated by lighting projects in the DIY path did not change much compared to last year (87%), the percentage of total gross savings generated by lighting projects in the audit path has seen an important increase, accounting for about 48 percent of the audit path's gross savings in 2017, compared to only 20 percent last year.

2 SBES EVALUATION METHODOLOGY

This section describes the methodology used and the activities carried out for the SBES 2017 evaluation. Figure 6 below shows the various data-collection activities carried out for the evaluation.

Figure 6: Methodological Model



The Evaluator first reviewed the program component documentation and then held a meeting with the program manager in August 2017 to verify the implementation status of the previous evaluation recommendations and learn about the main program component changes that were made. Based on the information obtained from this meeting, a list of questions and topics to be included in the data-collection instruments were prepared.

Once the program manager meeting and the program component documentation review were completed, specific evaluation activities were undertaken, as described in the following subsections.

For evaluation activities that yield quantitative results based on a sample, the Evaluator aimed to achieve a maximum margin of error of 10 percent at a confidence level of 90 percent. This means that if measurement was conducted many times with different samples, the data would be within 10 percentage points above or below the percentage reported 90 percent of the time. Thus, the margin of error indicates the relative level of precision⁴ of the measurement, while its associated confidence level indicates the probability of a measurement falling within this margin of error.⁵

As part of this evaluation, the Evaluator calculated the margins of error for survey samples, free-ridership levels and savings adjustment ratios. The margins of error have been listed alongside the results in the applicable sections. Examples of calculations used to establish margins of error can be found in Appendix II of the 2017 DSM Programs Evaluation Executive Summary.

Participant Survey

In the fall of 2017, CRA conducted a telephone survey with a total of 70 SBES participants (50 DIY and 20 audit path participants), using computer-assisted telephone interviewing technology. The average duration of the survey was 12.5 minutes. The survey questionnaire is provided in Appendix II and the complete survey results, in Appendix III.

The participant survey was meant to collect feedback on the following aspects of SBES:

- › Satisfaction with SBES
- › Barriers
- › Recommendations for improvements
- › Free-ridership (including the cross-influence from ENS promotion and other programs)
- › Firmographics

The total number of participants in SBES was 266 for the entire year of 2017. Drawing a random sample of 70 from a population of 266 has yielded a margin of error of 8.5 percent at a 90 percent confidence level.

Project Reviews and On-site Visits

In October and November 2017, a technical review of the project documentation and on-site visits were carried out by Equilibrium Engineering for a sample of projects. The sampling methodology and the protocol used to conduct the visits are provided in Appendix IV.

⁴ Precision refers to how reproducible a set of measurements is. It does not take into account, however, how close the measured values are to the true values, as this would refer to accuracy.

⁵ As part of this evaluation, the confidence level and the margin of error only take random sampling errors into account; they do not reflect non-sampling errors or biases, such as data entry errors, inaccurate responses from respondents or the inability to contact certain people.

A total of 50 SBES projects were reviewed, including 35 DIY path projects and 15 audit path projects. These project reviews and visits were conducted to validate whether the measures implemented were consistent with the information contained in the tracking sheet. Additionally, the hours of operation, various operating conditions and, wherever possible, the old and new equipment's characteristics (wattage, horsepower, efficiency, etc.) were validated. These elements were used to revise the gross savings, by adjusting savings of individual projects or applying an adjustment factor to all the projects in a given category if the sample size was big enough. The same adjustment ratios were applied to the gross savings of both the pilot projects and the regular projects. During the site visits, spillover was also assessed by asking questions to determine if the participants had implemented additional energy efficiency measures as a result of their participation in SBES, without receiving an incentive from ENS.

On-site Visits during the Audits

From October through December 2017, Equilibrium Engineering conducted five on-site visits with SBEAs during the energy audit of audit-path projects to observe and evaluate the audit process. Appendix V shows the protocol used for this purpose.

Effective Useful Life Review

As part of the 2017 evaluation, to review the effective useful life (EUL) values used by ENS to calculate lifetime energy savings, the Evaluator conducted a thorough literature review by consulting technical reference manuals (TRMs), evaluation reports and relevant studies.

3 SBES MARKET EVALUATION

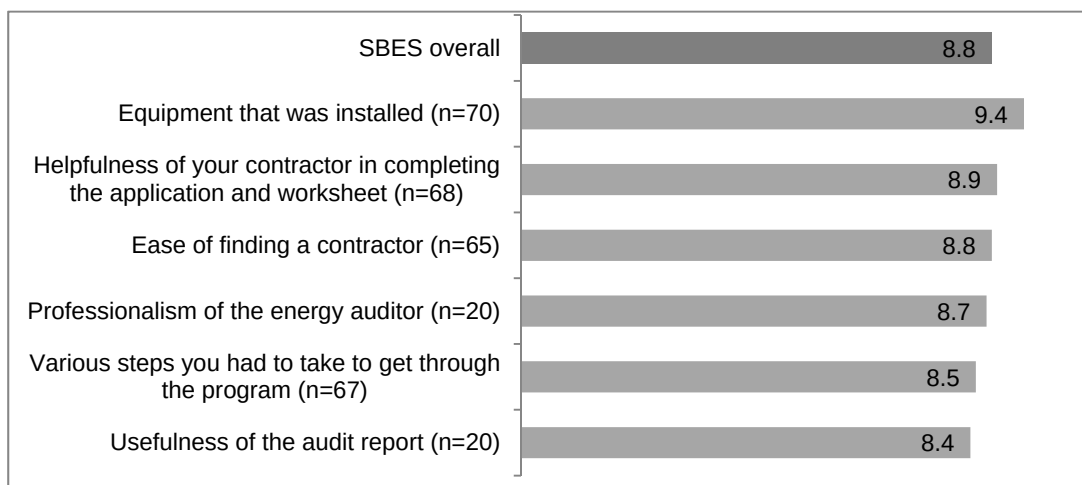
This section discusses the 2017 SBES market evaluation's findings.

3.1 Participants Perspective

A survey of 70 SBES participants was conducted as part of the SBES evaluation. It should be noted that one half of the participants had participated in another ENS program before SBES.

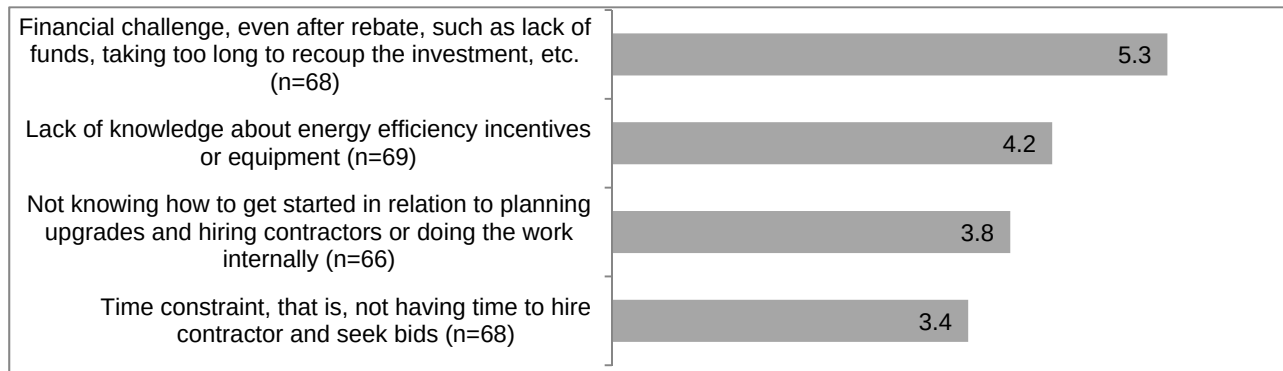
There is a high level of satisfaction with SBES, as indicated by an average rating of 8.8 on a 10-point scale (with 1 meaning "not at all satisfied" and 10, "completely satisfied"). The few participants who were less satisfied mentioned dissatisfaction with the contractor or vendor (n=2), the amount of the incentive (n=2) and the energy savings achieved (n=2), among other reasons. Figure 7 below shows satisfaction ratings for aspects of SBES. Participants were highly satisfied with the various aspects of SBES, and particularly with the equipment installed through their participation in SBES (9.4).

Figure 7: Participant Satisfaction with SBES (10-point scale)



When asked to rate predetermined factors as barriers to installing energy efficiency upgrades, participants did not rate any one factor as being a major barrier. Figure 8 shows financial challenges received a rating of 5.3 on a 10-point scale (with 1 meaning "not at all a barrier" and 10, "a major barrier"), followed by lack of knowledge about incentives and equipment (4.2).

Figure 8: Barriers to Installing Energy Efficiency Upgrades (10-point scale)



While two-thirds of the participants made no recommendation on how to improve SBES, a small number mentioned better promoting the program component (11%), improving communication (10%), increasing the rebate amount (9%), speeding up the process for receiving the rebate (6%), simplifying the program component (6%), and improving the contractors' quality of work (6%).

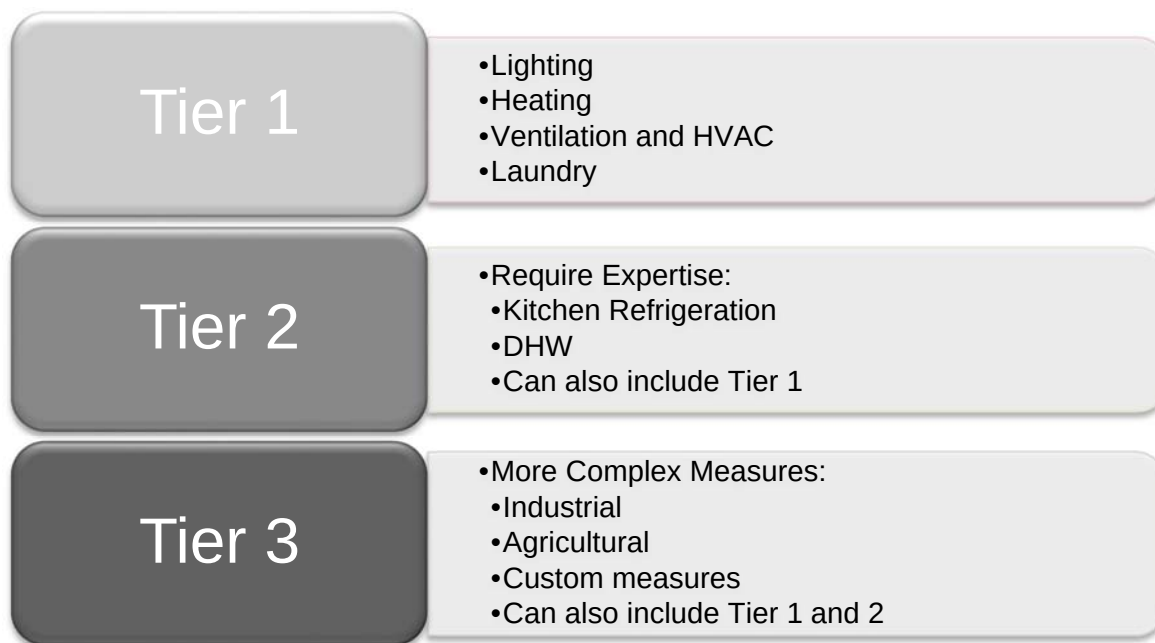
4 SBES IMPACT EVALUATION

The objective of the 2017 SBES impact evaluation is to determine the gross and net electrical energy and peak demand savings. This section discusses the gross and net savings results, as well as the findings from the on-site visits conducted during the energy audits.

4.1 On-site Visits during Energy Audits

Five site visits were conducted with three SBEA companies (two companies were reviewed twice with the same auditor on each visit). The protocol used to gather information during the site visits was similar to the 2016 version and was revised to include recent program component changes, including the categorization of projects and auditors into three tiers. Figure 9 below shows the new system of classification for the SBES energy audits.

Figure 9: Classification of SBES Energy Audits



Of the five audits sampled, two were classified as Tier 1, one as Tier 2 and two as Tier 3. The three SBEAs with whom the Evaluator conducted visits were all qualified to conduct Tier 3 audits. Two SBEAs were Professional Engineers and the third was a Certified Engineering Technologist. All SBEAs had a minimum of 3 years' experience auditing commercial buildings and one had 10 years of experience specifically with large industrial facilities. The Evaluator felt that the SBEAs were all comfortable performing their assigned audits.

In 2016, ENS developed and issued a set of standard operation procedures (SOPs) to provide guidance for the SBEAs. This document was updated in 2017 and provided to the SBEAs at the signature of their new contracts with ENS in the fall of 2017. The SOP lays out the procedures to be followed before, during, and after an SBES audit is conducted and provides a detailed list of steps to be followed in conducting the audit. The Evaluator determined that all the SBEAs read the SOPs and followed these procedures when conducting the audits.

In addition to the SOPs, ENS also provided SBEAs with an audit checklist developed by the Washington State University⁶ to improve the consistency and comprehensiveness of audits. The SBEAs are free to use this checklist and adapt it at their own discretion.

Regarding the methodology used to prepare for and conduct the audits, all the SBEAs indicated they received and reviewed the Business Profile before conducting the audit. The equipment, building components, and schedules were documented and photographed during the audits. However, the level of detail varied among the SBEAs. For instance, one SBEA checked lighting fixtures to visually confirm the ballast type, while another SBEA never examined ballasts during the lighting audits. The equipment and resources used by SBEAs to record and document audits also varied. One SBEA only used a cellphone's camera for audits; actually, during one Tier 3 audit the cellphone camera was unable to capture a legible photo of the nameplate for an HVAC unit where a proper digital camera could have accomplished the task. In contrast, a SBEA providing more details in audit documentation did employ a more professional auditing toolkit for a Tier 2 audit, during which the SBEA measured the attic insulation depth with a tape measure and used a laser measuring tape to measure the building perimeter and recorded the measurements needed to create an accurate RETScreen model.

The Evaluator noted that the compressed air systems were not identified in two audits performed by two different SBEAs. In both visits, the SBEAs reviewed the Business Profiles provided to them and determined that the audits would be mainly concerned with HVAC and lighting. Since SBEAs' main duty is to identify potential energy-saving opportunities, their failure to notice the air compressors installed and used on site, means that additional energy-saving opportunities were overlooked.

Overall, all SBEAs conducted their audits in a professional and safe manner and completed the audits without interfering with the participants' operations. However, the Evaluator believes that some SBEAs could make improvements in their documentation and that a checklist showing the pieces of equipment installed and used on site could be added to the initial participant interviews to ensure no energy-saving opportunity gets overlooked.

⁶ Washington State University, *Energy Auditor Checklist*, <http://www.energy.wsu.edu/Documents/OMchecklists.pdf> (Last accessed January 22, 2018).

4.2 Gross Savings

The gross savings correspond to the change in energy consumption resulting from actions taken by participants, regardless of their reasons to participate.⁷ For each SBES project, ENS tracks the gross savings using the standard equations defined in the CIRx Screening Tool or the custom calculations performed by energy auditors and documented in the audit reports.

The Evaluator reviewed ENS's gross savings estimates by conducting a desk review using the information contained in the tracking system, the CIRx Screening Tool and the findings of the on-site visits.

In 2017, the SBES tracking sheet records a total of 1,823 measures implemented by 266 participants across 10 measure categories; these included 16 measures implemented by two pilot participants. The Evaluator conducted 15 on-site visits for audit-path participants and 35 site visits for DIY participants. These 50 projects encompassed 193 individual measures from the following categories: lighting, HVAC, kitchen and custom. No site visit was conducted for the motors and drives, water-heating, laundry, pumping, and agriculture measure categories, which altogether represented only about 2 percent of the total savings.

The lighting vertical measure group makes up 94 percent of all the measures in SBES and accounts for approximately 80 percent of the total savings. Because of the lighting measures' predominance in SBES, a stratified sampling methodology based on projects' sizes was thus preferred this year instead of a sampling approach based on measure categories to select a sample which is representative of the program component population. A more detailed explanation of sample selection can be found in Appendix IV.

The following subsections report the impact results of both lighting and non-lighting measure categories covered by the audit and DIY paths.

4.2.1 Lighting Measures

The 2017 SBES sample included 43 lighting projects which contained 186 of the total 1,713 measures in this category. Similar to the 2016 evaluation findings, the Evaluator noted that most of the adjustments made to the tracked savings were revisions to the baseline wattage, the efficient wattage, or the annual hours of use (HOU).

⁷ Definition adapted from: National Renewable Energy Laboratory, *The Uniform Methods Project Chapter 23: Estimating Net Savings: Common Practices*, September 2014, p. 3, http://energy.gov/sites/prod/files/2015/02/f19/UMChapter23-estimating-net-savings_0.pdf (Last accessed November 25, 2016).

There were two kinds of typical baseline wattage adjustments. The first kind of adjustment was made because the ballast factor was not applied to the bare lamp wattage. The second kind of adjustment was made because the tracked fixture wattage did not correspond to the type found during the site visit. Among the adjustments made, ballast factors were applied to high-intensity discharge (HID) fixtures according to the Duke Energy Fixture Wattage Table⁸, and a default 0.88 ballast factor was applied to fluorescent lamp use unless otherwise specified. The most common adjustment made by the Evaluator was to apply a ballast factor to the linear fixtures that only had bare lamp wattage tracked, which resulted in a positive adjustment. Although the ballast factor represented one of the largest type of adjustment made in the 2017 evaluation, it should be noted that the tracked baseline wattages were correctly documented for 80 percent of all the lighting measures, a small improvement over the 76 percent observed in 2016.

In comparison, the efficient wattage was correctly tracked (within a 5% margin of error) for 72 percent of the evaluated measures. The most common type of error detected involved tracking light-emitting diode (LED) replacement tubes' nominal wattages instead of the system wattage of the fixture. The whole-system wattage includes the ballast factor for the replacement lamp and is not always indicated in specifications sheets. In those cases where manufacturers only list the bare lamp wattage, the Evaluator revised the efficient wattage to match the values declared in the Design Lights Consortium Qualified Product List.⁹

As in the last few years, the Evaluator had to adjust the HOU for the lighting measures for about half of the sample. Several common reasons caused the differences between the tracked and the claimed HOU. First, the person responsible for completing the application paperwork is not always the on-site contact person interviewed by the Evaluator. Second, due to the nature of some businesses, the HOU can change in response to market demand, which is common in the service and manufacturing sectors. Third, the applicant or the contractor applies a single facility schedule to an operation that involves several sub-schedules, like the schedule of a warehouse connected with an office.

The peak coincidence factor (PCF) values were changed for over half of the sampled measures evaluated in 2017. In most of these cases, only minor modifications were made to reflect the actual facility operating schedules verified and documented during the site visits. However, in some cases, the PCF values were revised from one to nil because the lighting operating schedule did not coincide with the system peak demand period. Such adjustments were the main reason causing the adjustment ratio for peak demand savings to be lower than the ratio for energy savings.

Overall, the modifications made by the Evaluator this year were not much different from the previous evaluations, with some minor improvement over the 2016 evaluation results.

⁸ Duke Energy Progress, *Energy Efficiency for Business - Fixture Wattage Table*, 2013.

⁹ DesignLights Consortium - Search. Available at <https://www.designlights.org/search/> (Last accessed January 23, 2018)

4.2.2 Non-lighting Measures

Three HVAC projects, one custom project and three kitchen projects were visited as part of the 2017 SBES evaluation. For two of the three kitchen measures, the tracked savings were calculated using custom approaches instead of using the Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment. The savings tracked for the custom project were calculated using NRCan's RETScreen software. All of the non-lighting measures required some level of adjustment.

The main adjustments made to the HVAC category were either related to the application of the baseline air-conditioning factor or revisions to the units' heating capacity. In one case, the tracked heating capacity was changed to match the listed Air-conditioning, Heating & Refrigeration Institute test value. In another case, a measure's low-temperature heating capacity and low-temperature efficiency was changed to match the values contained in the NEEP Cold Climate Heat Pump list.¹⁰

Of the three kitchen measures reviewed in 2017, custom calculation methodologies were used for two, although one could have been determined using the Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment. To be consistent with the process, the Evaluator revised the tracked values by using the ENERGY STAR tool and found that the custom HOU's were overestimated, and the tracked savings calculation had not factored in the equipment idle rate. The revised calculation resulted in downward adjustments to both energy and peak demand savings. Because two of the three kitchen measures did not include demand calculations, the Evaluator recalculated the peak demand savings using the methodology outlined in the CIRx Screening Tool. Overall, the adjustments made to the kitchen measures increased both the energy and peak demand savings. The Evaluator recommends that in the future, ENS provide copies of the Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment to ensure that all of the input model variables can be confirmed.

Only one custom measure was included in the visits sample. This project involved a building envelope upgrade for an arena and was removed from the 2017 tracked savings due to issues with the modelled results. The supplied energy model made assumptions about the operation of the building and equipment that are not in line with industry-accepted best practices and resulted in savings estimates that could not be accurately verified. Arenas have a complex mechanical system with unique thermal requirements, which the RETScreen software is not able to handle. For such a project, the auditor should have determined the savings using another modelling software or performed the calculations using industry-accepted engineering equations. Because the missing information could not be gathered at the time of the evaluation, the Evaluator and ENS decided to remove this project from the 2017 tracked savings so that ENS can submit an amended version of the project in 2018.

¹⁰ Northeast Energy Efficiency Partnerships – Search. Available at <http://www.neep.org/initiatives/high-efficiency-products/emerging-technologies/ashp/cold-climate-air-source-heat-pump> (Last accessed January 24, 2018)

Since custom measures have higher per-measure savings than other measure categories and are more complex, the Evaluator recommends that their savings calculations be reviewed in greater detail to ensure that tracked performance values agree with standard reference sources and industry best practices.

4.2.3 Summary of Adjustments to Gross Savings

Table 6 below summarizes the adjustment ratios used for all measure categories, as discussed in Sections 4.2.1 and 4.2.2. The difference between the adjustment ratios for the audit and DIY paths was not statistically significant, therefore the Evaluator calculated adjustment ratios based on all reviewed projects in both paths.

Table 6: Overall Adjustment Ratios

Population		Energy Savings		Peak Demand Savings	
Total	Sample	Overall Adjustment Ratio	Margin of Error	Overall Adjustment Ratio	Margin of Error
1,822 measures	193 measures	0.889	9.3%	0.744	10.4%

4.2.4 Interactive Effects

When a measure installed as part of SBES is affected by interactive effects, this is taken into account by the gross savings standard equation in ENS's CIRx Screening Tool¹¹. Since 2016, specific interactive effects factors have been taken into account for both energy and peak demand savings. In 2017, with the Evaluator's help, ENS reviewed the methodology for calculating the interactive effects in lighting projects to make this methodology consistent with the other commercial program components (namely BER and Custom). To implement the Evaluator's recommendation, this new and improved methodology has since been applied to all 2017 lighting projects. In this year's evaluation, no other changes are suggested regarding the interactive effects' calculation methodology.

4.2.5 Effective Useful Life

As part of the 2017 evaluation, the Evaluator reviewed the EUL values used by SBES in the calculations of energy savings that are expected to persist over time. The EUL values of all the measures eligible for the program component were reviewed based on the findings of a literature review. When establishing a measure's EUL, the Evaluator considered the most common values found in TRMs, evaluation reports and relevant studies. The Evaluator assigned a revised EUL to every measure type and then applied measure-specific EUL values to all measures found in the 2017 tracking sheet.

¹¹ Internal tool which references and defines, for each category of measure, the standard equations to be used for the gross savings calculations

Table 7 below lists the tracked and the revised EUL values by measure category. The revised equivalent EUL represents the average EUL in each measure category, weighted with revised gross savings of each measure. This average was not used in calculations; it is listed to provide a comparison with the tracked EUL value.

Table 7: Summary of Effective Useful Life Values by Measure Category

Measure Category	ENS Average Tracked EUL	Revised Average Equivalent EUL
Agriculture	13	15.0
Custom	10	11.2
HVAC	14	15.0
Kitchen	7	12.0
Laundry	11	11.0
Lighting	13	12.3
Motors and VFDs	15	15.0
Pumps	15	15.0
Refrigeration	10	15.0
Water heating	15	15.0

Overall, the revised equivalent EUL values are similar to those tracked by ENS. The most important increases in EUL were for kitchen (5 years) and refrigeration products (5 years), while the only two decreases in EUL values were for custom (1.2 years) and lighting measures (0.7 year).

For lighting products, which represented over 82 percent of the program component's gross energy savings, the decrease in EUL was mostly caused by a decrease in linear replacement lamps' EUL from an average of 13.3 years to 11.3 years. Since this type of lamp made up about 79 percent of all the new lamps installed, this adjustment was the main reason for the one-year decrease in lighting's EUL value.

Overall, despite the Evaluator's revisions to the measure-level EUL values, the revised EUL for SBES was established at 12.8 years, which is the same as the tracked weighted average EUL. More details on how EUL was established are provided in Appendix VI.

4.2.6 Revised Gross Savings

Table 8 and Table 9 show the revised total gross savings at the meter and at the generator for both paths. The savings at the generator were calculated by applying a line loss factor of 1.072 for the audit path and 1.071 for the DIY path. These values are a weighted average of the line loss factors provided by NSP for each rate code, and the corresponding energy savings listed in the tracking report.

The total gross energy and peak demand savings at the generator are 1.519 GWh and 0.266 MW for the audit path, and at 7.401 GWh and 1.273 MW for the DIY path respectively. The total gross energy savings for SBES are 8.920 GWh at the generator, which translates to 113.926 GWh in lifetime energy savings, based on a weighted average EUL value of 12.8 years. The total gross peak demand savings are 1.538 MW at the generator.

Table 8: Revised Gross Energy and Peak Demand Savings for SBES – Audit Path

Measure Category	Lighting	HVAC	Refrigeration	Motors and Drives	Agricultural	Kitchen	Water Heating	Pumping	Laundry	Custom	Total
Evaluated Energy Savings											
Tracked Energy Savings (GWh)	0.769	0.572	0.039	0.000	0.009	0.013	0.025	0.000	0.000	0.167	1.594
Savings Adjustment Ratio	0.889	0.889	0.889	0.889	0.889	0.889	0.889	0.889	0.889	0.889	0.889
Total Gross Energy Savings - at the Meter (GWh)	0.684	0.508	0.035	0.000	0.008	0.011	0.023	0.000	0.000	0.148	1.417
Line Loss Factor	1.072	1.072	1.072	1.072	1.072	1.072	1.072	1.072	1.072	1.072	-
Total Gross Energy Savings at the Generator (GWh)	0.733	0.545	0.037	0.000	0.008	0.012	0.024	0.000	0.000	0.159	1.519
Average Effective Useful Life (years)	12.3	15.0	15.0	15.0	15.0	12.0	15.0	15.0	11.0	11.2	-
Gross Lifetime Energy Savings – at the Generator (GWh)	9.048	8.156	0.558	0.000	0.123	0.145	0.364	0.000	0.000	1.785	20.178
Evaluated Peak Demand Savings											
Tracked Peak Demand Savings (MW)	0.149	0.171	0.004	0.000	0.003	0.003	0.002	0.000	0.000	0.000	0.333
Savings Adjustment Ratio	0.744	0.744	0.744	0.744	0.744	0.744	0.744	0.744	0.744	0.744	-
Total Gross Peak Demand Savings - at the Meter (MW)	0.111	0.127	0.003	0.000	0.002	0.002	0.002	0.000	0.000	0.000	0.248
Line Loss Factor	1.072	1.072	1.072	1.072	1.072	1.072	1.072	1.072	1.072	1.072	-
Total Gross Peak Demand Savings – at the Generator (MW)	0.119	0.136	0.004	0.000	0.003	0.002	0.002	0.000	0.000	0.000	0.266

Table 9: Revised Gross Energy and Peak Demand Savings for SBES – DIY Path

Measure Category	Lighting	HVAC	Refrigeration	Motors and Drives	Agricultural	Kitchen	Water Heating	Pumping	Laundry	Custom	Total
Evaluated Energy Savings											
Tracked Energy Savings (GWh)	6.752	0.794	0.000	0.005	0.170	0.013	0.000	0.005	0.002	0.031	7.772
Savings Adjustment Ratio	0.889	0.889	0.889	0.889	0.889	0.889	0.889	0.889	0.889	0.889	0.889
Total Gross Energy Savings - at the Meter (GWh)	6.001	0.705	0.000	0.005	0.151	0.012	0.000	0.005	0.001	0.028	6.907
Line Loss Factor	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	-
Total Gross Energy Savings at the Generator (GWh)	6.430	0.756	0.000	0.005	0.162	0.013	0.000	0.005	0.001	0.030	7.401
Effective Useful Life (years)	12.3	15.0	15.0	15.0	15.0	12.0	15.0	15.0	11.0	11.2	-
Gross Lifetime Energy Savings – at the Generator (GWh)	79.351	11.317	0.000	0.075	2.431	0.152	0.000	0.073	0.016	0.333	93.748
Evaluated Peak Demand Savings											
Tracked Peak Demand Savings (MW)	1.353	0.188	0.000	0.001	0.052	0.000	0.000	0.001	0.001	0.000	1.597
Savings Adjustment Ratio	0.744	0.744	0.744	0.744	0.744	0.744	0.744	0.744	0.744	0.744	0.744
Total Gross Peak Demand Savings - at the Meter (MW)	1.007	0.140	0.000	0.000	0.038	0.000	0.000	0.001	0.001	0.000	1.188
Line Loss Factor	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	-
Total Gross Peak Demand Savings – at the Generator (MW)	1.079	0.150	0.000	0.000	0.041	0.000	0.000	0.001	0.001	0.000	1.273

4.3 Net-to-gross Ratio

The net-to-gross ratio (NTGR) allows for determining the net savings, i.e., the energy savings that can be reliably attributed to a program component. More precisely, the NTGR is established by giving due consideration to such effects as free-ridership and spillover that positively or negatively affect the energy savings generated by a program component.

4.3.1 Free-ridership

Free-ridership occurs when participants would have installed the energy efficiency upgrades and measures in the absence of the program component. The free-ridership level was assessed using a self-reporting approach which involved asking participants a set of questions during a telephone survey.

Three different series of questions were asked depending on whether the participants followed the audit or the DIY-path, and if they followed the DIY-path, whether they installed lighting and/or HVAC measures. The questions assess the likelihood for participants to have installed the energy-efficient upgrades in the absence of SBES. The questionnaire considers all the applicable variables of the decision-making process, including planning, efficiency, timing and cost. In 2017, the Evaluator adjusted the timing and cost variables to ensure they were only taken into account for participants who had indicated an intention of installing the measure in the absence of the program component.

Some questions were also used to determine the extent to which participants' decisions on whether to have products installed had been influenced by previous participation in one of ENS energy-efficiency program components or ENS efforts to raise awareness about energy efficiency. When participants' answers indicated that they had been significantly influenced by these two factors, the free-ridership level was adjusted downward.

The feedback collected from the participant survey was converted into an overall free-ridership level using two algorithms, one for the audit path and one for the DIY path. The algorithms underlying free-ridership calculations are presented in Appendix VII.

The survey results obtained by using this approach revealed a free-ridership level of 7 percent for the audit path and 13 percent for the DIY path. In contrast to participants following the audit path, participants following the DIY path identify the energy-efficiency measures themselves, which may result in some program component participants who have already decided which energy-efficient upgrades to install and explain the higher free-ridership level for this path.

Table 10 below lists the free-ridership levels calculated for each path and the overall level. These values represent weighted averages which were obtained by assigning each respondent's free-ridership level a weight corresponding to their proportion of tracked gross savings with respect to the total gross savings of the sample. Overall, the free-ridership level for SBES is equal to 12 percent, which is lower than that established for SBES in 2016 (17%). This reduction is mainly due to the improvement made in the free-ridership algorithm to better account for the quantity and timing variables.

Table 10: Average Free-ridership Level by Path

Project Path	Average Free-ridership Level	Sample Size	Population Size ¹²	Margin of Error	Percentage of Gross Energy Savings in SBES Population
Audit	7%	20	49	2.9%	18%
DIY	13%	47	358	3.4%	82%

4.3.2 Internal Spillover

For SBES, internal spillover occurs when participants implement eligible energy efficiency measures under the influence of their previous participation in the program component without having had any kind of additional support. The Evaluator used on-site visits to directly question participants about any potential spillover effects. The algorithm used to determine the level of internal spillover is presented in Appendix VIII.

The 2017 spillover was found to be nil since no surveyed participants installed additional measures without receiving an incentive.

4.3.3 NTGR Calculation

The NTGR for SBES has been calculated using the following equation:

$$NTGR = (1 - \% \text{ free-ridership} + \% \text{ internal spillover}).$$

By applying the free-ridership and spillover levels established for SBES, the NTGR value is estimated at 0.93 for the audit path and 0.87 for the DIY path.

4.4 Net Savings

Net savings are defined as the energy use reductions that are specifically attributable to SBES. Program components' net impacts were estimated by applying the NTGR listed above to the revised gross savings, and using the following equation:

$$Net\ Savings = Revised\ Gross\ Savings \times NTGR$$

It should be noted that the NTGR was not applied to the revised gross savings of the 10 pilot projects, given the specific context in which they participated in the program. An NTGR value of 1 was thus applied to these projects.

¹² Population size excluding the 10 MURB Affordable Housing pilot projects.

The net energy and peak demand savings at the generator for the audit path are 1.415 GWh and 0.247 MW respectively. The net energy and peak demand savings at the generator for the DIY path are 6.472 GWh and 1.116 MW respectively. The total net energy and peak demand savings at the generator for both paths combined were established at 7.887 GWh and 1.363 MW respectively. The detailed results are listed in Table 11 and Table 12. Overall, using the Nova Scotia-specific factor¹³ of GHG generated by electricity production, i.e., 0.6531 kg CO₂ eq/kWh, it was estimated that the net energy savings resulted in 5,151 tonnes of avoided CO₂ eq annually. Based on the average EUL of 12.8 years for both DIY and Audit projects combined, the net lifetime energy savings were established at 100.854 GWh.

¹³ At the time of writing, 2017 data was not yet available. The Nova Scotia-specific factor was obtained from Nova Scotia Power's 2016 total system emissions data (7,079,268 CO₂ eq tonnes) and total electricity generation (10,839 GWh) was found in the following two sources:

Nova Scotia Power, *Total System Emissions*, <http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx>, (Last accessed December 17, 2017).

Emera inc., *Management's Discussion & Analysis As at February 10, 2017*, <http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693>, (Last accessed December 17, 2017).

Table 11: Evaluated Net Energy and Peak Demand Savings for SBES – Audit Path

Category of Project	Lighting	HVAC	Refrigeration	Motors and Drives	Agricultural	Kitchen	Water-heating	Pumping	Laundry	Custom	Total
Energy Savings											
Revised Gross Energy Savings – at the Meter (GWh)	0.684	0.508	0.035	0.000	0.008	0.011	0.023	0.000	0.000	0.148	1.417
NTGR	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	-
Net Energy Savings – at the Meter (GWh)	0.637	0.472	0.032	0.000	0.007	0.010	0.021	0.000	0.000	0.139	1.320
Line Loss Factor	1.072	1.072	1.072	1.072	1.072	1.072	1.072	1.072	1.072	1.072	-
Net Energy Savings – at the Generator (GWh)	0.683	0.506	0.035	0.000	0.008	0.011	0.023	0.000	0.000	0.149	1.415
Average Effective Useful Life (years)	12.3	15.0	15.0	15.0	15.0	12.0	15.0	15.0	11.0	11.2	-
Net Lifetime Energy Savings – At the Generator (GWh)	8.434	7.585	0.519	0.000	0.114	0.135	0.339	0.000	0.000	1.670	18.796
Peak Demand Savings											
Revised Gross Peak Demand Savings – at the Meter (MW)	0.111	0.127	0.003	0.000	0.002	0.002	0.002	0.000	0.000	0.000	0.248
NTGR	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	-
Net Peak Demand Savings – at the Meter (MW)	0.104	0.118	0.003	0.000	0.002	0.002	0.002	0.000	0.000	0.000	0.231
Line Loss Factor	1.072	1.072	1.072	1.072	1.072	1.072	1.072	1.072	1.072	1.072	-
Net Peak Demand Savings – at the Generator (MW)	0.111	0.127	0.003	0.000	0.002	0.002	0.002	0.000	0.000	0.000	0.247

Table 12: Evaluated Net Energy and Peak Demand Savings for SBES – DIY Path

Category of Project	Lighting	HVAC	Refrigeration	Motors and Drives	Agricultural	Kitchen	Water-heating	Pumping	Laundry	Custom	Total
Energy Savings											
Revised Gross Energy Savings – at the Meter (GWh)	6.001	0.705	0.000	0.005	0.151	0.012	0.000	0.005	0.001	0.028	6.907
NTGR	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	-
Net Energy Savings – at the Meter (GWh)	5.221	0.645	0.000	0.004	0.132	0.010	0.000	0.004	0.001	0.024	6.040
Line Loss Factor	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	-
Net Energy Savings – at the Generator (GWh)	5.594	0.691	0.000	0.004	0.141	0.011	0.000	0.004	0.001	0.026	6.472
Effective Useful Life (years)	12.3	15.0	15.0	15.0	15.0	12.0	15.0	15.0	11.0	11.2	-
Net Lifetime Energy Savings – At the Generator (GWh)	69.036	10.343	0.000	0.065	2.115	0.132	0.000	0.064	0.014	0.290	82.058
Peak Demand Savings											
Revised Gross Peak Demand Savings – at the Meter (MW)	1.007	0.140	0.000	0.000	0.038	0.000	0.000	0.001	0.001	0.000	1.188
NTGR	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	-
Net Peak Demand Savings – at the Meter (MW)	0.876	0.130	0.000	0.000	0.033	0.000	0.000	0.001	0.001	0.000	1.041
Line Loss Factor	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	1.071	-
Net Peak Demand Savings – at the Generator (MW)	0.939	0.139	0.000	0.000	0.036	0.000	0.000	0.001	0.001	0.000	1.116

Table 13 compares the tracked energy and peak demand savings values with those established by the Evaluator.

Table 13: Comparison of Tracked and Evaluated Savings at the Generator for SBES

	Initial Gross Savings	Adjusted Gross Savings	NTGR	Net Savings
Energy Savings				
ENS Tracked Savings	10.036 GWh	10.036 GWh	0.87	8.757 GWh
Evaluation Results	10.036 GWh	8.920 GWh	0.88	7.887 GWh
Peak Demand Savings				
ENS Tracked Savings	2.068 MW	2.068 MW	0.87	1.804 MW
Evaluation Results	2.068 MW	1.538 MW	0.89	1.363 MW

The evaluated net energy savings are 10 percent below the corresponding tracked figure. This is mainly due to the adjustment made to the gross savings, since the 2017 evaluated NTGR was slightly higher than the tracked one. As explained previously in Section 4.2.1, these adjustments mostly affected lighting measures, for which discrepancies in HOU values and baseline and efficient wattages were detected during the site visits.

The evaluated net peak demand savings are 24 percent lower than the tracked value. Again, this downward adjustment is mainly due to the adjustments made to the peak demand savings of lighting measures, for which the peak coincidence factors had to be revised to zero for many cases where the lamps did not operate during the system peak hours.

Table 14 below summarizes the participation level, the gross savings and net savings for the audit and the DIY paths of SBES.

Table 14: SBES Overall Participation and Savings in 2017

	Participation Level	Gross Savings	NTGR	Net Savings
Audit Path				
Energy Savings	50 projects	1.519 GWh	0.93	1.415 GWh
Lifetime Energy Savings		20.178 GWh	0.93	18.796 GWh
Peak Demand Savings		0.266 MW	0.93	0.247 MW
DIY Path				
Energy Savings	367 projects	7.401 GWh	0.87	6.472 GWh
Lifetime Energy Savings		93.748 GWh	0.87	82.058GWh
Peak Demand Savings		1.273 MW	0.87	1.116 MW
TOTAL				
Energy Savings		8.920 GWh	0.88	7.887 GWh
Lifetime Energy Savings		113.926 GWh	0.88	100.854 GWh
Peak Demand Savings		1.538 MW	0.89	1.363 MW

CONCLUSIONS

SBES was launched in mid-2015 to replace BES, so 2017 marked SBES's second full year of operation. Even though participation nearly doubled and reached a new high, it was not sufficient to meet its energy and peak demand planned savings of 8.8 GWh and 1.9 MW respectively. SBES achieved 7.887 GWh in total net energy savings and 1.363 MW in total net peak demand savings at the generator in 2017, resulting in 5,151 tonnes of avoided CO₂ eq annually. The total net lifetime energy savings amount to 100.854 GWh.

Participation in SBES increased from 259 projects in 2016 to 417 projects in 2017, and both audit and DIY paths' participation levels increased. In its second year of operation, SBES managed to maintain high levels of participant satisfaction, as shown by an average score of 8.8, with 1 indicating "not at all satisfied" and 10, "completely satisfied". These high levels of participation and the high satisfaction ratings given by participants in both the audit and DIY paths indicate the program has gained quite a strong foothold in the market.

DIY projects contributed the most to SBES's total net energy and peak demand savings. Among the wide variety of energy-efficient measures offered by SBES, lighting measures accounted for most of the savings achieved. As for the audit path, the percentage of savings contributed by the lighting projects increased substantially from 20 percent in 2016 to 48 percent in 2017. As a result, the Evaluator believes that non-lighting measures have quite some untapped potential for achieving future energy and peak demand savings through SBES and therefore suggests looking for new ways to encourage the implementation of non-lighting measures.

The Evaluator also found that there was still room for improving the accuracy of the tracked savings and especially the savings from complex custom projects, which require more technical knowledge and a more in-depth review procedure. ENS has already taken actions to improve the accuracy of lighting measures' savings by improving the quality of information collected in application forms. It is expected that this effort will yield results in 2018, thus allowing ENS to better monitor whether or not SBES is on track to meeting planned energy savings set throughout next year.

LIST OF APPENDICES

The following are presented in the Direct Installation Program – Appendices.

SBES

Appendix I - SBES: 2017 Recommendations

Appendix II - SBES: Participant Survey Questionnaire

Appendix III - SBES: Participant Survey Results

Appendix IV - SBES: On-site Visit Sampling Methodology and Protocol

Appendix V - SBES: On-site Visit During Audit Protocol

Appendix VI - SBES: Effective Useful Life

Appendix VII - SBES: Algorithm for Free-ridership Calculation

Appendix VIII - SBES: Algorithm for Internal Spillover Calculation

Appendix IX - SBES: Calculation Example



ECONOLER

DIRECT INSTALLATION PROGRAM

2017 DSM EVALUATION

EFFICIENCY NOVA SCOTIA

Appendix Report

March 15, 2018



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Appendix I

2017 RECOMMENDATIONS

This appendix summarizes all the recommendations made by the Evaluator as part of the 2017 evaluation, as well as all 2016 evaluation recommendations that were not fully implemented.

Sections	Recommendations
Executive Summary	1. Implement an internal procedure to identify and thoroughly review the most complex custom projects to ensure savings calculation accuracy. During the projects review, the Evaluator found one large custom project which was based on an incorrect energy model and that could not be revised with the limited information available. Modelling software or complex engineering equations are often used to estimate custom projects' savings. Validating their savings requires specialized technical knowledge and a more in-depth review procedure, unlike other more typical SBES projects. Since custom measures often represent the ones with the largest savings, ENS should review in greater detail the savings calculations for these custom measures. To that end, it may be advisable for the SBES team to seek assistance from the Custom Incentive Program's personnel, who already have the skills and expertise needed for reviewing this type of project.
	2. Closely monitor the new lighting application forms' effectiveness to confirm that they are achieving their intended goals. Following last year's recommendations, ENS developed new lighting application forms to better document on-site operating conditions, thereby enabling more accurate savings estimates. Since these forms were not put in use until January 2018, the Evaluator could not judge the impact these new forms had with respect to their intended goals. Nonetheless, the similarities between this year and last year in the adjustments made to lighting projects suggest that these new forms, if properly used, could indeed help improve savings calculation accuracy. ENS should carefully monitor how participants complete these forms and how the collected information is used to calculate the savings. Special attention should be paid to the peak coincidence factor used to calculate the peak demand savings to ensure that the daily operating schedule coincides with the system peak demand period, since the Evaluator found multiple cases where adjustments were required.
	3. Investigate new ways to encourage the implementation of non-lighting measures to increase their share of savings and ultimately increase SBES's total savings. Although SBES offers a wide variety of measures, lighting retrofits accounted for 82 percent of SBES's total gross savings in 2017. This predominance is not surprising among DIY participants, because lighting upgrades are energy-saving opportunities which are easy to identify. Surveyed participants mentioned that a lack of knowledge about equipment is one main barrier to installing energy-efficiency upgrades; so this is consistent with the small number of projects that include technologies that are more complex than lighting. With SBES gaining in

Sections	Recommendations
	maturity and as the market for energy efficient lighting becomes saturated, the Evaluator believes that ENS would benefit from exploring various options to favor a wider variety of measures among the DIY participants to ensure SBES's continued strong performance. Such options could include the development of new marketing and educational materials to better promote non-lighting measures and educate DIY participants with respect to dormant energy-saving opportunities, other than lighting, in their facilities. Project analyses under in the audit path can be used to identify sector-specific opportunities and provide content for the development of success stories on non-lighting measures. Another option would be to provide additional support to participants who do not complete the audit path, for instance by having an ENS staff member follow up to help them consider non-lighting measures if the facility includes other large energy-consuming equipment.
2016 Recommendations	4. Consider working with auditors to make the process of developing cost estimates less burdensome for auditors, contractors, and distributors. Currently, the audit path requires auditors to obtain new cost estimates for each project. Auditors call distributors and contractors who then voluntarily provide bids for the identified measures of a project. These contractors and distributors are unlikely to obtain the project simply because the auditor contacted them, partly because the auditor cannot recommend these contractors to participants. To address this issue, ENS could meet with auditors to discuss alternative methods for estimating costs.
Impact Evaluation – 4.2.2 Non-lighting Measures	5. The Evaluator recommends that in the future, ENS provide copies of the Savings Calculator for ENERGY STAR Certified Commercial Kitchen Equipment to ensure that all of the input model variables can be confirmed.

Appendix II PARTICIPANT SURVEY QUESTIONNAIRE

Could I speak with [INSERT NAME]?

- 1 Yes [GO TO INTRODUCTION]
- 2 No [SAY “Perhaps you can help me anyway.” GO TO INTRODUCTION]

Introduction

Hello, my name is _____ and I am calling from Corporate Research Associates, a Halifax-based survey research company. We are performing an evaluation of energy efficiency services and programs provided by Efficiency Nova Scotia. Our records indicate that your company recently participated in Efficiency Nova Scotia’s Small Business Energy Solutions Program. We would appreciate your help in answering questions related to your participation in this program. The information you provide will be used to help Efficiency Nova Scotia evaluate and improve the program. Is this a good time for you?

(IF NEEDED: As part of this program, you received rebates and/or financing for energy efficient upgrades that were installed in your facility.)

(IF NEEDED: You may have recently been contacted by Corporate Research Associates or by an Efficiency Nova Scotia representative about your experience with the program. This survey is different as it focuses on other aspects of your participation in the program.)

(IF NEEDED: The survey will take about ten minutes.)

1. Yes [CONTINUE]
2. No, I don’t remember the program / Don’t know [PROMPT: “Are you sure? The program offers small businesses access to energy efficiency contractors and rebates for the installation of energy efficient upgrades. You would have completed your business profile and submitted documentation for approval before purchasing and installing your energy efficient upgrades.” RECODE AS “YES” IF THE PROMPT WORKS; IF RESPONDENT STILL SAYS NO: Is there someone else in your company who would know about having participated in this Efficiency Nova Scotia program?

Yes [ASK TO SPEAK TO THEM AND REPEAT INTRODUCTION]

No [THANK, TERMINATE, RECORD, AND KEEP DATA]

99. Refused [THANK, TERMINATE, RECORD, AND KEEP DATA]

[IF REFUSED, ASK “Can we schedule a more convenient time for you to conduct this survey?”

[SCHEDULED, IF NECESSARY, FOR: _____]

Respondent

- R1. What is your job title or role? [DO NOT READ, ALLOW MULTIPLE RESPONSE]
1. (President/CEO/Owner)
 2. (Facilities Manager)
 3. (Energy Manager)
 4. (Other facilities management/maintenance position)
 5. (Chief Financial Officer)
 6. (Other financial/administrative position)
 7. (Manager)
 96. (Other, please specify: _____)
 98. (Don't know)
 99. (Refused)
- R2. WHICH OF THE FOLLOWING, IF ANY, DOES YOUR COMPANY HAVE IN PLACE AT [FACILITY NAME] FACILITY? [READ AND ROTATE, ALLOW ONLY ONE RESPONSE PER STATEMENT]
- a. A person responsible for monitoring or managing energy usage
 - b. Defined energy saving goals
 - c. A specific policy requiring that energy efficiency be considered when purchasing equipment
 1. YES
 2. NO
 8. (DON'T KNOW)
 9. (Refused)

Verification and Recall (Series V)

- V1. a. [READ IF PROJECT QTY=1] According to our information, through its participation in the Small Business Energy Solutions Program, your organization installed [MEASURE CATEGORY 1, MEASURE CATEGORY 2, MEASURE CATEGORY 3] upgrades in the [FACILITY NAME] facility located in [CITY2]. For this project, Efficiency Nova Scotia offered you a \$[TOTAL ENS REBATE] rebate [IF FINANCING=YES] and \$[TOTAL AMOUNT FINANCING] loan.
- b. [READ IF PROJECT QTY>1] According to our information, your organization participated more than once in the Small Business Energy Solutions Program. Today's questions will be about the project in which you installed [MEASURE CATEGORY 1, MEASURE CATEGORY 2, MEASURE CATEGORY 3] upgrades at your [FACILITY NAME] facility located at [FACILITY ADDRESS]. For this project, Efficiency Nova Scotia offered you [IF REBATE>0] a \$[TOTAL ENS REBATE] rebate [IF FINANCING=YES] and \$[TOTAL AMOUNT FINANCING] loan. When answering the survey questions, please take into account this specific project.

Participation (Series P)

P1. Regarding your organization's decision to apply for the Small Business Energy Solutions incentive program, who initiated the discussion about this incentive opportunity? Would you say . . . [ACCEPT ONE RESPONSE]

1. Your organization initiated it
2. Your vendor or contractor initiated it
3. The idea arose in discussion between your organization and your vendor or contractor

~OR WOULD YOU SAY~

4. Someone from ENS suggested the program
96. (Other, please specify: _____)
98. (Don't know)
99. (Refused)

Free-Ridership for Audit Path (Series FR-AU)

[IF PROJECT TYPE=AUDIT, ASK FR1-AU to FR4-AU; OTHERWISE SKIP TO FREE-RIDERSHIP FOR DIY PATH]

FR1-AU. BEFORE having your facility evaluated by a Small Business Energy Auditor, did your organization have plans to install the specific energy-efficient upgrades that were installed as part of the Small Business Energy Solutions program? Did you... [READ OPTIONS IN ORDER – CODE ONLY ONE]

1. Have plans to install all of the upgrades
2. Have plans to install some of the upgrades
3. Have no plans to install any of the upgrades
98. (Don't know)
99. (Refused)

[IF FR1-AU=1 or 2, THEN ASK:]

FR1a-AU. I just want to make sure I understand - Before you had your facility evaluated by a Small Business Energy Auditor, you had already made the decision to install [all/some of] the energy efficiency upgrades that were installed as part of the program?

1. Yes
2. No
98. (Don't know)
99. (Refused)

FR2- AU. a. [IF FINANCING=NO] Efficiency Nova Scotia gave a rebate to your organization of \$[TOTAL ENS REBATE] for the energy-efficient upgrades. If your organization had not received the rebate from Efficiency Nova Scotia, would you have paid for the full cost of the energy-efficient upgrades you installed? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely **Would Not** Have Paid” and a 10 indicating that you “Definitely **Would Have** Paid.” [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response ___98 Don't Know ___99 Refused

b. [IF REBATE AND FINANCING=YES] Efficiency Nova Scotia gave a rebate to your organization of \$[TOTAL SBES REBATE] and provided you with a \$[TOTAL AMOUNT FINANCED] loan for the energy-efficient upgrades. If you had not received the rebate and financing from Efficiency Nova Scotia, would your organization have paid and financed the cost of the energy-efficient upgrades you installed? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely **Would Not** Have Paid and Financed” and a 10 indicating that you “Definitely **Would Have** Paid and Financed.” [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response ___98 Don't Know ___99 Refused

[READ FIRST TIME THROUGH ONLY] Now I would like to ask you to consider what actions your organization would have taken if the Small Business Energy Solutions program had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely,” and a 10 indicating that it is “Very Likely.”

[DO NOT ACCEPT A RANGE – POSE FR3-AU a-c SEQUENCE IN ORDER/DO NOT RANDOMIZE]

FR3a-AU. If the audit, rebate and/or financing had not been offered, what is the likelihood that you would have installed standard equipment or that you would have simply kept your old equipment instead of installing energy-efficient equipment in your facility?

___ Response ___98 Don't Know ___99 Refused

FR3b-AU. [ASK IF TOTAL MEASURE QTY>1] If the audit, rebate and/or financing had not been offered, what is the likelihood that you would have installed exactly the same quantity of energy-efficient upgrades that were installed through the Small Business Energy Solutions program?

___ Response ___98 Don't Know ___99 Refused

FR3c-AU. [ASK IF FR2-AU a or b ≥5] If the audit, rebate and/or financing had not been offered, what is the likelihood that you would have postponed making energy efficient upgrades to your facility by at least one year?

___ Response ___98 Don't Know ___99 Refused

FR4-AU. Using a scale of 0 to 10, where 0 means “No influence” and 10 means “Great influence”, please rate the importance of each of the following in your organization’s decision to install the energy-efficient upgrades:

Factor (READ AND RANDOMIZE)	Responses
The free audit	___ Response ___98 Don't Know ___99 Refused
b. Information or advice from the small business energy <u>auditor</u> .	___ Response ___98 Don't Know ___99 Refused
c. [IF REBATE=YES] The program rebate	___ Response ___98 Don't Know ___99 Refused
d. [IF FINANCING =YES] d. The program on-bill financing	___ Response ___98 Don't Know ___99 Refused
e. Information or advice provided by Efficiency Nova Scotia's staff.	___ Response ___98 Don't Know ___99 Refused
f. Information or advice provided by a contractor	___ Response ___98 Don't Know ___99 Refused
g. The availability of a list of contractors through the Efficiency Trade Network	___ Response ___98 Don't Know ___99 Refused

Free-Ridership for DIY Path (Series FR-M1 and FR-M2)

INSTRUCTION: RESPONDENTS WILL BE ASKED ABOUT UP TO TWO MEASURE CATEGORIES: LIGHTING AND HVAC. NO RESPONDENT WILL ANSWER ABOUT OTHER MEASURE CATEGORIES IN THE FREE-RIDERSHIP SECTION.

LIGHTING MEASURES SECTION

[IF PROJECT TYPE=DIY AND LIGHTING=YES, ASK FR1-M1 to FR4-M1; OTHERWISE SKIP TO HVAC SECTION]

The next questions will be about the **lighting upgrades** that were rebated and/or financed through the Small Business Energy Solutions Program and installed in your facility.

FR1-M1. Had your organization **already** decided to install the energy-efficient lighting upgrades BEFORE learning about the Small Business Energy Solutions Program? **[CODE ONE ONLY]**

1. Yes
2. No
98. (Don't know)
99. Refused

[IF FR1-M1=YES, THEN ASK:]

FR1a-M1. I just want to make sure I understand - Before you learned about the Small Business Energy Solutions Program and the rebates offered through the program, you had already made the decision to install the energy-efficient lighting upgrades? **[CODE ONE ONLY]**

- 1. Yes
- 2. No
- 98. (Don't know)
- 99. (Refused)

FR2-M1. a. [IF FINANCING=NO] Efficiency Nova Scotia provided your organization with a rebate for the energy-efficient lighting upgrades. If your organization had not received the rebate from Efficiency Nova Scotia, would you have paid the full cost of the lighting upgrades? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely **Would Not** Have Paid” and a 10 indicating that you “Definitely **Would Have** Paid.” [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response ___98 Don't Know ___99 Refused

b. [IF REBATE and FINANCING=YES] Efficiency Nova Scotia provided your organization with a rebate and a loan for the energy-efficient lighting upgrades. If your organization had not received the rebate and financing from Efficiency Nova Scotia, would you have paid and financed the cost of the lighting upgrades? Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely **Would Not** Have Paid and Financed” and a 10 indicating that you “Definitely **Would Have** Paid and Financed.” [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response ___98 Don't Know ___99 Refused

FR3d_M1. Were you aware that the lighting products rebated through the Small Business Energy Solution Program are premium products certified by Design Light Consortium or ENERGY STAR®?

- 1. YES
- 2. NO
- 8. (DON'T KNOW)
- 9. (Refused)

[READ FIRST TIME THROUGH ONLY] Now I would like to ask you to consider what actions your organization would have taken if the Small Business Energy Solutions program had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely,” and a 10 indicating that it is “Very likely.”

[DO NOT ACCEPT A RANGE – POSE FR3-M1 a-c SEQUENCE IN ORDER/DO NOT RANDOMIZE]

FR3a-M1. If the program rebate or financing had not been offered, what is the likelihood that you would have installed the exact same model of lighting products?

___ Response ___ 98 Don't Know ___ 99 Refused

FR3b-M1. [ASK IF TOTAL LIGHTING QTY>1] If the program rebate or financing had not been offered, what is the likelihood that you would have installed exactly the same quantity of lighting products that you installed through the program?

___ Response ___ 98 Don't Know ___ 99 Refused

FR3c-M1. [ASK IF FR2-M1 a or b ≥5] If the program rebate or financing had not been offered, what is the likelihood that you would have postponed installing the lighting upgrades by at least one year?

___ Response ___ 98 Don't Know ___ 99 Refused

FR4-M1. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to install the energy-efficient lighting upgrades. Using a scale of 0 to 10, where 0 means “No influence” and 10 means “Great influence”, please rate the importance of each of the following in your decision to install the energy-efficient lighting upgrades:

Factor (READ AND RANDOMIZE)	Responses
a. [ASK IF REBATE=YES] The program rebate	___ Response ___ 98 Don't Know ___ 99 Refused
b. [IF FINANCING =YES] The program on-bill financing	___ Response ___ 98 Don't Know ___ 99 Refused
c. Information or advice received by Efficiency Nova Scotia's staff.	___ Response ___ 98 Don't Know ___ 99 Refused
d. Information or advice provided by a contractor	___ Response ___ 98 Don't Know ___ 99 Refused
e. The availability of a list of contractors through the Efficiency Trade Network	___ Response ___ 98 Don't Know ___ 99 Refused

HVAC MEASURES SECTION

[IF PROJECT TYPE=DIY AND HVAC=YES, ASK FR1-M2 to FR4-M2; OTHERWISE SKIP TO CI SERIES]

The next questions will be about the **heating, ventilation and air conditioning upgrades, also known as HVAC upgrades**, which were rebated or financed through the Program and installed in your facility.

FR1-M2. Had your organization **already** decided to install the energy-efficient HVAC upgrades BEFORE learning about the Small Business Energy Solutions Program? **[CODE ONE ONLY]**

- 1. Yes
- 2. No
- 98. (Don't know)
- 99. (Refused)

[IF FR1-M2=YES, THEN ASK:]

FR1a-M2. I just want to make sure I understand - Before you learned about the Small Business Energy Solutions Program, you had already made the decision to install the energy-efficient HVAC upgrades? **[CODE ONE ONLY]**

- 1. Yes
- 2. No
- 98. (Don't know)
- 99. (Refused)

FR2-M2. a. [IF FINANCING=NO] Efficiency Nova Scotia provided your organization with a rebate for the energy-efficient HVAC upgrades. If your organization had not received the rebate from Efficiency Nova Scotia, would you have paid the full cost of the HVAC upgrades? Please answer on a scale of 0 to 10, with a 0 indicating that you "Definitely **Would Not** Have Paid" and a 10 indicating that you "Definitely **Would Have** Paid." [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response ___ 98 Don't Know ___ 99 Refused

b. [IF REBATE and FINANCING=YES] Efficiency Nova Scotia provided your organization with a rebate and loan for the energy-efficient HVAC upgrades. If your organization had not received the rebate and financing from Efficiency Nova Scotia, would you have paid and financed the cost of the HVAC upgrades? Please answer on a scale of 0 to 10, with a 0 indicating that you "Definitely **Would Not** Have Paid and Financed" and a 10 indicating that you "Definitely **Would Have** Paid and Financed." [PROBE FOR SPECIFIC RESPONSE – DO NOT ACCEPT A RANGE]

___ Response ___ 98 Don't Know ___ 99 Refused

[READ FIRST TIME THROUGH ONLY] Now I would like to ask you to consider what actions your organization would have taken if the Small Business Energy Solutions program had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely,” and a 10 indicating that it is “Very Likely.”

[DO NOT ACCEPT A RANGE – POSE FR3-M2 a,c SEQUENCE IN ORDER/DO NOT RANDOMIZE]

FR3a-M2. If the program rebate or financing had not been offered, what is the likelihood that you would have installed exactly the same energy-efficient HVAC upgrades that were rebated or financed through the Program?

___ Response ___98 Don't Know ___99 Refused

FR3c-M2. [ASK IF FR2-M2 a or b ≥ 5] If the program rebate or financing had not been offered, what is the likelihood that you would have postponed installing the HVAC upgrades by at least one year?

___ Response ___98 Don't Know ___99 Refused

FR4-M2. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to install the energy-efficient HVAC upgrades. Using a scale of 0 to 10, where 0 means “No influence” and 10 means “Great influence”, please rate the importance of each of the following in your decision to install the energy-efficient HVAC upgrades:

Factor (READ AND RANDOMIZE)	Responses
a. [IF REBATE=YES] The program rebate	___ Response ___98 Don't Know ___99 Refused
b.[IF FINANCING =YES] The program on-bill financing	___ Response ___98 Don't Know ___99 Refused
c. Information or advice received by Efficiency Nova Scotia's staff.	___ Response ___98 Don't Know ___99 Refused
d. Information or advice provided by a contractor	___ Response ___98 Don't Know ___99 Refused
e. The availability of a list of contractors through the Efficiency Trade Network	___ Response ___98 Don't Know ___99 Refused

Cross-Influence [CI Series]

READ AND ROTATE (CI1 + CI2a-c) AND (CI3 + CI4a-c) SEQUENCES

CI1. Before participating in the Small Business Energy Solutions program in [DATE], had your organization at any time in the past already participated in any other Efficiency Nova Scotia programs?

- 1. Yes
- 2. No
- 98. (Don't know)
- 99. (Refused)

For the following statements, please indicate whether you agree or disagree.

CI2a. [IF CI1=1] Your company's previous participation in an Efficiency Nova Scotia program was a major factor in the decision to install energy-efficient upgrades in your facility.

- 1. Agree
- 2. Disagree
- 98. (Don't know)
- 99. (Refused)

CI2b. [IF CI1=1 and FR1-AU=1 OR FR1-AU=2 OR FR1-M1=1 OR FR1-M2=1] Because of your company's previous participation in an Efficiency Nova Scotia program and what was learned by participating in that program, you had already considered implementing energy efficiency measures in your facility before participating in Small Business Energy Solutions.

- 1. Agree
- 2. Disagree
- 98. (Don't know)
- 99. (Refused)

CI2c. [IF CI1=1] Because of your company's previous participation in an Efficiency Nova Scotia program and what was learned by participating in that program, a company representative took into account the cost-effectiveness of energy efficient upgrades when evaluating different options for the facility.

- 1. Agree
- 2. Disagree
- 98. (Don't know)
- 99. (Refused)

- CI3. Before participating in the Small Business Energy Solutions program in [DATE], had you at any time in the past already seen Efficiency Nova Scotia promotional materials advertising the benefits of energy efficiency?
1. Yes
 2. No
 98. (Don't know)
 99. (Refused)

For the following statements, please indicate whether you agree or disagree.

- CI4a. [IF CI3=1] The energy efficiency promotional materials distributed by Efficiency Nova Scotia were a major factor in your company's decision to install energy-efficient upgrades.
1. Agree
 2. Disagree
 98. (Don't know)
 99. (Refused)
- CI4b. [IF CI3=1 and FR1-AU=1 OR FR1-AU=2 OR FR1-M1=1 OR FR1-M2=1] The energy-efficiency promotional materials distributed by Efficiency Nova Scotia prompted you to consider implementing energy efficiency measures in your facility before participating in Small Business Energy Solutions.
1. Agree
 2. Disagree
 98. (Don't know)
 99. (Refused)
- CI4c. [IF CI3=1] The energy-efficiency promotional materials distributed by Efficiency Nova Scotia prompted a company representative to take into account the cost-effectiveness of energy efficient upgrades when evaluating different options for the facility.
1. Agree
 2. Disagree
 98. (Don't know)
 99. (Refused)

Satisfaction with Program (Series S)

- S1a. Using a scale from 1 to 10 where 1 is “not at all satisfied” and 10 is “completely satisfied” how would you rate your satisfaction with the program overall? [RECORD NUMBER, 98=Don’t know, 99 Refused]
- S1b. [IF S1a<8] What was the most important reason you were not more satisfied with the program overall? [PROBE FOR SPECIFIC REASON. ACCEPT MULTIPLE RESPONSES BUT DO NOT PROBE]
96. RECORD VERBATIM: _____
98. (Don’t know)
99. (Refused)
- S2. Using a 10-point scale where 1 is *not at all satisfied* and 10 is *completely satisfied*, how satisfied were you with the following aspects of your participation in the program? [READ] [DO NOT RANDOMIZE] [RECORD NUMBER 1 TO 10, 97=Not applicable, 98=Don’t know, 99=Refused]
- [IF PROJECT TYPE=AUDIT] The professionalism of the energy auditor
 - [IF PROJECT TYPE=AUDIT] The usefulness of the audit report
 - The ease of finding a contractor
 - The helpfulness of your contractor in completing the application and worksheet
 - The equipment that was installed
 - The various steps you had to take to get through the program

Barriers and Recommendations [B Series]

- A9. Generally speaking, how much of a barrier, if any, are each of the following in preventing your organization from installing energy efficiency upgrades? Please answer on a scale of 1 to 10, where 1 means ‘not at all a barrier’ and 10 means ‘a major barrier’. [ROTATE. RECORD RESPONSE BETWEEN 1 AND 10. 98=DON’T KNOW, 99=REFUSED]
- Financial challenge, even after rebate, such as lack of funds, taking too long to recoup the investment, etc.
 - Time constraint, that is, not having time to hire contractor and seek bids
 - Lack of knowledge about energy efficiency incentives or equipment
 - Not knowing how to get started in relation to planning upgrades and hiring contractors or doing the work internally

- S3. Do you have any recommendations for improving the Small Business Energy Solutions program? Probe: Anything else? [DO NOT READ. ACCEPT ALL RESPONSES]
1. (Improve contractors' quality of work)
 2. (Improve communication)
 3. (Simplify the program/Less paperwork)
 4. (Better marketing/awareness)
 5. (Increase rebates)
 6. (Speed up process/receive rebate quicker)
 7. (Offer more measures eligible for rebates)
 8. (Lengthen timeframe to complete work)
 9. (No recommendation)
 96. (Other SPECIFY) : _____
 98. (Don't know)
 99. (Refused)

Firmographics (Series F)

These final questions are asked for statistical purposes only. The information collected is strictly confidential.

F1. What is the main activity of the facility where the energy efficiency improvements were installed under the Small Business Energy Solutions Program? [DO NOT READ—BUT CONFIRM WITH RESPONDENT THAT THE CATEGORY YOU CHOOSE IS CORRECT]

1. (Education)
2. (Food Sales (grocery))
3. (Food Service (restaurant))
4. (Health Care – Inpatient)
5. (Health Care – Outpatient)
6. (Lodging)
7. (Mercantile – Enclosed and Strip Malls)
8. (Mercantile – Retail (Other than Mall))
9. (Office)
10. (Public Assembly)
11. (Public Order and Safety)
12. (Religious Worship)
13. (Service)
14. (Warehouse and Storage)
15. (Manufacturing) (Identify Industry Type _____
(e.g., chemical, food, paper, etc.))
16. (Other: please explain _____)
17. (Vacant building)
98. (Don't know)
99. (Refused)

F2. Approximately how many full-time equivalent workers are employed at this facility? [DO NOT READ, CODE APPROPRIATE CATEGORY]

1. (Fewer than 5)
2. (5 to 9)
3. (10 to 19)
4. (20 to 49)
5. (50 to 99)
6. (100 to 249)
7. (250 or More)
98. (Don't know)
99. (Refused)

F3. Is your organization independent, or part of a larger company?

- 1. (Independent)
- 2. (Part of a larger company)
- 96. (Other: please explain: _____)
- 98. (Don't know)
- 99. (Refused)

F4. How many business locations does your organization have in Nova Scotia? [RECORD A
NUMBER 1-99; 998 = Don't know, 999 = Refused]

END: Those are all the questions I have for you. I thank you very much for your time and cooperation
and have a nice day!

Appendix III PARTICIPANT SURVEY RESULTS

The participant survey results are presented in the following tables.

R1. What is your job title or role?

Job Title of Respondent	2016	2017
Sample Size	37	70
President/CEO/Owner	54%	49%
Manager/Director	22%	23%
Facilities Manager	3%	9%
Other financial/administrative position	14%	5%
Other facilities management/maintenance position	11%	1%
Others	-	14%

R2. Which of the following, if any, does your company have in place at [FACILITY NAME] FACILITY?

Processes in Place in Facilities Where Measures Were Implemented	2016		2017	
Sample Size	37		70	
	Yes	No/Don't know	Yes	No/Don't know
A person responsible for monitoring or managing energy usage	57%	43%	53%	47%
A specific policy requiring that energy efficiency be considered when purchasing equipment	54%	46%	40%	60%
Defined energy saving goals	41%	59%	31%	69%

P1. Regarding your organization's decision to apply for the Small Business Energy Solutions incentive program, who initiated the discussion about this incentive opportunity? Would you say...?

Who Initiated the Discussion About Incentive Opportunities	2016	2017
Sample Size	37	70
Your organization initiated it	41%	47%
Your vendor or contractor initiated it	22%	29%
The idea arose in discussion between your organization and your vendor or contractor	27%	17%
Someone from ENS suggested the program	5%	6%
Others	5%	-
Don't know/Refused	-	1%

A9. Generally speaking, how much of a barrier, if any, are each of the following in preventing your organization from installing energy efficiency upgrades? Please answer on a scale of 1 to 10, where 1 means 'not at all a barrier' and 10 means 'a major barrier'.

Barriers to Implementation	2017	
	Sample Size	Mean*
Financial challenge, even after rebate, such as lack of funds, taking too long to recoup the investment, etc.	68	5.3
Lack of knowledge about energy efficiency incentives or equipment	69	4.2
Not knowing how to get started in relation to planning upgrades and hiring contractors or doing the work internally	66	3.8
Time constraint, that is, not having time to hire contractor and seek bids	68	3.4
*Don't know/Refused excluded from calculations		

S1a. Using a scale from 1 to 10 where 1 is 'not at all satisfied' and 10 is 'completely satisfied', how would you rate your satisfaction with the program overall?

Satisfaction with SBES Overall	2016	2017
Sample Size	37	70
Mean*	8.9	8.8
*Don't know/Refused excluded from calculations		

S1b. What was the most important reason you were not more satisfied with the program overall?

Reasons Not More Satisfied with SBES	2016 (#)	2017** (#)
Sample Size*	4	10
Dissatisfied with the contractor/vendor	-	2
I would have liked a higher incentive/Incentive too low	1	2
I expected more/faster savings	-	2
Wasn't cost effective	-	1
The administration was disorganized	-	1
Report could have been more comprehensive	-	1
Too much paperwork	1	1
Expected more to be done/They didn't replace fixtures	-	1
Poor installation/Products not installed properly	2	1
The energy evaluation took too long	-	1
*Base: Respondents who were not satisfied with SBES (NOT SATISFIED: S1<8)		
**Multiple responses		

S2. Using a 10-point scale where 1 is not at all satisfied and 10 is completely satisfied, how satisfied were you with the following aspects of your participation in the program?

Satisfaction with Aspects of SBES	2017	
	Sample Size	Mean*
Mean (1 = 'Not at all satisfied', 10 = 'Completely satisfied')		
The equipment that was installed	70	9.4
The helpfulness of your contractor in completing the application and worksheet	68	8.9
The ease of finding a contractor	65	8.8
AUDIT: The professionalism of the energy auditor	20	8.7
The various steps you had to take to get through the program	67	8.5
AUDIT: The usefulness of the audit report	20	8.4
*Don't know/Not applicable/Refused excluded from calculations		

S3. Do you have any recommendations for improving the Small Business Energy Solutions program? Anything else?

Participant Suggestions for SBES*	2016	2017
Sample Size	37	70
Better marketing/awareness	5%	11%
Improve communication	8%	10%
Increase rebates	8%	9%
Speed up the process/receive rebate quicker	3%	6%
Simplify the program/Less paperwork	8%	6%
Improve contractors' quality of work	8%	6%
Offer more measures eligible for rebates	3%	4%
Offer financing/help with cost	3%	1%
Lengthen timeframe to complete work	3%	1%
Others	5%	6%
No recommendations	5%	64%
Don't know/Refused	46%	-
*Multiple responses		

Audit Path

FR1-AU. BEFORE having your facility evaluated by a Small Business Energy Auditor, did your organization have plans to install the specific energy-efficient upgrades that were installed as part of the Small Business Energy Solutions program? Did you...

FR1a-AU. I just want to make sure I understand - Before you had your facility evaluated by a Small Business Energy Auditor, you had already made the decision to install [all/some of] the energy efficiency upgrades that were installed as part of the program?

Already Made Decision to Install Energy Efficient Upgrades Prior to Program	2016 (#)	2017 (%)
Sample Size*	9	20
Yes	1	40%
No	8	60%
Don't know/Refused	-	-
*Base: Respondents who had an audit		

FR2- AU. a. [IF FINANCING=NO] Efficiency Nova Scotia gave a rebate to your organization of \$[TOTAL ENS REBATE] for the energy-efficient upgrades. If your organization had not received the rebate from Efficiency Nova Scotia, would you have paid for the full cost of the energy-efficient upgrades you installed?

b. [IF REBATE AND FINANCING=YES] Efficiency Nova Scotia gave a rebate to your organization of \$[TOTAL SBES REBATE] and provided you with a \$[TOTAL AMOUNT FINANCED] loan for the energy-efficient upgrades. If you had not received the rebate and financing from Efficiency Nova Scotia, would your organization have paid and financed the cost of the energy-efficient upgrades you installed?

Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely Would Not Have Paid and Financed” and a 10 indicating that you “Definitely Would Have Paid and Financed.”

Would Have Paid/Financed Cost of Upgrades	2016		2017	
	Sample Size*	Mean	Sample Size*	Mean*
Would have paid/financed full cost of upgrades	9	3.2	20	3.8
*Don't know/Refused excluded from calculations				

FR3-AU. Now I would like to ask you to consider what actions your organization would have taken if the Small Business Energy Solutions program had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely,” and a 10 indicating that it is “Very Likely.”

Actions Taken in Absence of Program	2016		2017	
	Sample Size	Mean*	Sample Size	Mean*
Postponed making energy efficient upgrades to your facility by at least one year**	2	9.0	9	7.3
Installed standard equipment or that you would have simply kept your old equipment instead of installing energy-efficient equipment in your facility	9	6.8	20	6.6
Installed exactly the same quantity of energy-efficient upgrades that were installed through the Small Business Energy Solutions program***	7	2.9	16	3.0
*Don't know/refused excluded from calculations				
**Base: Respondents who would not likely have paid or financed the cost of the energy-efficient upgrades they installed in absence of SBES (FR2-AU a or b ≥5)				
***Base: Respondents who installed more than one measure				

FR4-AU. Using a scale of 0 to 10, where 0 means “No influence” and 10 means “Great influence”, please rate the importance of each of the following in your organization’s decision to install the energy-efficient upgrades:

Influence on Decision to Install Energy-efficient Upgrades	2016		2017	
	Sample Size	Mean*	Sample Size	Mean*
Program rebate**	9	8.8	20	8.7
Free audit	9	7.2	20	8.0
Information or advice provided by a contractor	9	5.9	19	8.0
Program on-bill financing***	2	8.5	7	7.4
Information or advice from the small business energy auditor	9	8.8	20	6.8
Information received by ENS staff****	9	7.9	19	6.8
Availability of a list of contractors through the Efficiency Trade Network	-	-	17	3.9
*Don't know/Refused excluded from calculations **Base: Respondents who received a rebate ***Base: Respondents who received financing ****Wording change in 2017				

DIY Path (Lighting only)

FR1-M1. Had your organization **already** decided to install the energy-efficient lighting upgrades BEFORE learning about the Small Business Energy Solutions Program? **[CODE ONE ONLY]**

FR1a-M1. I just want to make sure I understand - Before you learned about the Small Business Energy Solutions Program, you had already made the decision to install the energy-efficient lighting upgrades?

Already Made Decision to Install Energy Efficient Lighting Upgrades Prior to Program	2016	2017
Sample Size	21	39
Yes	24%	8%
No	67%	90%
Don't know/Refused	10%	3%

FR2-M1. a. [IF FINANCING=NO] Efficiency Nova Scotia provided your organization with a rebate for the energy-efficient lighting upgrades. If your organization had not received the rebate from Efficiency Nova Scotia, would you have paid the full cost of the lighting upgrades?

FR2-M1. b [IF REBATE and FINANCING=YES] Efficiency Nova Scotia provided your organization with a rebate and a loan for the energy-efficient lighting upgrades. If your organization had not received the rebate and financing from Efficiency Nova Scotia, would you have paid and financed the cost of the lighting upgrades?

Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely **Would Not Have Paid and Financed**” and a 10 indicating that you “Definitely **Would Have Paid and Financed.**”

Would Have Paid/Financed Cost of Lighting Upgrades	2016		2017	
	Sample Size	Mean*	Sample Size	Mean*
Would have paid/financed full cost of upgrades	21	4.0	37	2.9
*Don't know/Refused excluded from calculations				

FR3d_M1. Were you aware that the lighting products rebated through the Small Business Energy Solution Program are premium products certified by Design Light Consortium or ENERGY STAR®?

Aware Lighting Products are Certified by Design Light Consortium	2017
Sample Size*	39
Yes	59%
No	36%
Don't know/Refused	5%
*Base: Respondents in Lighting and DIY path	

FR3-M1. Now I would like to ask you to consider what actions your organization would have taken if the Small Business Energy Solutions program had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely,” and a 10 indicating that it is “Very Likely.”

Actions Taken in Absence of SBES	2016		2017	
	Sample Size	Mean*	Sample Size	Mean*
Postponed installing the lighting upgrades by at least one year***	11	7.5	11	6.9
Installed exactly the same quantity of lighting products that you installed through the program**	20	3.6	30	3.9
Installed exactly the same model of lighting products****	20	3.4	38	2.3
*Don't know/Refused excluded from calculations **Base: Respondents who installed more than one lighting measure ***Base: Respondents who would not likely have paid or financed the cost of the lighting upgrades in absence of SBES (FR2-M1 a or b ≥5) ****Wording change in 2017				

FR4-M1. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to install the energy-efficient lighting upgrades. Using a scale of 0 to 10, where 0 means “No influence” and 10 means “Great influence”, please rate the importance of each of the following in your decision to install the energy-efficient lighting upgrades:

Influence on Decision to Install Energy-efficient Upgrades	2016		2017	
	Sample Size	Mean*	Sample Size	Mean*
Program rebate**	20	8.8	38	8.7
Program on-bill financing***	-	-	14	7.7
Information or advice received by a contractor	20	7.6	39	7.5
Information or advice received by ENS staff	20	5.5	35	5.1
The availability of a list of contractors through the Efficiency Trade Network	19	4.6	36	4.0
*Don't know/Refused excluded from calculations **Base: Respondents who received a rebate ***Base: Respondents who received financing				

HVAC PATH

FR1-M2. Had your organization **already** decided to install the energy-efficient HVAC upgrades BEFORE learning about the Small Business Energy Solutions Program?

FR1a-M2.I just want to make sure I understand - Before you learned about the Small Business Energy Solutions Program, you had already made the decision to install the energy-efficient HVAC upgrades?

Already Made Decision to Install Energy Efficient HVAC Upgrades Prior to Program	2016 (#)	2017 (#)
Sample Size	8	8
Yes	2	2
No	6	5
Don't know/Refused	-	1

FR2-M2.a. Efficiency Nova Scotia provided your organization with a rebate for the energy-efficient HVAC upgrades. If your organization had not received the rebate from Efficiency Nova Scotia, would you have paid the full cost of the HVAC upgrades?

b. [Efficiency Nova Scotia provided your organization with a rebate and loan for the energy-efficient HVAC upgrades. If your organization had not received the rebate and financing from Efficiency Nova Scotia, would you have paid and financed the cost of the HVAC upgrades?

Please answer on a scale of 0 to 10, with a 0 indicating that you “Definitely **Would Not** Have Paid and Financed” and a 10 indicating that you “Definitely **Would Have** Paid and Financed.”

Would Have Paid/Financed Cost of HVAC Upgrades	2016		2017	
	Sample Size	Mean*	Sample Size	Mean*
Would have paid/financed full cost of upgrades	8	3.4	8	4.5
*Don't know/Refused excluded from calculations				

FR3-M2. Now I would like to ask you to consider what actions your organization would have taken if the Small Business Energy Solutions program had NOT been available. I will read you a few options. For each one, please answer on a scale of 0 to 10, with a 0 indicating that it is “Very Unlikely,” and a 10 indicating that it is “Very Likely.”

Actions Taken in Absence of SBES	2016		2017	
	Sample Size	Mean*	Sample Size	Mean*
Postponed installing the HVAC upgrades by at least one year**	4	8.8	4	5.3
Installed exactly the same energy-efficient HVAC upgrades that were rebated or financed through the Program	8	3.5	8	3.1
*Don't know/Refused excluded from calculations				
**Base: Respondents who would not likely have paid or financed the cost of the HVAC upgrades in absence of SBES (FR2-M2 a or b ≥5)				

FR4-M2. Next, I'm going to ask you to rate the importance of factors that might have influenced your decision to install the energy-efficient HVAC upgrades. Using a scale of 0 to 10, where 0 means “No influence” and 10 means “Great influence”, please rate the importance of each of the following in your decision to install the energy-efficient HVAC upgrades:

Influence on Decision to Install Energy-efficient Upgrades	2016		2017	
	Sample Size	Mean*	Sample Size	Mean*
Program on-bill financing**	1	10.0	2	10.0
Program rebate***	8	9.3	8	7.5
Information or advice received by ENS staff	8	6.8	8	5.9
Information or advice provided by a contractor	8	6.1	8	5.3
The availability of a list of contractors through the Efficiency Trade Network	6	4.2	8	3.0
*Don't know/refused removed from calculations				
**Base: Respondents who received financing				
***Base: Respondents who received a rebate				

CI1. Before participating in the Small Business Energy Solutions program in [DATE], had your organization at any time in the past already participated in any other Efficiency Nova Scotia programs?

Previous Participation in Another ENS Program	2016	2017
Sample Size	37	70
Yes	30%	50%
No	59%	46%
Don't know/Refused	11%	4%

CI2a. Your company's previous participation in an Efficiency Nova Scotia program was a major factor in the decision to install energy-efficient upgrades in your facility.

Previous Participation in Another ENS Program Component	2016 (#)	2017 (%)
Sample Size*	11	35
Agree	8	60%
Disagree	3	40%
Don't know	-	-
*Base: Respondents who previously participated in another ENS program component		

CI2b. Because of your company's previous participation in an Efficiency Nova Scotia program and what was learned by participating in that program, you had already considered implementing energy efficiency measures in your facility before participating in Small Business Energy Solutions.

Impact of Previous ENS Program Component Participation	2017 (#)
Sample Size*	11
Agree	10
Disagree	1
Don't know	-
*Base: Respondents who previously participated in another ENS program component, and respondents in Audit or DIY path	

- CI2c. Because of your company's previous participation in an Efficiency Nova Scotia program and what was learned by participating in that program, a company representative took into account the cost-effectiveness of energy efficient upgrades when evaluating different options for the facility.

Impact of Previous ENS Program Component Participation	2016 (#)	2017 (%)
Sample Size*	11	35
Agree	10	77%
Disagree	1	17%
Don't know	-	6%
*Base: Respondents who previously participated in another ENS program component-		

- CI3. Before participating in the Small Business Energy Solutions program in [DATE], had you at any time in the past already seen Efficiency Nova Scotia promotional materials advertising the benefits of energy efficiency?

Previously Seen Energy Efficiency Promotional Materials Distributed by ENS	2016	2017
Sample Size	37	70
Yes	89%	91%
No	11%	7%
Don't know/Refused	-	1%

- CI4a. The energy efficiency promotional materials distributed by Efficiency Nova Scotia were a major factor in your company's decision to install energy-efficient upgrades.

Impact of Previously Seen ENS Energy Efficiency Promotional Materials	2016	2017
Sample Size*	33	64
Agree	48%	64%
Disagree	52%	36%
Don't know	-	-
*Base: Respondents who previously saw ENS energy-efficiency promotional materials		

- CI4b. The energy-efficiency promotional materials distributed by Efficiency Nova Scotia prompted you to consider implementing energy efficiency measures in your facility before participating in Small Business Energy Solutions.

Impact of Previously Seen ENS Energy Efficiency Promotional Materials	2017 (#)
Sample Size*	17
Agree	12
Disagree	5
Don't know	-
*Base: Respondents who previously saw ENS energy-efficiency promotional materials and respondents who were part of the DIY path or Audit path	

- CI4c. The energy-efficiency promotional materials distributed by Efficiency Nova Scotia prompted a company representative to take into account the cost-effectiveness of energy efficient upgrades when evaluating different options for the facility.

Impact of Previously Seen ENS Energy Efficiency Promotional Materials	2016	2017
Sample Size*	33	64
Agree	79%	73%
Disagree	21%	25%
Don't know	-	2%
*Base: Respondents who previously saw ENS energy-efficiency promotional materials		

F1. What is the main activity of the facility where the energy efficiency improvements were implemented under the Business Energy Solutions Program?

Business Type	2015	2016	2017
Sample Size	71	37	70
Mercantile-Retail – Other than mall	17%	27%	29%
Food service/Restaurant	8%	11%	17%
Mercantile-Retail – Enclosed mall or strip mall	3%	3%	7%
Automotive repair	7%	5%	4%
Religious worship	-	5%	4%
Recreation centre/Community hall	-	3%	3%
Property management	14%	5%	3%
Farming	-	-	3%
Manufacturing	4%	3%	3%
Warehouse and storage	3%	3%	3%
Lodging	1%	11%	3%
Education	-	-	3%
Non-profit organization	1%	-	1%
Service	10%	-	1%
Office	4%	3%	1%
Health care – Outpatient	3%	-	1%
Public assembly	13%	11%	-
Public order and safety	1%	3%	-
Transportation	1%	-	-
Health care – Inpatient	1%	-	-
Others	4%	8%	13%
Don't know	3%	-	-
Refused	-	-	-

F2. Approximately how many full-time equivalent workers are employed at this facility?

Full-time Employees	2015	2016	2017
Sample Size	71	37	70
Fewer than 5	51%	46%	41%
5 to 9	20%	16%	17%
10 to 19	18%	22%	19%
20 to 49	6%	8%	19%
50 to 99	3%	3%	3%
100 to 249	1%	3%	-
250 or more	1%	-	-
Don't know/Refused	-	3%	1%

F3. Is your organization independent, or part of a larger company?

Type of Company	2015	2016	2017
Sample Size	71	37	70
Independent	76%	78%	64%
Part of a larger company	20%	22%	24%
Others	4%	-	10%
Don't know	-	-	1%
Refused	-	-	-

F4. How many business locations does your organization have in Nova Scotia?

Number of Locations	2015	2016	2017
Sample Size	71	37	70
1	70%	62%	64%
2-10	14%	27%	27%
11-30	-	6%	4%
More than 30	6%	3%	-
Don't know	9%	3%	4%
Refused	1%	-	-

Appendix IV

ON-SITE VISIT SAMPLING METHODOLOGY AND PROTOCOL

Sampling Methodology for Participant Visits

In 2017, a total of 50 on-site visits were conducted to evaluate the installation portion of Small Business Energy Solutions (SBES).

The sample was divided into the Audit path and the do-it-yourself (DIY) path. The sampling plan was developed using the tracking sheet received in October 2017, which included all projects to date. The tracking sheet contained a total of 318 projects and 200 participants. Of the 318 projects, 43 were audit projects and the remaining 275 projects followed the DIY path.

This year, both Audit and DIY projects' samples were generated using a stratified sampling method based on projects' total tracked savings. This allowed for the selection of a wide range of projects (smaller as well as larger ones) representative of the different sizes of projects involved in this program component in 2017. Projects' sampling was therefore done irrespective of the measures categories, since the vast majority of measures were lighting measures. Randomly selecting projects however resulted in a mix of measures categories that were representative of the program population. The Table 1 below shows the different strata within which projects were randomly selected to constitute the sample.

Table 1: Total Number of Projects and Strata Used for On-site Visit Sampling³

Audit path				DIY path			
Stratum	Maximum Savings (kWh/year)	Number of Projects per Stratum	Sample Size	Stratum	Maximum Savings (kWh/year)	Number of Projects per Stratum	Sample Size
1	10,000	19	5	1	9,000	117	7
2	40,000	12	5	2	18,000	51	7
3	170,000	9	5	3	30,000	43	7
				4	57,000	37	7
				5	138,000	15	7
Total		40	15			263	35

³ As of October 2017.

On-site Visit Protocol for Participant Visits

The SBES protocol was modelled after the Business Energy Rebates (BER) Mail-in protocol, as the installed measures are very similar, with the exception of building envelope insulation upgrades. The protocol contains fields for entering measure-specific data based on the parameters required for the savings calculations. The Excel-based format included one tab per measure category, each tab containing columns for all required information. A summary of each measure category's collection information is listed below.

On-Site Visit Data Collection Form

1. General Information

Site Visit Date:			
Project ID#:			
Rate Code:			
Company Name:			
Contact Name:			
Address/City:			
Telephone:			
Type of facility:	Retail: ☐	Manufacturing/ Industrial: ☐	Grocery/ Supermarket: ☐
	College/ University: ☐	Multi-Unit Res.: ☐	Other (Specify): ☐
Name of Contact Met with:			
Operation during Peak Period?	Yes ☐	No ☐	
If "yes", determine % Load Operational During Peak Period:			
Project type:	Early Replacement: ☐	End of Useful Life: ☐	New/No Replacement: ☐
State hours equipment operates b/w 5-7 pm in Dec/Jan/Feb			
If yes to previous, % load that is operational			

2. Building Heating/Cooling System Description *(used when applicable)*

Heating Systems: *Please fill the table below for each heating system at the site.*

	Heating System #1	Heating System #2
Heat Source		
% of Heat		
Type of System		

Cooling Systems: *Please fill the table below for each cooling system at the site.*

	Cooling System #1	Cooling System #2
% of Cooling		
Type of System		

Notes:

3. Facility Operation Hours and Lighting Usage

Facility Occupancy Schedule: *Please fill the table below for each different occupancy schedule.*

Business Hours (Mon-Fri)	Business Hours (Weekend)	Staff Early Open	Staff Early Close	Cleaning Hours per Week	Days/Year with No Occupancy	Working Days (365 days)	Annual HOU	Notes

Daily Lighting Operation Schedule: *(used when applicable)*

Weekday - Hours/Day with Regular Schedule	Weekend - Hours/Day with Regular Schedule	Hours/Day with Holiday Schedule	Hours/Day with no Occupancy	Notes

Notes:

4. Measure Information

Lighting: *Collect the information in the table below if lighting measures were installed. Econoler will then compare the information collected with the information in the tracking sheet.*

Location:	Tracking Sheet:
	Validated Onsite:
Is there heating/cooling installed in this location?	☐ Heating
	☐ Cooling
The percentage of lighting that remains on when the facility is closed:	
Quantity of burnt out lamps:	
If burnt out, how long has it been burnt out and will it be replaced?	
Are lights used seasonally?	
If lamps are missing, explain why?	
Are lamps installed inside or outside?	
Are lamps on occupancy sensors?	
Explain if quantity found on-site differs from the tracking sheet quantity:	
<i>Use the table below to record the information on the baseline and new lighting measures installed on site. For each type of equipment, indicate the quantity and wattage.</i>	

New equipment installed						
Type	Quantity		Wattage		HOU	Notes:
	Tracking Sheet	On-Site validation	Tracking Sheet	On-Site validation		

Baseline equipment						
Type	Quantity		Wattage		HOU	Additional Info
	Tracking Sheet	On-Site validation	Tracking Sheet	On-Site validation		

Additional information captured in the Notes sections of the Protocol varies by category type, but may include any of the following:

- › Number of lamps per fixture and length of lamps for linear measures.
- › If existing strips were T12 HO, indicate length.
- › Do dimmable measures replace non-dimmable?

5. Motors & VSDs

Collect the information in the table below if motor and/or VSDs measures were installed. Econoler will then compare the information collected with the information in the tracking sheet.



Motors and Drives:

Motors

Total number of motors installed:

Location:

Motor Type:

Motor Size [hp]:

National Electrical Manufacturers Association (NEMA) Nominal Efficiency (nameplate):

Load Factor:

Approx. product run time [hr/week]:

Do the new motors operate at least 2,000 hours a year?

Are the new motors listed in the CEE Premium Efficiency Motors List²?

Are the motors controlled by a VSD? Specify RPM:

Specify the type of application:

Total number of VSDs installed:

Validate that the new VSDs do not replace old VSDs?

Validate that the new VSDs are operational?

If not, why and since when?

Was the VSD commissioned? (Y/N):

[illegible]

² Web Site : www.cee1.org/resrc/news_items/CEEMotorsList.php3

What is VSD using as feedback mechanism? (VSD either modulates speed through a range or at fixed setpoints):

Specify the hp of the motor controlled by the VSDs:

Specify the type of equipment controlled:
(Supply fan, return fan, exhaust fan, chilled water pump, boiler feed water, or other (Specify)):

Hours of use (Indicate the corresponding schedule number):

Specify Manufacturer and Model Number of VSD:

Heating, Ventilation and Air Conditioning (HVAC):

Total number of AC & Air-Source Heat Pumps (Split & Unitary) installed:

Total number of Ground & Water Source Heat Pumps installed:

Are there any other heating and cooling systems than the ones being replaced/installed? (note % of heating/cooling being provided)

	Existing HVAC 1	Existing HVAC 2	Existing HVAC 3	New HVAC 1	New HVAC 2	New HVAC 3
AC & Air-Source Heat Pumps						
Location on site:						
Manufacturer:						
Model number:						
Number of units						
Space heating source (electricity, fuel, etc.):						
HSPF V						
Seasonal Energy Efficiency Ratio (SEER):						
Energy Efficiency Ratio (EER):						
Nominal kBtu/h per unit:						
Hours of use (Indicate the corresponding schedule number):						
Heating set point and setback (if any) temperature [°C] :						
Cooling set point and setback (if any) temperature [°C] :						
Validate if the HVAC systems are properly installed and still operational:						
If no, why, and since when?						
Is unit > 65kBtu/h? (Y/N):						
Ground & Water Source Heat Pumps						
Manufacturer:						
Model number:						
Number of units:						
Original heat source (Electricity or other (specify)):						
Specify if open or closed loop:						
Specify if water-to-air, water-to-water, or air-to-water:						
Energy Efficiency Ratio (EER):						
Coefficient Of Performance (COP):						
Nominal capacity [kBtu/h]:						

	Existing HVAC 1	Existing HVAC 2	Existing HVAC 3	New HVAC 1	New HVAC 2	New HVAC 3
Hours of use for equipment (Indicate the corresponding schedule number for each section):						
Heating set point and setback (if any) temperature [°C] :						
Cooling set point and setback (if any) temperature [°C] :						
Validate if the HVAC systems are properly installed and still operational:						
If no, why, and since when?						

Water Heating:

Heat Pump or Switch to Natural Gas

New HP COP:

Manufacturer & Model #:

Is the HWHP used for DHW heating?

Space Heating Energy Type?

Hot Water Demand Metric

Hot Water temp?

Hours per day operation?

Is HWHP in conditioned location?

Does HWHP replace electric DHW heater?

Is the HWHP operational?

Kitchen:

*Collect the information in the table below if **commercial kitchen measures** were installed. Use on-site observation and contact declaration. Use additional sheets if required. The information collected will then be compared with the information in the tracking sheet by Econoler. Additionally, record Manufacturer and Model Number, and all Technical Data (Operating Temp, CFM, Size, Control Info)*

Commercial Dish Washers Installed (Low T°)

Under-counter commercial dish washer

Quantity Installed:

Location: _____

Manufacturer: _____

Model number: _____

Is the equipment used for commercial purpose? _____

Is the equipment still used? _____

If not, why and since when? _____

Does it use electricity heated hot water? _____

Validate the equipment is ENERGY STAR certified: _____

Operation [days/year]: _____

Operation [number of racks washed/day]: _____

Single-tank door type commercial dish washer _____

Quantity Installed:

Location: _____

Manufacturer: _____

Model number: _____

Is the equipment used for commercial purpose? _____

Is the equipment still used? _____

If not, why and since when? _____

Does it use electricity heated hot water? _____

Validate the equipment is ENERGY STAR certified: _____

Operation [days/year]: _____

Operation [number of racks washed/day]: _____

Single/Multi-tank conveyor commercial dishwasher _____

Quantity Installed:

Specify if single or multi-tank:

Location:

Manufacturer:

Model number:

Is the equipment used for commercial purpose?

Is the equipment still used?

If not, why and since when?

Does it use electricity heated hot water?

Validate the equipment is ENERGY STAR
certified:

Operation [days/year]:

Operation [number of racks washed/day]:

Commercial Dish Washers Installed (High T°)

Does it use a built-in booster heater?

If yes, specify booster water heater fuel type:

Commercial Fryers

Standard capacity commercial fryer

Quantity Installed:

Specify if electric or gas?

Does it replace an electric fryer?

Is it a new installation?

Is the equipment still used?

If not, why and since when?

Validate the equipment is ENERGY STAR
certified:

Operation [days/year]:

Operation [hours/day]:

Commercial RefrigerationInterior Volume (ft³)

Specify if solid door or glass door:

Manufacturer:

Model number:

Is it a standalone unit?

Does it replace an existing solid
door refrigerator?Does it replace an existing glass
door refrigerator?

Is the equipment still used?

If not, why and since when?

Validate the equipment is ENERGY STAR
certified:

Commercial Freezers

Interior Volume (ft³)

Specify if solid door or glass door:

Manufacturer:

Model number:

Is it a standalone unit?

Does it replace an existing solid door freezer?

Does it replace an existing glass door freezer?

Is the equipment still used?

If not, why and since when?

Validate the equipment is ENERGY STAR certified:

Commercial Ice Makers

Ice making head

Quantity Installed:

Manufacturer:

Model number:

Harvest [lbs/day]:

Is the equipment still used?

If not, why and since when?

Does it replace non- ENERGY STAR icemaker?

Validate the equipment is ENERGY STAR certified:

Remote condensing unit

Quantity Installed:

Manufacturer:

Model number:

Harvest [lbs/day]:

Is the equipment still used?

If not, why and since when?

Does it replace non- ENERGY STAR ice maker?

Validate the equipment is ENERGY STAR certified:

Self-contained

Quantity Installed:

Manufacturer:

Model number:

Harvest [lbs/day]:

Is the equipment still used?

If not, why and since when?

Does it replace non- ENERGY STAR ice maker?

Validate the equipment is ENERGY STAR certified:

Commercial Convection Ovens

Standard convection commercial oven

Quantity Installed:

Specify if electric or gas:

Specify if full size or half size:

Oven efficiency:

Idle [kW]:

Pre-heat[kW]:

Is the equipment still used?

If not, why and since when?

Does it replace an electric convection oven?

Is it a new installation?

Validate the equipment is ENERGY STAR certified:

Commercial Kitchen Ventilation Hoods

VSD for kitchen exhaust fans

Quantity Installed:

Size of the fan controlled by the VSD [hp]:

Is the equipment still used?

If not, why and since when?

Is the equipment controlled by T° and optical sensors located in exhaust hood?

Operation [hours/year]:

Laundry:

*Collect the information in the table below if **commercial laundry measures** were installed. Use on-site observation and contact declaration. Use additional sheets if required. The information collected will then be compared with the information in the tracking sheet by Econoler. Additionally, record Manufacturer and Model Number, and all Technical Data (Operating Temp, CFM, Size, Control Info)*

Water heating source: _____

Commercial Washing Machines Installed

ENERGY STAR certified commercial washing machine

Quantity Installed: _____

Manufacturer: _____

Model number: _____

Size [cubic feet]: _____

Is the equipment used for commercial purpose? _____

Is the equipment still used? _____

If not, why and since when? _____

Validate the equipment is ENERGY STAR certified: _____

Operation [cycles/week]: _____

CEE Tier 2 commercial washing machine

Quantity Installed: _____

Manufacturer: _____

Model number: _____

Size [cubic feet]: _____

Is the equipment used for commercial purpose? _____

Is the equipment still used? _____

If not, why and since when? _____

Validate the equipment is CEE Tier 2 listed: _____

Operation [cycles/week]: _____

CEE Tier 3 commercial washing machine

Quantity Installed:

Manufacturer:

Model number:

Size [cubic feet]:

Is the equipment used for commercial purpose?

Is the equipment still used?

If not, why and since when?

Validate the equipment is CEE Tier 3 listed:

Operation [cycles/week]:

Appendix V ON-SITE VISIT DURING AUDIT PROTOCOL

This year the Evaluator conducted five site visits during the energy audit portion of the SBES process. A separate protocol was developed in order to evaluate the methodology used by the Small Business Energy Advisors (SBEA).

On-site Visit Protocol for SBEA Visits

The 2017 protocol was reviewed and modified slightly based on last year's evaluation. It included four main categories and a notes section. A more detailed view of the specific questions are listed below.

General information:

- › Site Visit Date
- › SBEA Company and Auditor name
- › Participating Company Name and Address
- › Building type (i.e. Commercial, industrial, institutional, office, retail, etc.)

SBEA Interview Questions:

- › How long have you been auditing commercial buildings?
- › Under which Tier (1, 2 or 3) did you qualify for under SBEA?
- › What tier of audit is this being done under?
- › Did you receive a business profile from ENS?
- › When did you receive the audit lead?
- › How many days between the receipt of the lead and the audit booking?
- › What audit equipment do you use?
- › What do you use to collect data?
- › Do you make recommendations on vendors/installers?
- › Are you a certified CEA, CEM, or CMVP professional?
- › What tools are used for EEM calculations?
- › Were you provided, and did you read, the ENS Standard Operating Procedure (SOP)?

Site Information Collected by SBEA:

- › Does the auditor validate space function and system summary?
- › Does the auditor understand the facility operations, occupancy schedule, and function?
- › Does the auditor confirm heating sources and energy?
- › Does the auditor confirm heating setpoint(s)?
- › Does the auditor confirm cooling sources and energy?
- › Does the auditor confirm cooling setpoint(s)?
- › Does the auditor complete a full lighting inventory?
- › Does the auditor complete a full HVAC inventory?
- › Does the auditor complete a full process equipment inventory?
- › Does the auditor complete a full DHW equipment inventory?
- › Does the auditor complete a full building automation/controls inventory?
- › Does the auditor document equipment with photographs?
- › Does the auditor perform any measurements?

Audit Wrap-Up:

- › Did the auditor provide the client with a summary of preliminary EEMs?
- › Did the auditor provide the client with a timeline for the report?
- › Did the auditor give any indication of the potential savings identified?
- › Was the auditor professional? Did they identify themselves to the client and provide photo ID?
- › What was the total duration of the audit?

Appendix VI EFFECTIVE USEFUL LIFE

This appendix presents the revised equivalent effective useful life (EUL) of product types offered in the SBES program component. First, the EUL of lighting products are presented, followed by the other types of measures rebated through the program.

Lighting Measures

The Evaluator reviewed the tracked EUL values of each lighting measure type. The EUL was obtained by dividing the rated lifetime of lamps or fixtures by the annual hours of use (HOU), and then adjusted to account for increases in baselines throughout the lifetime of the measure to obtain the equivalent EUL. This value corresponds to the number of years by which the first-year savings estimate is multiplied to obtain lifetime energy savings. A summary of the revised equivalent EUL values by product type are presented in Table 3 at the end of this subsection. The following provides details on the methodology for establishing equivalent EUL values for LED lamps and fixtures.

The Evaluator used the annual HOU values from BER Instant Rebates since there is no fixed HOU values determined for SBES. The Evaluator also consulted the specification sheets of the most popular products of each measure type to establish their rated lifetimes.

Changes in regulation and baseline evolution

The Evaluator examined the possibility of the baseline increasing over the lifetime of the product for general-use lamps, decorative lamps, reflector lamps, and light-emitting diode (LED) downlight fixtures (for which the typical baseline would be a fixture using general-use or reflector lamps). This analysis was based on current and projected Canadian regulations for general service lamps. For other measures, since no major upgrades in energy efficiency requirements are planned in Canada, it was assumed the baseline remains unchanged throughout the measure EUL.

The current Canadian regulation bans the import of 40 W, 60 W, 75 W and 100 W incandescent general-use lamps, imposes minimum efficiency to be achieved by efficient incandescent light bulbs (also called halogen incandescent light bulbs),³ and reflects U.S. federal legislation.

The U.S. Energy Independence and Security Act (EISA) will raise the minimum efficiency of general service lamps in 2020.⁴ This regulation will affect general-use, decorative and reflector lamps generating more than 310 lumens, for which a minimum efficiency of 45 lumens/watt is expected.

³ Natural Resources Canada. *Energy Efficiency Regulations. General Service Lamps and Modified Spectrum Incandescent Lamps*, www.nrcan.gc.ca/energy/regulations-codes-standards/products/6869 (Last accessed January 24, 2018).

⁴ US EPA. "Summary of the Energy Independence and Security Act. Public Law 110-140 (2007)".

Online: www.epa.gov/laws-regulations/summary-energy-independence-and-security-act.

Natural Resources Canada has included an update to the general service lamps minimum energy performance requirement in Amendment 16 which is planned for pre-consultation in 2019⁵ (and should therefore be applied within a few years thereafter). This update will likely align the Canadian regulation with EISA 2020. Since this regulation will effectively ban the import and fabrication of efficient incandescent light bulbs, these are still expected to be available in retail outlets until stocks are depleted for up to two years after the legislation is implemented. With this information, the Evaluator reached the conclusion that the baseline change will occur in 2024.

The following paragraphs discuss the lamp types for which baseline increases will occur during their EUL, namely general-use and decorative lamps, reflector lamps, non-recessed downlight fixtures, and recessed downlight fixtures.

General-use and decorative lamps

The methodology used for establishing the equivalent EUL of general-use and decorative lamps is based on the information presented in Table 2Table 1 and the equation below. The equivalent EUL calculation is based on 9 W lamps being the most common product purchased for these list categories in 2017 SBES' tracking sheet. The baseline technology is a mix of 60 W incandescent lamps and 43 W halogen incandescent lamps, which yields an average baseline of 52 W.

Since incandescent lamps can no longer be replaced by incandescent lamps, there is a first increase in the baseline upon burnout. The Evaluator assumes these lamps have a remaining lifetime of 1,000 hours, which translates to 0.23 years with an annual HOU of 4,410 hours. However, since SBES targets commercial customers, the Evaluator assumes that some of customers might have incandescent lamps stocked, and therefore the duration of this baseline was increased to a full year. Based on the LED A-type lamp rated life of 25,000 hours, the EUL of this product is 5.7 years, meaning the corresponding baseline will not be affected by the change in legislation occurring seven years from now in 2024. Therefore, halogen incandescent lamps are considered to be the baseline technology for the remaining lifetime of LED A-type lamps. With the information presented in Table 2, the following equation sets the equivalent EUL of general-use lamps at 4.7 years.

$$\begin{aligned} \text{Equivalent EUL} &= \frac{\Delta W_{\text{Halogen Incandescent and Incandescent}} \times 1 \text{ years} + \Delta W_{\text{Halogen Incandescent}} \times 4.7 \text{ years}}{\Delta W_{\text{Halogen Incandescent}}} \\ &= 4.7 \text{ years} \end{aligned}$$

⁵ Natural Resources Canada. "Forward Regulatory Plan 2017-19". Online: <http://www.nrcan.gc.ca/energy/regulations-codes-standards/18318>, (last modified July 25, 2017).

Table 2: Baseline Evolution During the Effective Useful Life of LED A-type Lamps

Typical Replaced Lamp (W)	Typical Efficient Lamp (W)	Halogen Incandescent and Incandescent Baseline 1 year (2017)		Halogen Incandescent Baseline 4.7 years (2018-2022)	
		Baseline (W)	Displaced Wattage (W)	Baseline (W)	Displaced Wattage (W)
43	9	52	43	43	34

Reflector lamps

LED reflector lamps typically replace halogen lamps. Their average rated life is estimated at 25,000 hours, which translates to an EUL of 5.7 years. The baseline for this lighting product will therefore not increase throughout its EUL and so the equivalent EUL is equal to the EUL of 5.7 years.

Non-recessed downlight fixtures

Since non-recessed LED downlight fixtures replace fixtures using A-type lamps, the methodology for establishing their equivalent EUL is similar to what was described for A-type lamps. Once again, the equivalent EUL calculation is based on an example with 9 W LED lamps and their first baseline increase occurs one year following the anticipated burnout of incandescent lamps. However, since their rated life of 50,000 hours and corresponding EUL of 11.3 years are longer, their baseline is affected by the change in regulation effective in 2024. In other words, a second baseline increase will occur in 2024 (after changing from a baseline mix of 43 W halogen incandescent lamps and 60 W incandescent lamps to a 43 W halogen incandescent baseline in 2018). Starting in 2024 and for the remaining lifetime of the fixture (4.3 years), the baseline will be a 20 W compact fluorescent lamp (CFL) equivalent lamp. The equation and Table 3 below present the information used to calculate the equivalent EUL of 6.8 years.

Equivalent EUL

$$= \frac{\Delta W_{\text{Halogen Incandescent and Incandescent}} \times 1 \text{ year} \times \Delta W_{\text{Halogen Incandescent}} \times 6 \text{ years} \times \Delta W_{\text{CFL}} \times 4.3 \text{ years}}{\Delta W_{\text{Halogen Incandescent}}}$$

$$= 6.8 \text{ years}$$

Table 3: Baseline Evolution During the Effective Useful Life of LED A-type Lamps for Downlight Fixtures

Typical Replaced Lamp (W)	Typical Efficient Lamp (W)	Halogen Incandescent and Incandescent Baseline 1 year (2017)		Halogen Incandescent Baseline 6 years (2018-2023)		CFL Equivalent Baseline American Legislation ⁶ 4.3 years (2024-202)	
		Baseline (W)	Displaced Wattage (W)	Baseline (W)	Displaced Wattage (W)	Baseline (W)	Displaced Wattage (W)
43	9	52	43	43	34	20	11

⁶ As imposed by U.S. federal legislation. Incandescent Equivalent 2nd Tier EISA 2007.

Recessed downlight fixtures

LED recessed downlight fixtures typically replace fixtures housing reflector lamps for which the baseline technology is halogen lamps. The EUL of LED recessed downlight fixtures is established at 11.3 years based on a rated life of 50,000 hours. The equivalent EUL calculation is based on the typical case 12 W LED reflector lamp replacing a 43 W halogen lamp. As previously mentioned, Canadian regulations are expected to change in 2024, which will increase the baseline to an equivalent CFL. Therefore, after 43 W halogen lamps being the baseline technology for seven years, 20 W CFL equivalent lamps will become the baseline for the remaining lifetime of LED recessed downlight fixtures (4.3 years). The equivalent EUL of 8.8 years was calculated with the information presented in Table 4.

$$\text{Equivalent EUL} = \frac{\Delta W_{\text{Halogen}} \times 7 \text{ years} + \Delta W_{\text{CFL}} \times 4.3 \text{ years}}{\Delta W_{\text{Halogen}}} = 8.8 \text{ years}$$

Table 4: Baseline Evolution During the Effective Useful Life of LED Reflector Lamps in Downlight Fixtures

Typical Replaced Lamp (W)	Typical Efficient Lamp (W)	Halogen Baseline 7 years (2017-2023)		CFL Equivalent Baseline American Legislation ⁷ 4.3 years (2024-2028)	
		Baseline (W)	Displaced Wattage (W)	Baseline (W)	Displaced Wattage (W)
43	12	48	31	20	13

Other lighting products

For products other than general-service lamps, there is no indication that regulations will significantly change over the lifetime of these products. Furthermore, in the case of linear ambient luminaires, linear replacement lamps, and metal halide lamps, the typical baseline products are already more efficient than the current regulation, which further suggests that a change in regulations would not affect the baseline efficiency in the near future.

Efficiency Nova Scotia (ENS) tracked an EUL value of 10 years for occupancy sensors. The Evaluator found that the most common values used in other jurisdictions for occupancy sensors is either eight or 10 years, based on a 2007 GDS report⁸ and the Database for Energy Efficiency Resources (DEER) 2008⁹ respectively. The Evaluator therefore agrees with ENS that an EUL of 10 years is justified.

A summary of the EUL and equivalent EUL of all lighting product types offered in SBES is presented in Table 5.

⁷ As imposed by U.S. federal legislation. Incandescent Equivalent 2nd Tier EISA 2007.

⁸ GDS Associates. *Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures*, June 2007.

⁹ Database for Energy Efficiency Resources (DEER), *DEER 2008 EUL Table*, 2008.

Table 5: Revised Equivalent Effective Useful Life Values by Lighting Measure Category

Lighting Measure	List Category	Rated Life (hours)	Annual HOU	Tracked EUL (years)	EUL (years)	Equivalent EUL (years)
BER Instant Rebate Measures						
Linear LED Fixtures	1 x 4 Luminaires	50 000	4 410	15	11,3	11,3
	2 x 2 Luminaires & Retrofit Kits					
	2 x 4 Luminaires & Retrofit Kits					
	Linear Ambient & Low Bay Luminaires					
Linear LED Lamps	4-foot Replacement Lamps	50,000	4,410	10, 14, 14.2 or 15	11.3	11.3
	2-foot Replacement Lamps					
General-use and Decorative LED Lamps	LED Decorative (chandelier)	25,000	4,410	10, 14, 14.2 or 15	5.7	4.7
	LED Omnidirectional (A-lamp and globe)					
Reflector LED Lamps	Small LED Reflector Lamp - PAR, MR, MRX 16	25 000	4,410	10, 14, 14.2 or 15	5.7	5.7
	Small LED Reflector Lamp - PAR, R 20					
	Large LED Reflector Lamp - PAR, BR, R 30/30L					
	Large LED Reflector Lamp - PAR, BR, R 38/40					
LED Downlight Fixtures	LED Recessed	50,000	4,410	14	11.3	8.8
	LED Ceiling Mount, LED Surface Mount, LED Solid State Retrofit, LED Inseparable Solid State Luminaire, LED Wall Sconces, LED Wall Sconce Retrofit	50,000	4,410	10, 14, 14.2 or 15	11.3	6.8
Outdoor LED Fixtures	Outdoor Full-cutoff Wall-mounted Area Luminaires	50,000	4,380	14 or 15	11.4	11.4
	Flood and Spot Luminaires	75,000	4,380	12, 14, 15 or 18	17.1	17.1
Occupancy Sensors	Ceiling Remote-mounted	-	-	10	10	10
	Wall Remote-mounted					
	Fixture Mounted					
	Wall Switch					
	Exterior					
Additional BER Mail-In Measures						
Linear LED Fixtures	High-bay Luminaires	100,000	4,410	10, 12 or 15	22.7	22.7
	Troffers	90,000	4,410	10, 14 or 15	20.4	20.4
Case Lighting	Case Lighting for Sign Retrofit Applications	50,000	4,410	15	11.3	11.3
Refrigerated Case Lighting	Strip Lighting	70,000	4,410	15	15.9	15.9

Lighting Measure	List Category	Rated Life (hours)	Annual HOU	Tracked EUL (years)	EUL (years)	Equivalent EUL (years)
Outdoor LED Fixtures	Fuel Pump Canopy Luminaires	50,000	4,380	15 or 21	11.4	11.4
	LED Replacement for HID Lamps	50,000	4,380	15	11.4	11.4
	Pole/Arm-mounted Area Luminaires	60,000	4,380	8, 14, 15 or 18	13.7	13.7
	Parking Garage Luminaires	100,000	4,380	15 or 18	22.8	22.8

Other Products

For product types other than lighting, the Evaluator established the EULs listed in Table 6. The EUL values of all measures eligible for the program component were reviewed based on the findings of a literature review. When establishing the EUL for a given measure, the Evaluator considered the most common values found in technical reference manuals, evaluation reports and relevant studies. The sources that based EUL estimates on measured data or other reliable methods were preferred when available.

Table 6: Revised Equivalent Effective Useful Life Values by Measure Category

Measure Category	Measure	Revised EUL (years)	Reference
Agriculture	Agriculture heat pads	10	IESO PMA, 2015 ¹⁰
	Dairy scroll compressors	15	PA Consulting Group, 2009 ¹¹
	Energy efficient ventilation and circulation fans	15	GDS, 2007 ¹² PA Consulting Group, 2009
	Heat reclaimer units	15	Pennsylvania TRM, 2016 ¹³
	High-volume low-speed fans	15	PA Consulting Group, 2009 DEER, 2008
	Low-energy and zero-energy livestock waterers	10	PA Consulting Group, 2009
	Milk pre-coolers	15	PA Consulting Group, 2009
	Natural and dual ventilation	15	IESO PMA, 2015
	Tractor engine block heater timers	5	Minnesota TRM, 2016 ¹⁴
	VFD for milk vacuum pumps	15	DEER, 2008 PA Consulting Group, 2009
Compressed Air	Air entraining air nozzles	15	PA Consulting Group, 2009
	Air receiver for load/no load screw compressors	15	PA Consulting Group, 2009 ERS 2005 ¹⁵
	Cycling air dryers	10	PA Consulting Group, 2009
	No loss drains	15	ERS, 2005
	VFD screw compressors	15	ERS, 2005
HVAC	Air source heat pumps greater than or equal to 65,000 BTU/hr;	15	GDS, 2007 ERS, 2005 DEER, 2008
	Air source heat pumps less than 65,000 Btu/hr (excluding air-to-water)	15	GDS, 2007 ERS, 2005 DEER, 2008
	Air-to-water heat pumps;	15	GDS, 2007 ERS, 2005

¹⁰ Independent Electricity System Operator. *IESO Prescriptive Measures and Assumptions List*, October 2015. Accessed January 10, 2018 from IESO database.

¹¹ PA Consulting Group. *Focus on Energy Evaluation Business Programs: Measure Life Study*, August 25, 2009.

¹² GDS Associates. *Measure Life Report Residential and Commercial/Industrial Lighting and HVAC Measures*, June 2007.

¹³ Pennsylvania Public Utility Commission, *Technical Reference Manual – State of Pennsylvania*, June 2016. Errata Update February 2017.

¹⁴ Minnesota Department of Commerce Division of Energy Resources, *State of Minnesota Technical Reference Manual for Energy Conservation Improvement Programs Version 2.1 Final*, December 2016.

¹⁵ Energy & Resource Solutions. *Measure Life Study Report prepared for The Massachusetts Joint Utilities*, 2005.

Measure Category	Measure	Revised EUL (years)	Reference
	Commercial heat pump clothes dryers	11	DEER, 2008 DEER, 2014
	Ground source heat pumps;	15	ERS, 2005 GDS, 2007 DEER, 2008, 2014
	HVAC hotel occupancy sensors	8	DEER, 2008
	Packaged terminal heat pumps (PTHP)	15	GDS, 2007
	Water source heat pumps;	15	GDS, 2007 ERS, 2005 DEER, 2008, 2014
HVAC/ Kitchen	Dual-enthalpy economizer controls	10	ERS, 2005 GDS, 2007
IT & Datacenters	Server-based power management software	5	Illinois TRM, 2017 ¹⁶ Pennsylvania TRM, 2016
Kitchen	Demand controlled kitchen exhausts	15	PG&E Workpapers, 2004, 2007, 2012 DEER, 2014
	Dishwashers	10 or 15	Energy Star Calculator ¹⁷ 10 for under the counter, 15 for door type
	Freezers/refrigerators	12	DEER, 2008, 2011, 2014 EnergyStar Calculator GDS, 2007
	Fryers	12	DEER, 2008, 2011 EnergyStar Calculator PG&E, 2007
	Griddles	12	DEER, 2008, 2011 EnergyStar Calculator
	Hot food holding cabinets	12	DEER, 2008, 2011 EnergyStar Calculator PG&E, 2007
	Ice machines	10	DEER, 2008, 2011, 2014 PA Consulting Group, 2009
	Ovens	12	DEER, 2008, 2011 EnergyStar Calculator PG&E, 2007
	Steam cookers	12	DEER, 2008, 2011 EnergyStar Calculator
Laundry	Commercial clothes dryers (NG conversion)	14	Vermont TRM, 2015 ¹⁸
	Commercial washing machines	11	DEER 2011 Department of Energy, 2016 ¹⁹

¹⁶ Illinois Energy Efficiency Stakeholder Advisory Group, *Illinois Statewide Technical Reference Manual for Energy Efficiency Version 6.0*, February 2017.

¹⁷ ENERGY STAR, *Commercial Food Service Equipment*, https://www.energystar.gov/products/commercial_food_service_equipment (last accessed January 19, 2018).

¹⁸ Efficiency Vermont, *Technical Reference User Manual Measure Savings Algorithms and Cost Assumptions*, March 2015.

¹⁹ William Goetzler et al., *Energy Savings Potential and RD&D Opportunities for Commercial Building Appliances*, U.S. Department of Energy, June 2016.

Measure Category	Measure	Revised EUL (years)	Reference
Motors and VFDs	Brushless DC motors	15	PA Consulting Group, 2009 ERS, 2005 DEER, 2008
	Energy efficient motors	15	DEER, 2014
	Variable Frequency Drives	15	DEER, 2008 ERS, 2005 Navigant, 2013 ²⁰
Pumping	High efficiency circulator pumps	15	PA Consulting Group, 2009
Refrigeration	Display case strip curtains	4	DEER, 2014
	Door heater controls	12	DEER, 2004 and 2008
	Efficient refrigeration compressors	15	DEER, 2014 ERS, 2005
	Evaporator fan motor controls	10	ERS, 2005
	Intelligent freezer defrost controls	10	ERS, 2005
	Refrigerated vending machine controllers	5	DEER, 2008, 2014 ERS, 2005
	Refrigeration economizers	15	Illinois TRM, 2017 Vermont TRM, 2015
	Vertical refrigeration open to closed cooler conversions	12	DEER, 2008
	Zero energy doors	12	DEER 2008
Water Heating	Electric to natural gas water heating	15	DEER, 2014
	Heat pump water heaters	10	DEER, 2008, 2014
	Water heater tank wrap	7	DEER, 2014
Custom	Insulation (Wall)	25	DEER, 2014 PA Consulting Group, 2009
	Air Curtain	5	PA Consulting Group, 2009

²⁰ Navigant. *Incremental Cost Study Phase Two Final Report*. Burlington, MA, 2013.

Appendix VII

ALGORITHM FOR FREE-RIDERSHIP CALCULATION

The figures below present the algorithms for calculating the free-ridership level of SBES measures for the audit-path and the DIY-path for lighting and HVAC measures. The participant survey questionnaire included questions designed to assess the planning, quantity, efficiency, timing, cost and influence of the program. Each group of questions was transposed into a level of program attribution, which was used to calculate the free-ridership level associated with each participant.

AUDIT PATH

FR2ab. If your organization had not received the rebate or the financing from ENS, would you have paid for the full cost of the energy-efficient upgrades you installed? (Scale 0 to 10)	FR2ab = Answer x 10% IF DK OR REF: FR2 = EMPTY
FR3a. If the audit, rebate and/or financing had <u>not been</u> offered, what is the likelihood that you would have installed standard equipment or that you would have simply kept your old equipment instead of installing energy-efficient equipment in your facility? (Scale 0 to 10)	FR3a = (10 - Answer) x 10% IF DK OR REF: FR3a = EMPTY
PA1 Score:	MEAN VALUE OF: (FR2ab; FR3a)
FR1. Before having your facility evaluated by a SBEA, did your organization have plans to install the specific energy-efficient upgrades that were installed as part of SBES program ? 1. Have plans to implement all of the upgrades 2. Have plans to implement some of the upgrades 3. Have no plan to implement any of the upgrades	IF 1 OR 2: GO TO FR1a IF 3 OR DK OR REF: FR1a = 0%
FR1a. [ASK IF FR1=1 OR 2] I just want to make sure I understand - Before you had your facility evaluated by a SBEA, you had already made the decision to install [all/some of] the energy efficiency upgrades that were installed as part of the program?	IF 1. Yes and FR1 = 1: FR1a = 100% IF 1. Yes and FR1 = 2: FR1a = 25% IF 2. No OR DK OR REF: FR1 = 0%
PA2 Score:	FR1a
FR4. Level of influence – 7 factors (Scale 0 to 10)	FR4 = MAX(a; b; c; d; e; f; g)
PA3 Score:	(10 – FR4) x 10%
FR3b. [ASK IF TOTAL MEASURE QTY>1] If the audit, rebate and/or financing had not been offered, what is the likelihood that you would have installed exactly the same quantity of energy-efficient upgrades that were installed through the SBES program? (Scale 0 to 10)	FR3b = Answer x 10% IF 98 OR 99: FR3b = EMPTY
FR3c. [ASK IF FR2a or b ≥5] If the audit, rebate and/or financing had not been offered, what is the likelihood that you would have postponed making energy efficient upgrades to your facility by at least one year? (Scale 0 to 10)	FR3c = (10 – Answer) x 10% IF DK OR REF: FR3b = EMPTY

PA4 Score:	Min (FR3b; FR3c)
Inconsistency Test PA1	IF ABS(FR2ab – FR3a) ≥ 50% PA1 = MIN(FR2ab; FR3a)
Inconsistency Test PA2	IF FR1a = 100% AND FR2 < 70%: PA2 = EMPTY
Free-Ridership	IF PA4 < MEAN (PA1; PA2; PA3): MEAN (PA1; PA2; PA3; PA4) OTHERWISE MEAN (PA1; PA2; PA3)
C12/4a. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] was a major factor in your decision to install energy efficient upgrades in your facility. C12/4b. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted a company representative to examine the energy efficiency options for the facility or to ask for an energy audit of your facility. C12/4c. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted a company representative to take into account the cost-effectiveness of energy efficient upgrades when evaluating different options for the facility. (Agree or Disagree)	CI = IF(CI2a OR CI4a = Agree; 1) + IF(CI2b OR CI4b = Agree; 1) + IF(CI2c OR CI4c = Agree; 1)
Revised Free-Ridership	IF CI = 0 OR 1: Revised FR = FR IF CI = 2: Revised FR = FR*.75 IF CI = 3: Revised FR = FR*.50

DIY PATH – LIGHTING

FR2ab. If your organization had not received the rebate or the financing from ENS, would you have paid for the full cost of the lighting upgrades? (Scale 0 to 10)

FR2ab = Answer x 10%
IF DK OR REF: FR2 = EMPTY

FR3d. Were you aware that the lighting products rebated through the Small Business Energy Solution Program are premium products certified by Design Light Consortium or ENERGY STAR®

IF 1. Yes: Use FR3a
IF 2. No OR DK OR REF:
FR3a = 0%

FR3a. [ASK IF FR3d=1] If the program rebate or financing had not been offered, what is the likelihood that you would have installed the exact same model of lighting products? (Scale 0 to 10)

FR3a = Answer x 10%
IF DK OR REF: FR3a = EMPTY

PA1 Score:

**MEAN VALUE OF:
(FR2ab; FR3a)**

FR1. Had your organization already decided to install the energy-efficient lighting system before learning about the SBES program?

IF 1. Yes: Use FR1a
IF 2. No OR DK OR REF:
FR1 = 0%

FR1a. [ASK IF FR1=1] I just want to make sure I understand - **Before** you learned about the SBES program and the rebates offered through the program, you had already made the decision to install the energy-efficient lighting?

IF 1. Yes: FR1 = 100%
IF 2. No OR DK OR REF:
FR1 = 0%

PA2 Score:

FR1

FR4. Level of influence– 5 factors (Scale 0 to 10)

FR4 = MAX(a; b; c; d; e)

PA3 Score:

(10 – FR4) x 10%

FR3b.[IF TOTAL LIGHTING QTY >1] If the program rebate or financing had not been offered, what is the likelihood that you would have installed exactly the same quantity of lighting products that you installed through the program? (Scale 0 to 10)

FR3b = Answer x 10%
IF DK OR REF: FR3b = EMPTY

FR3c. [ASK IF FR2 a or b ≥5] If the program rebate or financing had not been offered, what is the likelihood that you would have postponed installing the lighting upgrades **by at least one year?** (Scale 0 to 10)

FR3c = (10 – Answer) x 10%
IF DK OR REF: FR3b = EMPTY

PA4 Score:	Min (FR3b; FR3c)
Inconsistency Test PA1	IF ABS(FR2 – FR3a) ≥ 50% PA1 = MIN(FR2ab; FR3a)
Inconsistency Test PA2	IF FR1a = 100% AND FR2ab < 70%: PA2 = EMPTY
Free-Ridership	IF PA4 < MEAN (PA1; PA2; PA3): MEAN (PA1; PA2; PA3; PA4) OTHERWISE MEAN (PA1; PA2; PA3)
C12/4a. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] was a major factor in your decision to install energy efficient upgrades in your facility. C12/4b. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted a company representative to examine the energy efficiency options for the facility or to ask for an energy audit of your facility. C12/4c. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted a company representative to take into account the cost-effectiveness of energy efficient upgrades when evaluating different options for the facility. (Agree or Disagree)	CI = IF(CI2a OR CI4a = Agree; 1) + IF(CI2b OR CI4b = Agree; 1) + IF(CI2c OR CI4c = Agree; 1)
Revised Free-Ridership	IF CI = 0 OR 1: Revised FR = FR IF CI = 2; Revised FR = FR*.75 IF CI = 3; Revised FR = FR*.50

DIY PATH – HVAC

FR2ab. If your organization had not received the rebate or the financing from ENS, would you have paid for the full cost of the HVAC upgrades? (Scale 0 to 10)	FR2ab = Answer x 10% IF DK OR REF: FR2 = EMPTY
FR3a. If the program rebate or financing had <u>not been</u> offered, what is the likelihood that you would have installed exactly the same energy-efficient HVAC upgrades that were rebated or financed through the Program?	FR3a = Answer x 10% IF DK OR REF: FR3a = EMPTY
PA1 Score:	MEAN VALUE OF: (FR2ab; FR3a)
FR1. Had your organization already decided to install the energy-efficient HVAC system before learning about the SBES program?	IF 1. Yes: Use FR1a IF 2. No OR DK OR REF: FR1 = 0%
FR1a. [ASK IF FR1=1] I just want to make sure I understand - Before you learned about the SBES program and the rebates offered through the program, you had already made the decision to install the energy-efficient HVAC upgrades?	IF 1. Yes: FR1 = 100% IF 2. No OR DK OR REF: FR1 = 0%
PA2 Score:	FR1
FR4. Level of influence– 5 factors (Scale 0 to 10)	FR4 = MAX(a; b; c; d; e)
PA3 Score:	(10 – FR4) x 10%
FR3c. [ASK IF FR2 a or b ≥5] If the program rebate or financing had not been offered, what is the likelihood that you would have postponed installing the HVAC upgrades by at least one year? (Scale 0 to 10)	FR3c = (10 – Answer) x 10%
PA4 Score:	FR3c
Inconsistency Test PA1	IF ABS(FR2 – FR3a) ≥ 50% PA1 = MIN(FR2ab; FR3a)
Inconsistency Test PA2	IF FR1a = 100% AND FR2ab < 70%: PA2 = EMPTY

Free-Ridership	IF PA4 < MEAN (PA1; PA2; PA3): MEAN (PA1; PA2; PA3;PA4) OTHERWISE MEAN (PA1; PA2; PA3)
C12/4a. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] was a major factor in your decision to install energy efficient upgrades in your facility. C12/4b. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted a company representative to examine the energy efficiency options for the facility or to ask for an energy audit of your facility. C12/4c. [The company's previous participation in an ENS program]/[The energy efficiency promotional materials distributed by ENS] prompted a company representative to take into account the cost-effectiveness of energy efficient upgrades when evaluating different options for the facility. (Agree or Disagree)	CI = IF(CI2a OR CI4a = Agree; 1) + IF(CI2b OR CI4b = Agree; 1) + IF(CI2c OR CI4c = Agree; 1)
Revised Free-Ridership	IF CI = 0 OR 1: Revised FR = FR IF CI = 2; Revised FR = FR*.75 IF CI = 3; Revised FR = FR*.50

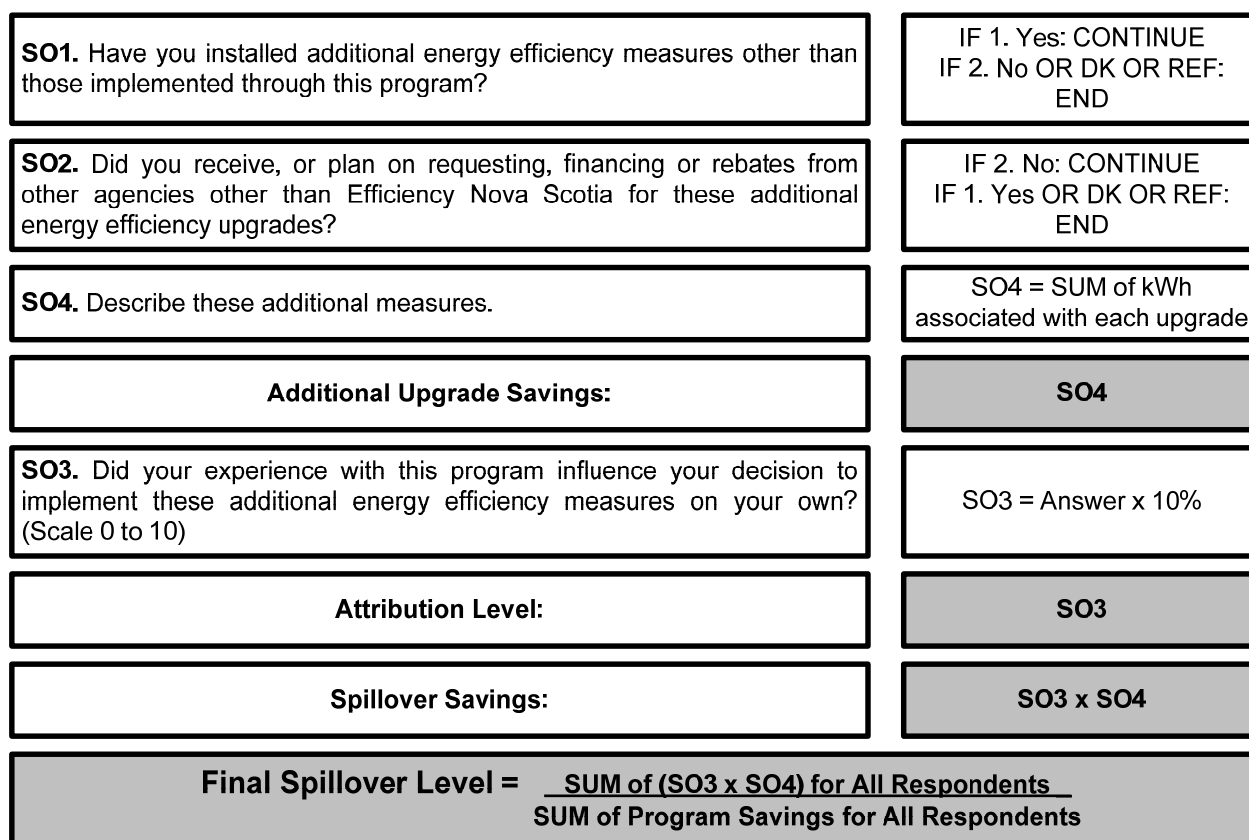
Appendix VIII

ALGORITHM FOR INTERNAL SPILLOVER CALCULATION

Internal spillover of SBES was measured using a participant survey conducted during the on-site visits. Participants were asked whether following their participation in SBES, they implemented any additional energy efficiency measures, without benefitting from any rebates or financing offered by ENS programs. If a participant said having implemented additional recommended measures, they were asked a set of questions designed to identify the additional energy efficiency measures implemented and to quantify their associated savings (type of measure, quantity, efficiency level, etc.). Subsequently, another question was asked to quantify the level of influence the program had on the participant's decision to implement these additional measures. The value established regarding this level of influence was used to determine the portion of the additional savings attributable to the program.

Then, the level of internal spillover was established by dividing the total quantity of the additional savings attributable to the program by the total quantity of savings achieved by the program for all the survey respondents.

The figure below illustrates the methodology used to calculate the internal spillover level.



Appendix IX CALCULATION EXAMPLE

This appendix presents a sample calculation to demonstrate the process of revising energy and peak demand savings. The lighting measure category accounted for 94 percent of the measures and 80 percent of the tracked energy and peak demand savings for SBES in 2017. Therefore, one of the lighting measures has been chosen to show details of the following:

- › the algorithms for calculating energy and peak demand savings;
- › the comparison of the tracked energy and peak demand savings calculation and the revised energy and peak demand savings calculation; and
- › the algorithm for establishing the adjustment ratio.

Energy and Peak Demand Savings Calculation Algorithms

The following algorithms include the parameters required to determine the annual energy savings and the annual peak demand savings associated with a linear lamp replacement measure.

$$Energy\ Savings\ \left[\frac{kWh}{yr} \right] = \frac{(Wattage_{Baseline} - Wattage_{Efficient}) \times Qty \times Hrs \times IE}{1,000\ W/kW}$$

$$Peak\ Demand\ Savings\ \left[\frac{kW}{yr} \right] = \frac{(Wattage_{Baseline} - Wattage_{Efficient}) \times Qty \times CF \times IEpd}{1,000\ W/kW}$$

Where:

- › $Wattage_{Baseline}$: the existing fixture's system wattage.
- › $Wattage_{Efficient}$: the efficient fixture's system wattage.
- › Hrs : the annual hours of use.
- › Qty : the quantity of fixtures.
- › IE : the interactive effects factor based on the location of the lighting measure.
- › $IEpd$: the interactive effects factor for peak demand based on the location of the lighting measure.
- › CF : the coincidence factor.

Tracked Savings Calculation

The baseline measure was tracked using the specifications stated in the SBES participant's application. The proposed measure wattage was found in the specifications sheet submitted with the application.

Table 7 below lists the values applied to a case where 200 W high-bay LED fixtures replaced the baseline 400 W MH fixtures.

Table 7: Tracked Variables Used in the Calculation Example

Baseline Measure – 400W High-bay MH Fixture		
Parameter	Value	Source
Existing Lamp Quantity	100	Tracking Report
Baseline Lamp Wattage (W)	400	Tracking Report
Hours of Use (hrs/year)	4,368	Tracking Report
Interactive Effects Factor (energy)	1.00	Tracking Report
Interactive Effects Factor (demand)	1.06	Tracking Report
Peak Coincidence Factor	0.86	Tracking Report
Annual Energy Consumption (kWh)	174,720	Calculation
Annual Peak Demand (kW)	36.464	Calculation
New Measure – 200W High-bay LED Fixture		
Efficient Lamp Quantity	100	Tracking Report
Efficient Lamp Wattage	200	Tracking Report
Hours of Use (hrs/year)	4,368	Tracking Report
Interactive Effects Factor (energy)	1.00	Tracking Report
Interactive Effects Factor (demand)	1.06	Tracking Report
Peak Coincidence Factor	0.86	Tracking Report
Annual Energy Consumption (kWh)	87,360	Calculation
Annual Peak Demand (kW)	18.232	Calculation
Tracked Savings		
Tracked Energy Savings (kWh)	87,360	Tracking Report
Tracked Demand Savings (kW)	18.232	Tracking Report

Revised Savings Calculation

A total of five adjustments were made to the savings calculations based on the site-visit findings. The first adjustment involved correcting the baseline wattage, because the nominal wattage was used for the 400 W metal halide fixture, instead of the system wattage of 458 W. Similarly, the efficient wattage of 200 W indicated in the specifications sheet was found to be a rounded figure and was therefore replaced with the DLC-listed value of 188 W. Additionally, the site visit revealed that the warehouse was not electrically heated and did not have cooling; thus, the 1.06 IEpd factor was revised to 1.00.

The last adjustment involved revising the HOU based on the information gathered on site about the operation schedule. During the site visit, it was found that the warehouse's hours of operation were Monday through Friday, from 6:30 a.m. to 5:00 p.m. and closed for weekends and six holidays. The warehouse manager indicated that 5:00 p.m. was the end of their business hours, but the staff usually spent one more hour finishing off end-of-day tasks and so the lights remained turned on until 6:00 p.m. The Evaluator considered all this information and revised the HOU to 11.5 hours per day over 255 days, or an annual total of 2,932.5 hours, and adjusted the CF to 0.5 based on the 6:00 p.m. shut-off.

The variables used in the calculation of the revised savings and the final results are listed in Table 8 below.

Table 8: Revised Variables Used in the Calculation Example

Baseline Measure – 400W High-bay MH Fixture		
Parameter	Value	Source
Existing Lamp Quantity	100	Validated on site
Revised Baseline Lamp Wattage (W)	458	Duke Energy Fixture Wattage for 400W MH
Revised Hours of Use(hrs/year)	2,932.5	Calculated as 3.5 hours per day, 365 days per year
Interactive Effects Factor (energy)	1.00	Non-electric Heating
Revised Interactive Effects Factor (demand)	1.00	No cooling
Revised Coincidence Factor	0.5	Validated on site
Annual Energy Consumption (kWh)	134,309	Calculation
Annual Peak Demand (kW)	22.9	Calculation
New Measure – 200W High-bay LED Fixture		
Efficient Lamp Quantity	100	Validated on site
Revised Efficient Lamp System Wattage (W)	188	DLC Product Listing
Revised Hours of Use(hrs/year)	2932.5	Same as the baseline fixtures
Interactive Effects Factor (energy)	1.00	Non-electric heating
Revised Interactive Effects Factor (demand)	1.00	No cooling
Revised Coincidence Factor	0.5	Validated on site
Annual Energy Consumption (kWh)	55,131	Calculation
Annual Peak Demand (kW)	9.4	Calculation
Revised Savings		
Revised Energy Savings (kWh)	79,178	Calculation
Revised Demand Savings (kW)	13.500	Calculation

Adjustment Ratio Algorithm

The adjustment ratio is determined by comparing the revised savings values with the tracked savings values. Because of the revisions made to this measure, the ratios were established at 0.906 for energy savings and at 0.785 for peak demand savings, as shown below.

$$\frac{\text{Revised ES}}{\text{Tracked ES}} = \frac{79,178 \text{ kWh}}{87,360 \text{ kWh}} = 0.906$$

$$\frac{\text{Revised Peak DS}}{\text{Tracked Peak DS}} = \frac{13.500 \text{ kW}}{18.232 \text{ kW}} = 0.785$$



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EFFICIENCY NOVA SCOTIA



Final Report



March 15, 2018



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ABBREVIATIONS

AHAM	Association of Home Appliance Manufacturers
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
C&S	Codes & Standards
CFL	Compact fluorescent lamp
CMHC	Canada Mortgage and Housing Corporation
DSM	Demand-side management
EFC	Electro-Federation Canada
ENS	Efficiency Nova Scotia
EPI	Efficient Product Installation
GHG	Greenhouse gas
HEA	Home Energy Assessment
HRM	Halifax Regional Municipality
LED	Light-emitting diode
MEPS	Minimum energy performance standards
MNECB	Model National Energy Code for Buildings
NBC	National Building Code
NECB	National Energy Code for Buildings
NERHOU	Northeast Residential Lighting Hours-of-Use Study
NHC	New Home Construction
NRCan	Natural Resources Canada
NSP	Nova Scotia Power

DEFINITIONS

Accuracy	Reflects the proximity of measurements to the true value.
Adjustment ratio	The ratio of evaluated results to tracked results. This ratio expresses the adjustment made to tracked savings or other tracked values such as effective useful life.
Base case	To determine gross savings, a base case is established providing detailed information about the reference (e.g. pre-existing or standard) measure or equipment chosen to be compared with the efficient measure or equipment. For the reference measure or equipment, the base case may include such information as the hours of operation, wattage and the base consumption.
Bias	Systematic deviations of measurements from the true value.
Billing calibration	An activity that consists of adjusting the expected energy savings based on the relative difference between the results of the energy simulations and the actual energy consumption of the building or system.
Confidence interval	The estimated range of values which is likely to include the unknown population parameters.
Displaced wattage	The displaced wattage is defined as the difference between the wattage values of the baseline equipment or product and the efficient equipment or product.
EnerGuide rating	An EnerGuide (official brand of Natural Resources Canada) rating is a standard measure of the home's energy performance. It is a measure of the efficiency of the building only and does not take into account occupant behaviour. It shows how energy efficient the home is through modelled heat losses of the home, based on several factors including building envelope characteristics, heated volume, heating systems and air leakage.
Effective useful life	The period a measure is expected to be in service and provide both energy and peak demand savings. This value combines the equipment life and the measure persistence, which includes factors such as business turnover or early retirement.
Equipment life	The number of years installed equipment will operate before it fails.
Equivalent CO ₂	A unit of measurement indicating the amount of carbon dioxide to which various kinds of emitted greenhouse gases are equivalent in terms of warming effects. In this report, the gases' global-warming potential is estimated over a timescale of 100 years.
Equivalent effective useful life	The number of years by which the first-year savings estimate is multiplied to obtain lifetime energy savings. This value takes into account variations in annual energy savings throughout the effective useful life due to increased baselines.

Evaluated savings	Gross and net savings calculated by the Evaluator using the parameters (unitary savings values, installation rates, interactive effects, net-to-gross ratio, etc.) validated or measured during the evaluation process. Unless otherwise specified, the evaluated savings are the first-year savings.
Evaluation plan	The evaluation plan summarizes the program description, objectives, base cases, documentation, evaluation methodology, budget and schedule.
First-year savings	The first full year of energy savings generated by an energy efficiency measure.
Free-ridership	Percentage of gross savings attributable to participants who would have implemented the same or similar energy efficiency measures, with no change in timing, in the absence of the program.
Gross energy savings	Energy savings generated by energy efficiency measures, before applying the net-to-gross ratio.
Induced consumption	Energy consumption of appliances that would have been unplugged and not replaced by participants in the absence of the program.
Interactive effects	Effects on the energy consumption of other systems in the building (such as heating and cooling) due to the installation of an energy efficiency measure.
Internal spillover	Savings attributable to participants who continue to implement the energy efficiency measure introduced by a program after participating in it once, without participating in the program a second time.
In-service rate	The proportion of incentivized products that are installed and operating. This rate is usually applied to programs through which rebates are offered in-store and products are likely to be stored for a certain period before being installed, such as LED bulbs.
Lifetime energy savings	The energy savings that occur over the lifetime of an energy efficiency measure. Lifetime energy savings account for a measure's effective useful life and any increase in the baseline efficiency level (which reduces attributable annual savings) over its lifetime.
Line loss factor	The multiplier to convert savings at the customer meter to savings at the utility generator. It accounts for the electrical losses of the transmission and distribution system.
Margin of error	The amount of random sampling error.
Market effects	The impact of the program on the market (such as increased product availability, practices, and prices) that extends beyond changing the program participants' behaviour. This includes spillover among non-participants.
Net energy savings	Energy savings that can be reliably attributed to a program. This includes effects, such as free-ridership and spillover, that negatively or positively affect the energy savings attributable to a program.
Net-to-gross ratio	The ratio of net energy savings to gross energy savings.

Non-sampling error	Errors arising during the course of all survey activities other than sampling. Non-sampling errors tend to lead to bias in measurements and are very difficult to quantify.
Peak coincidence factor	The percentage of measure demand savings that coincide in time with the annual peak demand of the entire electricity system.
Peak demand savings	The demand savings that coincide in time with the expected annual peak demand period of the entire electricity system.
Precision	The extent to which repeated measurements agree with one another.
Random sampling error	The error in measurement due to the fact that measurements are taken from a subset of the population and not the entire population.
Sample size	The number of observations or replicates included in a statistical sample.
Secondary market impacts	Energy consumption of appliances that would have been transferred to the secondary market if said appliances had not been retired.
Tracked savings	Gross and net savings calculated by ENS in the tracking system, based on various parameters such as number of participants, unitary savings values, installation rates, interactive effects, and the net-to-gross ratio.
Unitary savings	Energy or peak demand savings established on a unitary basis. This unit can either be a product (e.g., an 8 W LED lamp), a capacity (e.g., one-ton capacity of an air-source heat pump) or a participant (e.g., one participant taking part in a behaviour-based program).

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EXECUTIVE SUMMARY

This report presents the results of the 2017 demand-side management (DSM) impact evaluation of Codes & Standards (C&S). The 2017 evaluation was based on secondary data research and a number of interviews and exchanges conducted with industry associations, government and municipality representatives and retailers.

Context and Background

To improve the efficiency of energy-consuming products marketed in Canada, Natural Resources Canada (NRCan) has been implementing minimum energy efficiency regulations through amendments to the *Energy Efficiency Regulations*.¹ As part of Canada's Clean Air Regulatory Agenda established in 2006,² three recent amendments to the *Energy Efficiency Regulations* were planned "to deliver energy, greenhouse gas (GHG) and air pollutant reductions".³

These amendments have not only increased the stringency and/or scope of the existing minimum energy performance standards (MEPS) within the *Energy Efficiency Regulations*, but also introduced new MEPS.

The most recent change was related to the new amendment (Amendment 13) published on December 28, 2016⁴ and came into force on June 28, 2017, six months after its publication. Amendment 13 requires updating the existing energy-efficiency standards for 20 product categories to align with those requirements in force or soon to be put into force in the United States. Since retailers typically need a few months to sell their existing stocks, the impact of these standards was expected to be limited until January 2018. However, during the visits to retailers conducted by ENS in 2017 to observe what models were offered in their stores, it was found that the adoption of the new MEPS for clothes washers and refrigerators had taken place prior to the June 2017 enforcement. Therefore, the Evaluator decided to include the evaluation of new clothes washer (Tier 1) and refrigerator (Types 3, 5, 7 and 11) regulations in this year's evaluation.

¹Natural Resources Canada, *Guide to Canada's Energy Efficiency Regulations*, 2017, available at <<http://www.nrcan.gc.ca/energy/regulations-codes-standards/6861>> (Last accessed February 5, 2018)

² Environment Canada, *Clean Air Regulatory Agenda: Background*, <www.ec.gc.ca/default.asp?lang=En&n=56D4043B-1&news=295B1964-9737-4F80-B064-B3088D9910BE> (Last accessed February 5, 2018)

³ Natural Resources Canada, *Publication of Regulations Amending Canada's Energy Efficiency Regulations*, 2011, available at <<http://oee.nrcan.gc.ca/regulations/amendment12/publication.cfm>> (Last accessed February 5, 2018)

⁴ Natural Resources Canada, *Notice – Publication of Energy Efficiency Regulation, 2016- Amendment 13*. December 2016, available at <<http://www.nrcan.gc.ca/energy/regulations-codes-standards/18419>> (Last accessed February 5, 2018)

In addition to these new regulations, the 2017 evaluation also focuses on the same regulations as evaluated in 2016, namely the latest MEPS on general-service incandescent lamps (which came into force on January 1, 2014 for 75 W and 100 W bulbs and on December 31, 2014 for 40 W and 60 W bulbs),⁵ street lights⁶ and the latest energy code for houses, small buildings, large buildings, condos and apartments.

Table 1 lists the product categories assessed in this report.

Table 1: Products and Codes Impacted by Recent Changes to Canada and Nova Scotia's Energy Efficiency Regulations

Product	Existing MEPS before Provincial Initiative	Reference Standard
Incandescent light bulbs (75 W and 100 W)	Yes	CAN/CSA C862-09
Incandescent light bulbs (40 W and 60 W)	Yes	CAN/CSA C862-09
LED street lights	No	CAN/CSA C653-13
National Energy Code for houses and small buildings – National Building Code (NBC) – Revision 2012 – Part 9.36	Yes	Model National Energy Code for Buildings (MNECB) 1997
National Energy Code for large buildings, condos and apartments – Revision 2012 – Part 9	Yes	MNECB 1997
Clothes Washers- Tier 1	Yes	CAN/CSA-C360-13
Refrigerators	Yes	CAN/CSA-C300-15

To evaluate the impacts of the new regulations on these products and codes listed in Table 1, Efficiency Nova Scotia (ENS) contracted the Evaluator to assess the achieved annual incremental energy and peak demand savings since the regulations were introduced into the Nova Scotia market. Such an evaluation was carried out in 2012, 2013, 2014, 2015, and 2016 as part of ENS's annual evaluation and was done again in 2017.

Starting in 2015, the Evaluator modified the methodology used in the past evaluations by focusing its efforts on making the best use of Statistics Canada sources and collecting sales volume information from associations and retailers. For the 2017 evaluation, the Evaluator used an approach similar to that of 2015 and 2016 by focusing the information collection activities on industry associations and retailers to ensure that the most up-to-date market information is collected.

⁵ Natural Resources Canada, *Amendment to Canada's Energy Efficiency Regulations for Lighting Products*, January 2014, available at <<http://www.nrcan.gc.ca/energy/regulations-codes-standards/12342>> (Last accessed February 5, 2018)

⁶ Nova Scotia Canada, *New Law Means Road Lighting in Nova Scotia Must Be LED*, September 12, 2012, available at <<http://novascotia.ca/news/release/?id=20120912004>> (Last accessed February 5, 2018)

Key Findings

The 2017 evaluation has estimated the 2017 annual impact in terms of energy and peak demand savings as a result of introducing new regulations into the Nova Scotia market governing the products targeted by the federal government's Amendment 13 and the provincial regulations imposing greater stringency and a wider scope on existing MEPS.

The 2017 energy and peak demand savings at the generator for each type of product or building code evaluated are summarized in Table 2 below. The overall energy and peak demand savings for C&S have been estimated at 21.914 GWh and 4.028 MW at the generator respectively. These savings represent 14,312 tonnes of CO₂ eq in terms of annual avoided GHG emissions.

Table 2: Evaluated Energy and Peak Demand Savings at the Generator for 2017

Product	Energy Savings at the Generator (GWh)	Peak Demand Savings at the Generator (MW)
Incandescent Lamps	9.268	1.081
LED Street-lighting	5.194	1.293
New Energy Code for Houses and Small Buildings	1.419	0.402
New Energy Code for Large Buildings, Condos and Apartments	3.285	0.867
Clothes Washers - Tier 1	2.691	0.371
Refrigerators	0.057	0.008
Total	21.914	4.028

The savings attributable to C&S have resulted from increasing the mandatory minimum efficiency levels applicable to the targeted products and building codes in the market. Although similar products and buildings are targeted by ENS programs, it should be noted that their savings are distinct from those generated by C&S. The savings associated with ENS programs are based on increased product efficiency compared to the regulated minimum efficiency standard or the current baseline of that product category, whereas the savings associated with C&S result from an increase in that minimal efficiency standard. So, each set of savings is specifically attributable to either C&S or to ENS programs, and do not overlap.

Recommendation

International experience and the Evaluator's own experience suggest that evaluating the energy impact of regulations or policies is usually more difficult than calculating the impact of a DSM program, which has a list of participants and a range of products distributed. As for the evaluation of C&S, the main challenge is the need to understand the whole market of the targeted products. This involves not only establishing the quantity of products sold in a specific market, but also making in-depth characterization of this market (e.g., quantity by size, type, efficiency level, etc.). Depending on the product, this information can be hard or even impossible to obtain in some cases. Based on the results of the evaluation activities, the Evaluator makes the following recommendation on how to ensure the success of future C&S impact evaluations. The following recommendation can also be found in Appendix I of the Codes and Standards Appendix Report.

CS-R1. Include some Amendment 13 standards in the 2018 evaluation. The new standards set forth in Amendment 13 came into force at the end of June 2017. Most of these new standards were not included in the 2017 evaluation since their impact was expected to be limited until January 2018 while retailers sell their existing stocks. For the 2018 evaluation, these new standards should be considered for inclusion. However, a review of Amendment 13 shows that many of the new MEPS will only have a limited impact in terms of savings, since the new MEPS either bring very little change to the standard level or target products with small markets. The Evaluator therefore recommends selecting two or three products from the Amendment 13 standards based on their savings potential and a consideration of how much effort will be needed to estimate their market sizes. The 2017 evaluation showed that clothes washers (Amendment 13) provided considerable savings and should still be included in the 2018 evaluation, whereas refrigerators (Amendment 13), due to their low savings, should no longer be included. The Evaluator recommends continuing to evaluate the impacts associated with lighting, street-lighting and building codes in 2018 since they provide significant savings.

1 CONTEXT AND BACKGROUND

To improve the efficiency of energy-consuming products marketed in Canada, Natural Resources Canada (NRCan) has been implementing regulations regarding minimum energy efficiency standards by issuing a series of amendments to the *Energy Efficiency Regulations*. As part of Canada's Clean Air Regulatory Agenda established in 2006⁷, amendments to the *Energy Efficiency Regulations* have been regularly made to deliver energy, greenhouse gas (GHG) and air pollutant reductions.

The latest amendment to the *Energy Efficiency Regulations* was Amendment 13, which requires updating the existing energy-efficiency standards for 20 product categories to align with those requirements in force or soon to be put into force in the United States. Amendment 13 was published on December 28, 2016⁸ and came into force on June 28, 2017, six months after its publication.

Since retailers typically need a few months to sell their existing stocks following the introduction or amendment of the *Energy Efficiency Regulations*, the impact of these standards was expected to be limited until January 2018. However, during visits to retailers conducted by ENS in 2017 to observe what models were offered in their stores, it was found that early adoption of the new minimum energy performance standards (MEPS) for clothes washers and refrigerators had taken place prior to the June 2017 enforcement. Therefore, the Evaluator decided to include the evaluation of new clothes washer (Tier 1) and refrigerator (Types 3, 5, 7 and 11) standards in this year's evaluation.

In addition to these new standards, the 2017 evaluation also focuses on the same regulations as evaluated in 2016, namely the latest MEPS on general-service incandescent lamps (which came into force on January 1, 2014 for 75 W and 100 W bulbs and on December 31, 2014 for 40 W and 60 W bulbs)⁹, street lights¹⁰ and the latest energy code for houses, small buildings, large buildings, condos and apartments, as summarized in Table 3 below.¹¹

Table 3 below shows the product categories assessed in this report and the related standards referenced by the current *Energy Efficiency Regulations*.

⁷ Environment Canada, *Clean Air Regulatory Agenda: Background*, <http://www.ec.gc.ca/default.asp?lang=En&n=56D4043B-1&news=295B1964-9737-4F80-B064-B3088D9910BE> (Last accessed February 5, 2018).

⁸ Natural Resources Canada, *Notice – Publication of Energy Efficiency Regulation, 2016- Amendment 13*. December 2016, available at <<http://www.nrcan.gc.ca/energy/regulations-codes-standards/18419>> (Last accessed February 5, 2018)

⁹ Natural Resources Canada, *Amendment to Canada's Energy Efficiency Regulations for Lighting Products*, January 2014, available at <<http://www.nrcan.gc.ca/energy/regulations-codes-standards/12342>> (Last accessed February 5, 2018)

¹⁰ Nova Scotia Canada, *New Law Means Road Lighting in Nova Scotia Must Be LED*, September 12, 2012, available at <<http://novascotia.ca/news/release/?id=20120912004>> (Last accessed February 5, 2018)

¹¹ Nova Scotia Canada, *Summary of Changes Nova Scotia Building Code Regulation*, July 2013, available at <<http://www.novascotia.ca/dma/firesafety/buildingcode/docs/130625summaryofchangesnovascotiabuildingcoderegulation2.pdf>> (Last accessed February 5, 2018).

**Table 3: Product Categories and Codes Impacted by Recent Changes to
Nova Scotia's Energy-Efficiency Regulations**

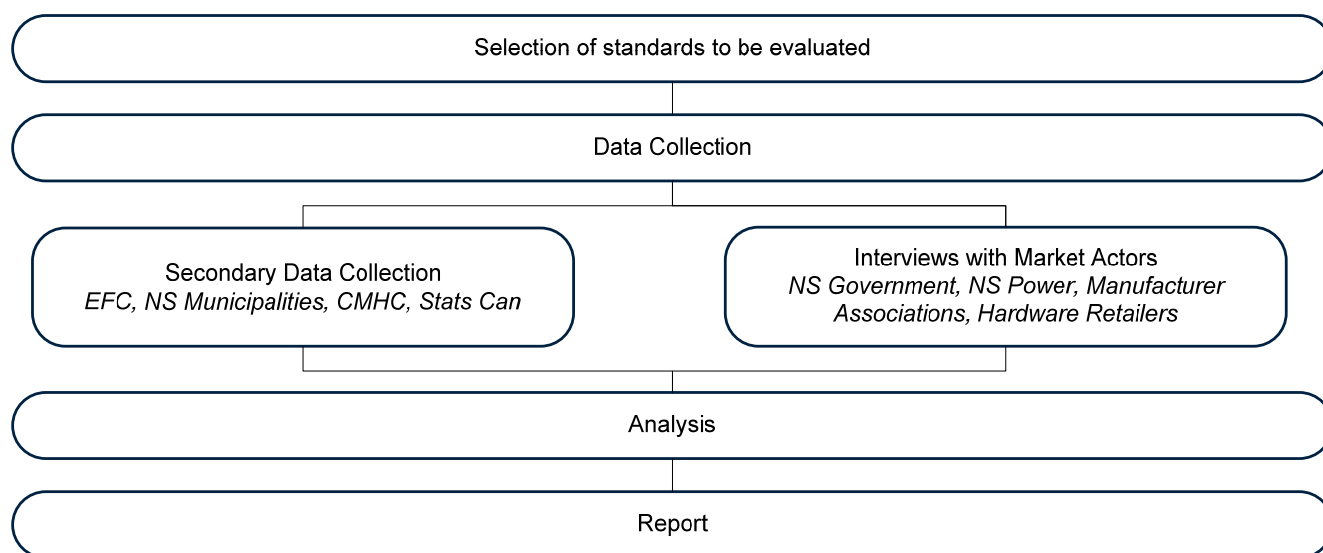
Product Category	Existing MEPS before Provincial Initiative	Reference Standard
Incandescent light bulbs (75 W and 100 W)	Yes	CAN/CSA C862-09
Incandescent light bulbs (40 W and 60 W)	Yes	CAN/CSA C862-09
LED street lights	No	CAN/CSA C653-13
National Energy Code for Houses and Small Buildings – National Building Code (NBC) – Revision 2012 – Part 9	Yes	Model National Energy Code for Buildings (MNECB) 1997
National Energy Code for Large Buildings, Condos and Apartments – Revision 2012 – Part 9	Yes	MNECB 1997
Clothes Washers – Tier 1	Yes	CAN/CSA-C360-13
Refrigerators	Yes	CAN/CSA-C300-15

To evaluate the impact of these regulations, Efficiency Nova Scotia (ENS) hired the Evaluator to assess the annual energy and peak demand savings achieved as a result of the introduction of these regulations into the Nova Scotia market. The Codes & Standards (C&S) evaluation was carried out annually from 2012 to 2017 as part of ENS's annual evaluation.

2 METHODOLOGY

Figure 1 below illustrates the research strategy used and the various activities carried out as part of the 2017 evaluation.

Figure 1: Methodological Model



The purpose of the 2017 evaluation was to quantify the annual impact of five regulations introduced in the Nova Scotia market. To this end, three major parameters were established:

- › the market size of each product category;
- › the proportion of the market on which the regulations have had an impact; and
- › the unitary savings values associated with each regulation, i.e., the difference between the energy consumption of products under the previous MEPS (baseline) and the energy consumption of products that meet the new regulations.

These parameters were assessed based on the information gathered from secondary data research and interviews with market actors and then compiled and analyzed, as described in more detail below.

Secondary Data Collection

This evaluation made extensive use of the market data provided by industry associations, particularly Electro-Federation Canada (EFC, with lamp shipment data), the Association of Home Appliance Manufacturers (AHAM Canada), NRCAN, Nova Scotia Municipalities (with street light stock data), the Canada Mortgage and Housing Corporation (CMHC, with building statistics), and Statistics Canada (Stats Can, with building permit data). These sources provided monthly, quarterly or annual data for 2017. An informal survey of other jurisdictions was also completed to better understand light-emitting diode (LED) street light programs in other jurisdictions in Canada.

To characterize the incandescent bulb market, the declining shipment trend from 2004 to 2013 (2013 was the last year before the standard was implemented) was used to make projections about the 2017 market.

When it was necessary to quantify the market size in Nova Scotia, the proportion of Atlantic Canada's shipments was usually estimated based on the provincial population ratios from the latest Statistics Canada data. Consequently, it was estimated that of all the evaluated product categories, the shipments delivered to Nova Scotia accounted for 39.8 percent of the total shipments sent to Atlantic Canada.

A number of research studies were also consulted and have been listed in footnotes where appropriate.

The methodology used to estimate the market sizes for all product categories is summarized in Table 4 below.

Table 4: Methodology Used to Estimate Market Sizes

	Method for Estimating Total Shipments Sent to Canada or the Atlantic Region	Method for Estimating Shipments Sent to Nova Scotia	Product Categories
Industry Associations	Database for 2017 in units or in dollar amounts	Using the population ratio of Nova Scotia (compared with Canada or the Atlantic Region)	› Incandescent lamps › Building construction
CMHC/Stats Can	Building statistics about NS	Already specific to Nova Scotia	› New energy code
Nova Scotia Municipalities & NS Power	Street light inventory	Already specific to Nova Scotia	› LED street lights
Association of Home Appliance Manufacturers	Database for 2017 in units or in dollar amounts	Using the population ratio of Nova Scotia (compared with Canada or the Atlantic Region)	› Refrigerators › Clothes washers

Interviews with Market Actors

From early December 2017 to the end of January 2018, representatives from industry associations and retailers provided help in explaining the data, confirming its reliability and indicating how to best use it for the evaluation. Information was also gathered from exchanges with Nova Scotia's municipal staff, provincial staff, and Nova Scotia Power (NSP). These interviews were valuable for understanding data updates for 2017, changes in the expected energy savings, and market activity.

The interviews with retailers stemmed from conversations with lamp manufacturer associations, who indicated that retailers continued to sell products after shipments stopped from manufacturers. Industry association and retailer representatives reported on the continuous availability of products and incandescent bulbs' current consumption patterns.

Analysis

Once all the interviews were completed and the data was collected, market size estimates were developed. Once the market size for each product category and the portion of the market impacted by the regulations were determined, it was possible to estimate: (1) the number of units impacted by the introduction of the new regulations in Nova Scotia; and (2) the savings resulting from each of the regulations, using the unitary savings values determined based on secondary data research.

The Evaluator made efforts to ensure that there was no overlap or double-counting with savings from ENS programs. The savings attributable to C&S have resulted from increasing the mandatory minimum efficiency applicable to the targeted products and building codes in the market. Although similar products and buildings are targeted by ENS programs, it should be noted that their savings are distinct from those generated by C&S. The savings associated with ENS programs are based on an increase in product efficiency compared to the minimum efficiency standard or the current baseline of that product category, whereas C&S savings have resulted from an increase in the regulated minimum efficiency standard. Thus, evaluated savings from C&S do not overlap with those of ENS's programs.

3 IMPACT EVALUATION

3.1 Incandescent Lamps

3.1.1 Product Description

For over 100 years, incandescent lamps have been widely used for lighting applications and their design and energy use have remained almost unchanged. Incandescent lamps are very inefficient converters of energy to light; most of the energy consumed is emitted as heat. Several other categories of products can meet consumers' lighting needs. However, until the late 2000s, their lighting characteristics and their costs did not provide consumers with a strong enough incentive to abandon the high-energy-consuming incandescent bulbs.

3.1.2 Regulation Description

Amendment 10 to the Regulations Amending the Energy Efficiency Regulations was developed and put into effect on January 1, 2012 to enable a phased-in introduction of lighting standards. The regulation was intended to encourage the use of higher-efficiency lamps to help replace and phase out incandescent bulbs, which are a major electricity end-use for lighting. This amendment was expected to result in a 30 percent improvement in overall lighting efficiency and electricity consumption.

In response to concerns raised by retailers, Amendment 12B was introduced, and the phased-in introduction was postponed by two years until January 1, 2014. The rationale for this delay was to allow more time for educating Canadians about the benefits of choosing energy-saving lighting solutions, for making further technology advances, and for addressing environmental and health concerns related to compact fluorescent lamps (CFLs).

Amendment 12B is intended to achieve three main objectives:

- › to provide Canadian customers with more lighting options, specifically a bulb which closely resembles and performs like a traditional incandescent bulb;
- › to reduce the regulatory compliance burden on the industry; and
- › to support the government's regulatory policy of aligning with the American standards, where feasible.

Energy impacts associated with the introduction of these standards were gradually felt for a number of reasons, including that the phase-out of incandescent bulbs was designed to be completed in two stages, as listed in Table 5: (1) effective on January 1, 2014, the regulations with respect to 100 W and 75 W bulbs came into force; and (2) the regulations with respect to 60 W and 40 W bulbs came into force on December 31, 2014. The new regulations require a level of lighting efficiency similar to that of a halogen incandescent bulb.

Table 5: Schedules for Light Bulbs' Compliance with New Standards¹²

Traditional Incandescent Light Bulb	Light Bulb New Standards	Type of Light Bulb		Effective Date
Maximum Wattage	Maximum Wattage	Standard Spectrum (Lumen Range)	Modified Spectrum (Lumen Range)	Manufactured On or After
100 W	72 W	1,490 – 2,600	1,118 – 1,950	January 1, 2014
75 W	53 W	1,050 – 1,489	788 – 1,117	January 1, 2014
60 W	43 W	750 – 1,049	563 – 787	December 31, 2014
40 W	29 W	310 – 749	232 – 562	December 31, 2014

The lighting market offers Canadian customers three main types of products that meet the maximum wattage requirements set by the new standard, namely the incandescent halogen, the CFL and the LED.

3.1.3 Market Size Estimate

EFC provided information about lighting product shipments to Atlantic Canada from 2004 to the end of 2017 and this information was converted into estimates for Nova Scotia. 2013 was the last year for receiving such shipments before the 75 W and 100 W new energy efficiency requirements were implemented. 2014 was the last year of shipment before the 40 W and 60 W requirements were implemented. The declining trend in shipments from 2004 to 2013 (-5.56% annual average) was applied to the 2013 data to estimate the expected market size for 2017, if the new standards had not been in force. The Evaluator selected 2013 as the final baseline year since the data provided by EFC is not categorized by wattage level, and applies instead to all lamp wattages. An estimate of wattage breakdown was obtained during the interview with EFC, which suggested the respective proportions for 100 W (24%), 75 W (2%), 60 W (65%) and 40 W (9%), based on an average for the historical sales of these product categories. These proportions can be applied to the market size until 2013, but do not reflect the market size since the implementation of the new standards in 2014. As such, it was decided to choose 2013 as the final baseline year.

Table 6 presents the projected market size in 2017 for a projected scenario where the standard was not implemented and compares it to actual shipment data obtained through EFC for the same year. The Evaluator assumes that the actual shipment quantities for 60 W and 40 W lamps represent incandescent lamp categories that are not affected by the new standards, such as R-shape and BR-shaped incandescent reflector light bulbs.

¹² Natural Resources Canada, *Amendment to Canada's Energy Efficiency Regulations for Lighting Products*, January 2014, available at <<http://www.nrcan.gc.ca/energy/regulations-codes-standards/12342>> (Last accessed February 5, 2018)

Table 6: Incandescent Lamp Market Size Estimate for Nova Scotia, 2017

Product Class	Projected Nova Scotia Market in 2017 (lamps)	Actual Shipments to Nova Scotia in 2017 (lamps)
100 W	200,087	-
75 W	16,674	-
60 W	541,903	346,025
40 W	75,033	47,911

3.1.4 Portion of the Market Impacted by the Regulation

The difference between the projected 2017 market and the actual shipments represents the impact achieved by the standard, as summarized in Table 7.

Table 7: Estimate of the Portion of the Incandescent Bulb Market Impacted by the Regulation

Product Class	Percentage of Total Projected Shipments to Nova Scotia Affected by the Regulation in 2017	Shipments to Nova Scotia Affected by the Standard in 2017 (lamps)
100 W	100%	200,087
75 W	100%	16,674
60 W	36%	195,878
40 W	36%	27,122

3.1.5 Unitary Savings Values

The minimum peak demand savings (W/unit) estimates have been made based on the data shown in Table 7 above. For example, a 100 W bulb must be replaced by a bulb of no more than 72 W (28 W savings). The annual energy savings (kWh/unit) estimates have been made based on the average annual usage of these products, as listed in Table 8. The overall average number of hours of use is estimated at 2.9 hours per day (the same value used in the Instant Savings program component). The Evaluator elected to use the hours of use from the residential sector since 90 percent of all incandescent lamps were sold in that sector. These estimates are applied to the peak demand savings per unit to calculate the annual energy savings estimates.

Table 8: Unitary Savings Values for Incandescent Lamps¹³

Product Category	Peak Demand Savings (W/unit)	Annual Energy Savings (kWh/unit)
100 W	28	30
75 W	22	23
60 W	17	18
40 W	11	12

3.1.6 Interactive Effects

In a home, interactive effects occur when the implementation of energy-efficiency measures has an impact on the energy consumption of other elements, such as heating and cooling. In the case of C&S, replacement of incandescent lamps with more efficient products, such as halogen incandescent lamps, causes an increase in the heating load during winter and a decrease in the cooling load during summer.

Table 9 below shows the interactive effects factor calculations for lighting products. These interactive effects were calculated as part of the Efficient Product Installation (EPI) program component evaluation. They were updated in 2017 by taking into consideration: (1) the percentages of houses using electric heating and air conditioning based on the information in the EPI tracking sheet, and (2) the addition of heat pumps to the existing combinations of heating and cooling systems. As with the assessment of the hours of use for the unitary savings values, the assessment of the interactive effects was focused on the residential sector since it was in this sector that 90 percent of the sales of incandescent lamps occurred.

Table 9: Interactive Effects Calculation for Lighting Products

Parameter	% of Homes	Energy Interactive Effects Factor ¹⁴	Peak Demand Interactive Effects Factor
Heat Pump Heating and Air Conditioning	13%	-24.0%	-90.0%
Electric Heating with Air Conditioning	8%	-54.4%	-90.0%
Electric Heating without Air Conditioning	24%	-58.0%	-90.0%
No Electric Heating with Air Conditioning	11%	3.6%	0%
With Neither Electric Heating Nor Air Conditioning	44%	0%	0%
Weighted Interactive Effects Factor	100%	-17.7%	-40.4%

¹³ Natural Resources Canada, *Energy Efficiency Act: Regulations Amending the Energy Efficiency Regulations*, September 22, 2011, available at <<http://canadagazette.gc.ca/rp-pr/p2/2011/2011-10-12/html/sor-dors182-eng.html>> (Last accessed February 5, 2018)

¹⁴ ADS ASSOCIÉS, *Évaluations des effets énergétiques combinés des mesures d'économies d'énergie – résidence unifamiliale*, report presented to Hydro-Québec, 1992.

3.1.7 At the Meter Energy Savings

The Evaluator estimates that the phase-out of incandescent light bulbs in Nova Scotia allowed for achieving a total of 8.425 GWh in energy savings in 2017, as summarized in Table 10.

Table 10: Energy Savings Associated with the Phase-out of Incandescent Light Bulbs in the Nova Scotia Market

Product Class	Shipments to Nova Scotia Affected by the Standard in 2017 (lamps)	Annual Energy Savings (kWh/yr/lamp)	Interactive Effects Factor	Total Energy Savings at the Meter in 2017 (GWh)
100 W	200,087	30	-17.70%	4.940
75 W	16,674	23	-17.70%	0.316
60 W	195,878	18	-17.70%	2.902
40 W	27,122	12	-17.70%	0.268
Total	439,761			8.425

3.1.8 At the Meter Peak Demand Savings

The peak demand savings correspond to the demand savings that coincide in time with the peak demand of the electricity system. The projected electricity-demand peak period in Nova Scotia is between 5 p.m. and 7 p.m. from December through February on a non-holiday weekday. In the evaluations of previous years, the peak demand savings were calculated using the on-peak demand-to-energy ratios developed by Navigant in the 2016-2018 demand-side management (DSM) Plan. These ratios were established for various measure categories, based on modelled system-coincident peak demand savings and energy savings for a projected deployment of measures. Navigant used local data to establish a ratio of 0.249 W/kWh for lighting products. For 2017, the Evaluator decided to compare the data obtained from the Residential Lighting Metering Study¹⁵ conducted in the EPI program component with the values found in the literature.

¹⁵ The Residential Lighting Metering Study is presented in the Appendix Report of the Existing Residential Program.

The study analyzed the hours of use values specifically for the peak demand period of the electricity system for each room type. The results showed that the peak-demand-to-energy ratio previously used for residential lighting (0.249 W/kWh) was overestimated, since the average value was established at 0.161 W/kWh $\pm$ 0.016 W/kWh. The Evaluator compared these results with those from the Northeast Residential Lighting Hours-of-Use Study (NERHOU),¹⁶ which obtained a result corresponding to a peak-demand-to-energy ratio of 0.162 W/kWh (with a peak coincidence factor of 16% and 2.7 hours of use per day). The Evaluator recommends using this result as it is very close to the 0.161 W/kWh obtained in the Residential Lighting Metering Study. In addition, the margin of error in the NERHOU study was one percent, which is lower than the 10 percent obtained in the Residential Lighting Metering Study. Furthermore, the sample also includes outdoor lamps (with proportions similar to those in EPI), thus eliminating the need to make assumptions for calculating their specific peak-demand-to-energy ratio. Therefore, the Evaluator recommends applying the NERHOU study result of 0.162 W/kWh to all indoor and outdoor lamps.

As shown in Table 11 below, the Evaluator estimates Nova Scotia's total peak demand savings at 0.988 MW in 2017.

Table 11: Peak Demand Savings Associated with the Introduction of Incandescent Bulbs Standards in the Nova Scotia Market

Product Class	Demand-to-energy Ratio (MW/GWh)	Interactive Effects Factor	Total Peak Demand Savings at the Meter in 2017 (MW)
100 W	0.162	-40.40%	0.580
75 W	0.162	-40.40%	0.037
60 W	0.162	-40.40%	0.340
40 W	0.162	-40.40%	0.031
Total			0.988

3.2 LED Street-lighting

3.2.1 Product Description

LED street lights provide a more energy-efficient means to meet the street-lighting requirements of Nova Scotia's municipalities. Many lighting manufacturers have been making strong efforts to develop LED products, and the technology has been advancing rapidly.¹⁷

¹⁶ NMR Group Inc. and DNV GL, *Northeast Residential Lighting Hours-of-Use Study*, May 5, 2014, p. 69.

¹⁷ DMD and Associates Ltd., *Energy Efficient Street Lighting Strategies for Nova Scotia Municipalities*, July 16, 2009, available at <https://unsm.ca/doc_download/1543-street-lighting-final-report-2009-07-16.html> (Last accessed February 5, 2018)

3.2.2 Regulation Description

In May 2011, the province of Nova Scotia passed legislation requiring lighting on Nova Scotia roads and highways to be replaced by LED lighting. Nova Scotia is the first Canadian province to commit to switching to LED for its existing street lights. Most street lights in the province are owned by NSP, while the remaining stock is owned by municipalities. NSP has until December 31, 2019¹⁸ to complete the replacements, while municipalities have until December 31, 2022.

The average life span of the most common street lights found in Nova Scotia (high-pressure sodium lights) is about five years, meaning that most of the existing stock will require replacement at some point well within the next 10-year period.

3.2.3 Market Size Estimate

In 2009, the Union of Nova Scotia Municipalities commissioned DMD & Associates Ltd.¹⁹ to prepare “Energy Efficient Street Lighting Strategies for Nova Scotia Municipalities”. As part of this work, a complete inventory of all the street lights in the province was compiled by type and 135,964 lights were reported in total. The inventory indicated the energy consumption range for an average month and the proportions respectively represented by various categories of lamps. The results are summarized in Table 12 below.

Table 12: Existing Lighting Units Inventory in Nova Scotia, 2009

Type	Energy Consumption Range for an Average Month (kWh/month)	Proportion of Inventory	Proportion of Total Power Consumed
High-pressure sodium	From 32 to 150	82%	73.5%
Mercury vapour	From 43 to 363	12%	16.0%
Metallic additive	From 50 to 360	2%	4.0%
Others :		4%	6.5%
> Incandescent	From 97 to 154	-	-
> Low-pressure sodium	From 60 to 80	-	-
> Fluorescent	From 30 to 222	-	-

¹⁸ Nova Scotia Canada, *Energy-efficient Appliances Regulations made under Section 5 of the Energy-efficient Appliances Act*, < <https://www.novascotia.ca/just/regulations/regs/eeappliances.htm>> (Last accessed February 5, 2018)

¹⁹ DMD and Associates Ltd., *Energy Efficient Street Lighting Strategies for Nova Scotia Municipalities*, July 16, 2009, available at <https://unsm.ca/doc_download/1543-street-lighting-final-report-2009-07-16.html> (Last accessed February 5, 2018)

3.2.4 Portion of the Market Impacted by the Regulation

In its report, DMD & Associates Ltd. estimated that the street lights' total electricity consumption in 2009 was 88,886,988 kWh. This would mean an annual average electricity use level of 653.8 kWh per lighting unit and an average power demand of 163 W per existing lighting unit, based on an annual total of 4,000 hours of operation per lighting unit.²⁰

A significant development related to the installation of LED street lights in Nova Scotia occurred in 2014. The Halifax Regional Municipality (HRM) took over the full ownership of all the street lights in its jurisdiction; approximately 44,000 units (one third of all the lights in the province). Two-thirds of these lights were previously owned by NSP. The ownership transfer occurred on August 1, 2014. Approximately 7,000 units had already been replaced with LEDs. HRM awarded a contract to a private firm in the fall of 2015 to replace the remaining units. During 2017, the contract was increased by \$8.0 million as HRM is discovering that more street lights are in existence than NSP information originally suggested.

During an interview with the Evaluator in January 2018, HRM officials reported that a total of 41,431 fixtures in the municipality had been converted by then. Since 6,000 units were claimed in the 2015 evaluation and 16,099 units were claimed in the 2016 evaluation, it can be concluded that an additional 19,332 units were installed in 2017.

NSP reported in 2015 that the total number of lights in its post-sale asset pool was 42,791, which are being scheduled for replacement over the next few years. As part of this year's evaluation, a request was sent to NSP for the number of replacements with LED lights completed in 2017. NSP declared that they had replaced 2,353 units in 2017.

It is estimated that in Nova Scotia a total of 21,685 LED street lights were replaced in 2017. This figure is the sum of the units replaced by HRM and NSP.

This estimate of 21,685 LED street lights installed in 2017 may be an underestimated figure since some municipalities owning their streetlights did not respond to the Evaluator's request for information.²¹ It should also be noted that the provincial Department of Transportation and Infrastructure Renewal reported that it had completed conversions prior to 2016 on all 100-series highways. The municipalities of Digby, East Hants, the Village of Kingston and the Town of Trenton completed all their conversions prior to 2016 as well.

²⁰ Nova Scotia Power, *Street and Area Lighting*, <<http://www.nspower.ca/en/home/about-us/electricity-rates-andregulations/rates/street-and-area-lighting.aspx>> (Last accessed January 29, 2017).

²¹ NSP, the Nova Scotia Department of Transportation and Infrastructure Renewal, and municipalities that own street lights were all contacted as part of this evaluation.

3.2.5 Unitary Savings Values

The Evaluator assumes that NSP replaced the least efficient units first (i.e., with a higher energy consumption level than the average consumption of the existing lighting units in Nova Scotia). The total reduction in energy need of those lights depends on the types replaced. However, since the efficiency levels of the replaced units are unknown, the Evaluator used a conservative approach by applying the average consumption value of 653.8 kWh per lamp for the 21,685 units replaced, resulting in 14,177,653 kWh in total energy consumption.

To estimate the total reduction in energy use resulting from replacements with LEDs, the Evaluator conducted a literature review of LED street-lighting study cases from other jurisdictions.

Table 13: Literature Review of LED Street-lighting Study Cases

Baseline - Existing Fixture	Minimum Savings	Maximum Savings	Average Savings	Source
High-pressure sodium 100 W	0%	41%	24%	Street lights for local roads, National Lighting Product Information Program, February 2011 ²²
High-pressure sodium 100 W	36%	68%	46%	Nova Scotia LED Roadway Lighting Pilot Installations, DMD & Associates Ltd., 2010 ²³
High-pressure sodium 100 W – 400W	31%	51%	39%	GATEWAY Program, Kansas City, 2013 ²⁴
High-pressure sodium 150 W	26%	57%	45%	GATEWAY Program, New York State, 2011 ²⁵
High-pressure sodium 150 W	10%	40%	25%	GATEWAY Program, Philadelphia, 2011 ²⁶

²² National Lighting Product Information Program, *Street Lights for Local Roads*, February 2011, available at <http://www.lrc.rpi.edu/programs/NLPIP/PDF/VIEW/SR_StreetlightsLocal.pdf>, (Last accessed January 5, 2018).

²³ DMD & Associates Ltd., *Nova Scotia LED Roadway Lighting Pilot Installations*, March 19, 2010, available at <<http://docshare01.docshare.tips/files/25144/251443242.pdf>> (Last accessed January 5, 2018).

²⁴ Office of Energy Efficiency and Renewable Energy, *Demonstration of LED Street Lighting*, June 2013, available at <http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2013_gateway-msslc_kc.pdf>, (Last accessed January 5, 2018).

²⁵ Office of Energy Efficiency and Renewable Energy, *Demonstration Assessment of Lighting-Emitting Diode (LED) Roadway Lighting*, December 2011, available at <apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2011_gateway_fdr-drive.pdf>, (Last accessed January 5, 2018).

²⁶ Office of Energy Efficiency and Renewable Energy, *SSL Demonstration: Roadway Lighting Philadelphia*, June 2013,, available at <http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/philadelphia_brief.pdf> (Last accessed January 5, 2018).

Although a similar baseline (high-pressure sodium) was used and most methodologies met the Illuminating Engineering Society of North America RP-8-00²⁷ criteria of the American National Standard Practice for Roadway Lighting, various levels of average savings were found, as listed in Table 13. A number of differences could have led to varying estimates in the levels of average savings, including the illuminance level differences between the existing roadway street lights and the new ones, and the efficiency of particular LED street lights. Furthermore, the specifications of the LED street-lighting installed by NSP were unknown. In light of these observations, a conservative approach was used: calculating a rounded average of the energy savings reported by all study cases reviewed. The rounded average was established at 35 percent and it was used to estimate the energy and peak demand savings. Thus, a unitary energy savings value of 229 kWh per street-lighting unit and a displaced wattage of 57 W per street-lighting unit were considered.

3.2.6 At the Meter Energy Savings

The total energy savings associated with the 21,685 LED lighting units installed in 2017 is estimated at 4.966 GWh, as summarized in Table 14 below.

Table 14: Energy Savings Associated with the Introduction of LED Street-lighting in the Nova Scotia Market

Product Class	Number of Lighting Units Replaced in 2017	Annual Energy Savings (kWh/unit)	Total Incremental Energy Savings at the Meter in 2017 (GWh)
LED Street Lighting (HRM and NSP)	21,685	229	4.966
Total	21,685		4.966

3.2.7 At the Meter Peak Demand Savings

The Evaluator estimates that 1.236 MW was saved at the meter in Nova Scotia in 2017 as a result of introducing LED street-lighting. As shown in Table 15 below, the peak coincidence factor of 100 percent was considered because savings always occur during the winter peak load period.

Table 15: Peak Demand Savings Associated with the Introduction of the LED Street-lighting in the Nova Scotia Market

Product Class	Number of Lighting Units Replaced in 2017	Peak Demand Savings (W/unit)	Peak Coincidence Factor (%)	Total Peak Demand Savings at the Meter in 2017 (MW)
LED Street Lighting (HRM and NSP)	21,685	57	100%	1.236
Total	21,685			1.236

²⁷ Illuminating Engineering Society of North America, <http://www.ies.org/>

3.3 New Building Energy Codes

3.3.1 Product Description

November 2011, the Canadian Commission on Building and Fire Codes released the National Energy Code for Buildings (NECB). This enhanced the minimum requirements for the design and construction of energy-efficient buildings contained in the 1997 MNECB. Generally, national building codes serve as guidance documents for provinces that can either develop their own or adopt the national standards.

The adoption of the NECB 2011 was gradually carried out across the Canadian provinces. Ontario²⁸, British Columbia²⁹ and Nova Scotia³⁰ have already implemented the 2011 NECB or an energy equivalent standard for large buildings. These adoptions are contributing to the fact that the building sector is shifting towards a higher energy efficiency level.

Nova Scotia's Building Code is based on the national code. In Nova Scotia, the NECB 2011 was adopted on December 31, 2013, but enforcement started one year later on December 31, 2014.³¹ Large buildings, condos and apartments are covered by the NECB 2011. However, new houses and small buildings are not covered;³² instead, they are covered by Revision 2012 of Part 9 of the NBC. In Nova Scotia, the 2012 Revision of the NBC (Part 9) was adopted in July 2013 and has also been in force since December 31, 2013. The following section looks at the annual incremental impact of this new regulation on new houses and small buildings as well as large buildings, condos and apartments in 2017.

²⁸ Government of Ontario - Ministry of Municipal Affairs and Housing, Ontario Building Code, *Are you ready? 2012 Requirements for New Construction*, December 2011, available at <http://www.oboa.on.ca/news/files/pamphlet2011.pdf> (Last accessed February 5, 2018).

²⁹ Government of British Columbia, Information Bulletin – Building and Safety Standards Branch, *New Energy Requirements*, May 22, 2013, available at < https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/construction-industry/building-codes-and-standards/bulletins/b13-05_new_energy_requirements.pdf> (Last accessed February 5, 2018).

³⁰ Nova Scotia Canada, *Summary of Changes Nova Scotia Building Code Regulation*, July 2013, available at <<http://www.novascotia.ca/dma/firesafety/buildingcode/docs/130625summaryofchangesnovascotiabuildingcoderegulation2.pdf>> (Last accessed February 5, 2018).

³¹ Nova Scotia Canada, *Nova Scotia Building Code Regulations – Made Under Section 4 of the Building Code Act*, <<https://novascotia.ca/just/regulations/regs/bcregs.htm>> (Last accessed February 28, 2017).

³² ²⁹ Nova Scotia Canada, *Summary of Changes Nova Scotia Building Code Regulation*, July 2013, available at <<http://www.novascotia.ca/dma/firesafety/buildingcode/docs/130625summaryofchangesnovascotiabuildingcoderegulation2.pdf>> (Last accessed February 5, 2018).

3.3.2 Regulation Description

In 2012, a new section entitled “Section 9.36. Energy Efficiency” was introduced to Part 9 (Houses and Small Buildings) of the 2010 edition of the NBC of Canada. This section was adopted to replace the former Part 10 of the Nova Scotia Building Code Regulations, which was originally adopted in 2009. By adopting the NBC for energy efficiency, Nova Scotia has aligned itself with agreed-upon minimum national standards for energy efficiency in the design and construction of houses and small buildings (smaller than 600 square meters).³³ These requirements were extensively reviewed both nationally and provincially with the participation of stakeholders from the energy conservation, construction and regulatory sectors. The NBC is aligned with the energy conservation measures supported by the federal and provincial energy departments and agencies for programs including EnerGuide for New Homes and for products displaying the ENERGY STAR® symbol, as well as other similar programs. In 2007, the Premiers’ Council of the Federation encouraged the responsible departments of provincial and territorial governments to request the National Research Council to provide a new updated NECB for large buildings, condos and apartments. The work to update the NECB began in 2008 and the new revised NECB was published in late 2011. Similar to the energy requirements for houses and small buildings, the NECB is aligned with energy conservation measures supported by the federal and provincial energy ministries and agencies.

3.3.3 Market Share Estimate

To estimate the market share, the Evaluator analyzed the data available from Statistics Canada regarding the monetary value represented by the building permits for residential and commercial/industrial buildings in the province of Nova Scotia. At the time of writing, data for 2017 was only available for January to the end of November. Table 16 below lists the key figures about building permits in Nova Scotia until November 2017.

³³ Nova Scotia Canada, *Summary of Changes Nova Scotia Building Code Regulation*, July 2013, available at <<http://www.novascotia.ca/dma/firesafety/buildingcode/docs/130625summaryofchangesnovascotiabuildingcoderegulation2.pdf>> (Last accessed January 29, 2017).

**Table 16: Key Figures about Nova Scotia's Building Permits
for January through November 2017**

	Total Value³⁴ (\$)	Estimated Floor Area (m²)
Residential	903,664,000	584,405 ³⁵
Non-residential	442,993,000	N/A
Commercial	294,678,000	109,170 ³⁶
Institutional/Government	82,924,000	30,665 ³⁷
Industrial	65,391,000	43,594 ³⁸

Similar to 2016, the total monetary value of building permits for commercial construction was about one-third of that of residential construction.

Houses and Small Buildings

Table 17 below shows the number of single house building permits issued in the residential sector in 2017.

**Table 17: Number of Dwelling Units – Data about Nova Scotia's Residential Building Permits
for January through November 2017³⁹**

	Single Houses (Detached and Mobile Homes)	Value of Building Permits (\$)	Estimated Floor Area (m²)
Houses and small buildings	1,740	405,420,000	289,586

The estimated residential market share has been determined on the basis of single residential units.

Table 17 shows that, by the end of November 2017, the total number of units was 1,740. The table also shows that the total monetary value of the single residential building permits issued in 2017 was over \$405.4 million, and the estimated total floor area was 289,586 m².

³⁴ Statistics Canada, *Catalogue No. 64-001-X, Building Permits*, December 2015, available at <http://www.statcan.gc.ca/pub/64-001-x/64-001-x2015012-eng.pdf> (Last accessed January 15, 2018).

³⁵ To calculate the residential square meter values, the estimates are made based on the assumption that: construction costs are \$143.176 per square foot. The total square foot figure is divided by 10.8 to convert it to a square meter figure.

³⁶ Based on construction costs of \$2,699.25 per square meter (all base year construction costs considered using Stats Can 327-0043).

³⁷ Based on construction costs of \$2,704.19 per square meter.

³⁸ Based on construction costs of \$1,500 per square meter.

³⁹ Statistics Canada, *Catalogue Table 026-0002 Building permits, dwelling units by type of dwelling and area*, 2016, available at <http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=260002> (Last accessed January 15, 2018).

Large Buildings, Condos and Apartments

Large buildings, apartments and condominiums are now covered by the 2012 Revision of Part 9 of the NBC. Therefore, these categories have been included in the energy savings estimates. The estimates of the market share associated with these categories are shown in Table 18.

The first line in Table 18 provides an estimate of the multiple housing units assumed to be apartment and condominium complexes. In total, based on the building permit data, it is estimated that the construction of 2,336 units has followed the National Energy Code in 2017. The dollar value of the residential apartment and condominium building permits is \$498.2 million. The estimated floor area is 294,819 m². Information about the number of buildings is not available from any published source. The Evaluator has assumed that most complexes are large and each complex on average is comprised of 50 units, meaning 63 buildings were built.

Table 18 also shows an estimate of the level of activity in the commercial sector as suggested by the building permit data. The total monetary value of the building permits for the commercial sector was \$295 million. By applying an assumed construction cost factor,⁴⁰ it is estimated that the total floor area of new buildings in the commercial sector is 109,170 m². To estimate the energy use associated with the commercial sector, a breakdown has been made between large-scale and small-scale development projects.

There is no published data available on this breakdown. The Evaluator used the findings from a 2009 NRCAN study, which reviewed energy use by the commercial sector in Canada.⁴¹ It contained data on the existing stock of buildings in Atlantic Canada. The Evaluator used this data as a means to estimate a reasonable breakdown between small and large structures based on the 2017 building permit data. Using the split ratio from the 2009 NRCAN study, the Evaluator has established that 8,325 m² of the floor area is attributable to small-scale commercial development projects and 100,845 m² to large-scale projects.

The total monetary value of the building permits for the industrial sector was \$65.4 million. By applying an assumed construction cost factor,⁴² it is estimated that the total floor area of industrial buildings built in 2017 is 43,594 m².

⁴⁰ Based on construction costs of \$2,800 per square meter for both small-scale and large-scale commercial development projects.

⁴¹ Natural Resources Canada completed a survey of commercial and industrial energy use in 2009 (CAT No. M 144 – 4/1-2012). In table F1 of that survey, the ratio of large to small buildings in Atlantic Canada was 92.3: 7.7 on a per-m² basis. The Evaluator has used the same ratio in this calculation. Natural Resources Canada, *Survey of Commercial and Institutional Energy Use – Buildings 2009*, December 2012, available at https://oee.nrcan.gc.ca/publications/statistics/scieu09/scieu_e.pdf (Last accessed January 15, 2018).

⁴² Based on a construction cost of \$1,500 per square meter.

Table 18: Estimated Floor Areas in the Commercial and Industrial Sectors

	Units	Value of Permits (\$)	Estimated Floor Area (m ²)	Number of Buildings
Residential Multiple Units	2,336 ⁴³	498,224,000 ⁴⁴	294,819 ⁴⁵	63 ⁴⁶
Commercial	N/A	294,678,000	109,170	76
Small		22,395,000	8,325	25
Large		272,283,000	100,845	51
Industrial	N/A	65,391,000	43,594	11

3.3.4 Unitary Savings Values

The Evaluator estimated the unitary savings values separately for (1) houses and small buildings and (2) large buildings, apartments and condos (including multi-unit residential units).

Houses and Small Buildings

NRCan performed analyses using HOT2000 simulations to establish the average energy performance level reached by the 2012 Revision of Part 9 of the NBC. As a result of these analyses, NRCan concluded that the average energy performance level corresponds to an EnerGuide rating of 78, based on the simulations made with Version 10 of the HOT2000 software.⁴⁷

The literature review conducted by the Evaluator did not show any detailed report of the practices followed in new construction in the residential market before the 2012 Revision was enforced. For the 2014 evaluation, ENS provided the Evaluator with a sample of 90 recently built houses (from 2010 to 2012) that participated in the Home Energy Assessment (HEA) program component just a few years after their construction. It can be assumed that most of these houses were built according to the standards of the industry. Therefore, the EnerGuide assessment ratings they obtained through their participation in HEA a few years later can be an indication of the baseline for standard residential houses built in Nova Scotia prior to the new regulation. The survey revealed an average EnerGuide rating of 77. Based on this analysis, the implementation of the new building regulations would result in an EnerGuide rating increase of 1.

⁴³ Statistics Canada, *Catalogue Table 026-0002 Building permits, dwelling units by type of dwelling and area*, 2016, available at <<http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=260002>> (Last accessed January 15, 2018).

⁴⁴ Statistics Canada, *Catalogue Table 026-0002 Building permits, dwelling units by type of dwelling and area*, 2016, available at <<http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=260002>> (Last accessed January 18, 2018).

⁴⁵ The estimated floor area is based on an assumption of approximately 1,000 sq. ft. per unit. To convert square feet values to square meters, a factor of 10.8 sq.ft per sq. meter is used.

⁴⁶ The majority of apartment and condominium buildings being built in Nova Scotia are large multi-storey buildings. The number of buildings is based on approximately 50 units per building on average.

⁴⁷ Natural Research Council Canada, *Energy Efficiency in Housing and Small Buildings – General Introduction*, March 2013, available at <http://www.nrc-cnrc.gc.ca/eng/solutions/advisory/codes_centre/presentations/2013/overview2013.html> (Last accessed February 5, 2018).

To determine the energy savings value of an EnerGuide rating point, the Evaluator used the unitary savings obtained from the 2015 evaluation, which was based on the evaluation of ENS's New Home Construction (NHC). In 2015, the Evaluator analyzed building simulations and used the houses' respective electricity billing data to calibrate the simulation results and estimate the gross energy savings in a more reliable manner. This analysis showed that the building simulations overestimated the electricity consumption by a margin of 16 percent compared to the actual billing data.

The average savings per EnerGuide point value was calculated for 2015 using the energy consumption values specific to NHC participants. The analysis was conducted for a total of 470 participants, including participants who used electricity as their main heating source and those who had both to-code and as-built EnerGuide ratings and consumption values available. Those participants with an unchanged EnerGuide rating were removed from the analysis. After selecting the participants, the Evaluator calculated the average savings per EnerGuide point of each participant, before calculating the sum of all the values.

The Evaluator established the overall average savings per EnerGuide point at 1,521 kWh/year. Using the overestimation ratio of 16 percent resulting from the billing analysis, the final savings value per EnerGuide point was established at 1,278 kWh/year.

The literature review conducted by the Evaluator regarding the current practices in Nova Scotia's residential market did not show any detailed information about the main heating source for new houses. According to a survey done by ENS in 2011, 33 percent of the existing households in Nova Scotia used electricity as a main heating source for their homes.⁴⁸ The Evaluator thinks that this ratio does not reflect the residential market of new construction.

Therefore, a cross-reference review of heating system types for new houses that participated in ENS's programs was conducted and a value of 91 percent was established for new houses built with electricity as their primary source for space heating. In fact, 91 percent of the houses from the ENS sample of 90 recently built houses and 89 percent of the houses registered in NHC in 2014 used electricity as their primary source for space heating. Since the number of units used to calculate the savings is already conservative (data for January through November 2017), the Evaluator decided not to apply any adjustment ratio to the percentage of households not heated electrically.

Moreover, in the ENS sample, 42 percent of the houses had an EnerGuide rating of 78 or higher and for these houses, the regulation enforced in 2014 was followed. This has resulted in a non-compliance rate of 58 percent, which was applied to the savings.

⁴⁸ Corporate Research Associates Inc., *2011 ENS Socket Study*, Final Report Prepared for Efficiency Nova Scotia, December 2011.

Large Buildings, Condos and Apartments

The National Research Council contracted Caneta Research Inc. in 2010 to prepare a report entitled “Performance Simulation of Proposed Changes to NECB Relative to MNECB and American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) 90.1-2007”.⁴⁹ This study was undertaken to determine the energy and operating cost savings associated with the proposed NECB – 2011 building code. As part of this study, the prescriptive requirements of each code were applied to six archetype buildings. Caneta then modelled the changes in seven locations in Canada; no modelling was done for Atlantic Canada. For this year’s evaluation, the Evaluator used the results in the Caneta study regarding Montreal as a proxy for Nova Scotia. The building archetypes used by the Caneta study for large buildings, apartments and condominiums are described in Table 19 below.

Table 19: Building Archetypes Used in the Caneta Study⁵⁰

Sector	Building Archetype	Building Size	Other
Multi-unit Residential	Mid-rise Apartment	3,900 m ²	3-storey
Small Commercial	Strip Mall	3,979 m ²	Ground floor only
Large Commercial	Large Office	13,380 m ²	10-storey
Industrial	Warehouse	3,891 m ²	1-storey building

Table 20 shows the Caneta study’s comparison of the estimated electric energy savings by building type. For ease of presentation, the electric energy savings have been calculated by comparing the annual energy consumption levels of NECB buildings with average MNECB and ASHRAE buildings.

Table 20: Electric Energy Savings by Building Type⁵¹

Building Type	Annual Energy Use (MWh)		Annual Savings (MWh)	Savings (%)
	NECB	Average of MNECB and ASHRAE		
Mid-rise Apartment	183.0	202.0	19.0	9.4%
Strip Mall	457.1	484.5	27.4	5.7%
Large office	1,595.0	1,836.5	241.5	13.2%
Warehouse	153.1	167.9	14.8	8.8%

Table 20 also shows the electric energy savings in percentages, ranging from 13.2 percent for large office buildings to 9.4 percent and 5.7 percent for mid-rise apartments and strip malls respectively. For warehouses, electric energy savings are estimated at 8.8 percent.

⁴⁹ Caneta Research, *Performance Simulation of Proposed Changes to NECB Relative to MNECB and ASHRAE 90.1-2007*, March 2011.

⁵⁰ Caneta Research, *Performance Simulation of Proposed Changes to NECB Relative to MNECB and ASHRAE 90.1-2007*, March 2011.

⁵¹ Caneta Research, *Performance Simulation of Proposed Changes to NECB Relative to MNECB and ASHRAE 90.1-2007*, March 2011.

Table 21 shows a comparison of the Caneta study's estimates of electricity peak demand savings across the building types. For ease of presentation, the electricity peak demand savings are calculated by comparing the peak demand values of NECB buildings and the averages of MNECB and ASHRAE.

Table 21: Electricity Peak Demand Savings by Building Type

Building Type	Peak Demand Use (kW)		Savings (kW)
	NECB	Average of MNECB and ASHRAE	
Mid-rise Apartment	89.1	95.3	6.2
Strip Mall	214.5	221.4	6.9
Large office	543.2	604.7	61.5
Warehouse	55.5	60.3	4.8

3.3.5 At the Meter Energy Savings

Houses and Small Buildings

The Evaluator estimates that the introduction of the regulation regarding the residential market generated 1.290 GWh in energy savings in Nova Scotia in 2017, as listed in Table 22.

Table 22: Energy Savings Associated with the Introduction of the Building Code Regulation in the Houses and Small Buildings Sectors in the Nova Scotia Market

Product Class	Number of Single Houses	Non-compliance Rate (%)	Annual Energy Savings (kWh/house)	Total Incremental Energy Savings at the Meter in 2017 (GWh)
Single houses	1,740	58%	1,278	1.290

Large Buildings, Condos and Apartments

To estimate the total energy savings associated with large buildings, apartments and condominiums, the Evaluator applied the per-square-meter energy-need factors found in the Caneta report, as shown in Table 23. These energy-savings factors were then applied to the estimated floor area of each of the subsectors. Then, the percentages of savings shown in the preceding sections were used to estimate the overall savings.

Table 23: Per-square-meter Electric Energy Needs by Building Archetype, as per the NECB

Building Archetype	Total Floor Area (m ²)	Electricity Used (MWh)	MWh/m ² Factor
Mid-rise Apartment	3,900	183.0	0.047
Strip Mall	3,979	457.1	0.115
Large office	13,380	1,595.0	0.119
Warehouse	3,891	153.1	0.039

The factors ranged from 0.047 MWh/m² for mid-rise apartments to 0.119 MWh/m² for a strip mall in the commercial sector. For warehouses (in the industrial sector), the factor was estimated at 0.039 MWh/m². To establish the total electric energy savings associated with large buildings, apartments and condominiums sectors, the Evaluator then applied these factors to the total floor area values estimated based on the building permit data. Then, the percentages of electric energy savings were used to estimate the total electric energy savings associated with the NECB for large buildings, apartments and condominiums.

Table 24: Energy Savings Associated with the Introduction of the Building Code Regulation for Large Buildings, Apartments and Condominiums

Building Type	Total Floor Area ¹ (m ²)	Total Electricity Use ² (GWh)	% Savings ³	Total Incremental Energy Savings at the Meter in 2017 (GWh)
Multi-unit Residential	294,819 ⁵²	13.856	9.40%	1.303
Small Commercial	8,325	0.957	5.70%	0.055
Large Commercial	100,845	12.001	13.20%	1.584
Industrial	43,594	1.700	8.80%	0.150
Total	313,962	28.515		3.091

1. Taken from Table 18

2. Based on MWh/m² in Table 23.

3. From Table 20.

The Evaluator estimates the total energy savings at 3.091 GWh, as shown in Table 24. Multi-unit residential buildings account for 42 percent of the total savings and large commercial buildings account for 51 percent.

3.3.6 At the Meter Peak Demand Savings

Houses and Small Buildings

The peak demand savings were calculated using an on-peak demand-to-energy ratio of 0.283 MW/GWh, which was applied to the 1,278 kWh unitary energy savings and resulted in 362 W of unitary peak demand savings. This ratio was established based on a weighted-average ratio of modelled system-coincident peak demand savings and energy savings for a projected deployment of measures supported by NHC, as developed by Navigant in the 2016-2018 DSM Plan. Navigant developed these ratios using a projected Nova Scotia system peak demand occurring in the months of December through February, between 5 p.m. and 7 p.m. on a non-holiday weekday. Navigant also used local data to establish this ratio. The Evaluator estimates that the introduction of the regulation generated 0.365 MW in peak savings in Nova Scotia in 2017, as summarized in Table 25.

⁵² The estimated floor area is based on an assumption of approximately 1,000 sq. ft. per unit. To convert square feet values to square meters, a factor of 10.8 sq.ft per sq. meter is used.

Table 25: Total Peak Demand Savings Associated with the Introduction of the Building Code Regulation for the Houses and Small Buildings Sectors in the Nova Scotia Market

Product Class	Number of Single Houses	Non-compliance Rate (%)	Annual Peak Demand Savings (W/house)	Peak Demand Savings at the Meter in 2017 (MW)
Single houses	1,740	58%	362	0.365

Large Buildings, Condos and Apartments

To estimate the total peak savings associated with large buildings, apartments and condominiums, the Evaluator applied a demand-to-energy ratio of 0.264 MW/GWh. This ratio was established based on Custom's New Construction service's peak demand savings, by extracting the maximum monthly demand values from energy simulation reports. All of the submitted project models were reviewed, and monthly peak demand savings of both the base case and the proposed case were compared. Since peak demand in Nova Scotia occurs in the months of December through February, peak demand savings were determined by using the average maximum monthly demand reduction for this three-month period. The energy savings used are based on Custom's New Construction service energy savings.

Table 26: Total Peak Demand Savings Associated with the Introduction of the Building Code Regulation for Large Buildings, Condos and Apartments

Product Class	Demand-to-energy Ratio (MW/GWh)	Total Peak Demand Savings at the Meter in 2017 (MW)
Multi-unit Residential	0.264	0.344
Small Commercial	0.264	0.014
Large Commercial	0.264	0.418
Industrial	0.264	0.039
Total		0.816

The Evaluator estimated the total peak demand savings at 0.816 MW, as summarized in Table 26. Multi-unit residential buildings accounted for 42 percent of the total peak savings and the large commercial accounted for 51 percent.

3.4 Clothes Washers

3.4.1 Product Description

Residential clothes washers are common household appliances. Clothes washers are classified in Canada according to size (standard over 45 L or compact under 45 L) and loading axis (top-loading or front-loading). According to the NRCAN National Energy Use Database, about 90 percent are standard-size and top-loading types are more common across the country. Residential clothes washers are electrically operated and do not require mechanical fastening to a floor or wall. The appliances have an internal control system that regulates the water temperature without the need for user intervention after the machine is set in operation. The water used may come from a source heated by electricity, oil, or natural gas; so, the energy savings analysis also categorizes clothes washers by water heating source.

3.4.2 Regulation Description

Amendment 13 to the Energy Efficiency Regulations was registered on December 9, 2016, published on December 28, 2016 and came into force on June 28, 2017. The new MEPS have been divided into two tiers: Tier 1 targets appliances manufactured on or after March 7, 2015 and before January 1, 2018 and is aligned with the U.S. standard in effect since March 2015, whereas Tier 2 targets appliances manufactured on or after January 1, 2018 and is aligned with the U.S. standard in effect January 2018.⁵³ Consequently, Tier 2 is not covered in this report.

3.4.3 Market Size Estimate

The AHAM Canada provided information about clothes washer shipments to Atlantic Canada from 2014 to 2017, and this information was converted into estimates for Nova Scotia based on its share of Atlantic Canada's total population. NRCAN's cost-benefit analysis report on the standards covered by Amendment 13⁵⁴ provided a breakdown of shipments by loading axis (top-loading or front-loading). Table 27 lists the market size in 2017 of each clothes washer type.

Table 27: Clothes Washers Market Size Estimates for Nova Scotia, 2017

Product Class	Atlantic Market in 2017	Nova Scotia Market in 2017
Top-loading	40,860	16,278
Front-loading	12,002	4,781
Total	52,862	21,059

⁵³ <http://www.nrcan.gc.ca/energy/regulations-codes-standards/products/6925> (Last accessed February 2, 2018).

⁵⁴ NRCAN (2016), *A cost-benefit analysis*, Canada Gazette, Part II, December 28, 2016.

3.4.4 Portion of the Market Impacted by the Regulation

The NRCan cost-benefit analysis report on the standards covered by Amendment 13 provided the non-compliance rate for Tier 1 clothes washers in Canada prior to the application of the new MEPS. Since no province-specific statistics are available, the non-compliance rate for Nova Scotia has been assumed to be the same as for Canada. The table below shows the estimated portion of the market impacted by the regulation on Tier 1 clothes washers.

Table 28: Estimate of the Portion of the Clothes Washers Market Impacted by the Regulation

Product Class	Percentage of Total Shipments to Nova Scotia Affected by the Regulation in 2017
Top-loading	51%
Front-loading	54%

3.4.5 Unitary Savings Values

In Amendment 13, NRCan specifies the average unitary savings values for Tier 1 clothes washer categories according to their water heating sources, as listed in Table 29. Higher-efficiency clothes washers use less water in their washing cycles, resulting in additional savings associated with a reduced load on the domestic hot water heating system (if electrically heated). The Evaluator used the proportions of electric and non-electric domestic water heating in Nova Scotia from the Instant Savings 2017 evaluation to calculate a weighted average of all types of clothes washers.

Table 29: Unitary Savings Values for Clothes Washers

Product Class		Annual Energy Savings (kWh/unit)	Annual Energy Savings (kWh/unit)	Weighted Average Electricity Energy Savings (kWh/unit)
Type	Domestic Water Heating Source			
Top-loading	Electric	286	67%	263
	Non-electric	217	33%	
Front-loading	Electric	123	67%	101
	Non-electric	58	33%	

3.4.6 At the Meter Energy Savings

By applying these unitary savings values, the market size estimates for Tier 1 clothes washers in Nova Scotia and the estimates of the total shipments to Nova Scotia affected by the regulation in 2017, the Evaluator estimates that the introduction of the regulation on Tier 1 clothes washers has resulted in energy savings of 2.447 GWh at the meter (see Table 30).

**Table 30: Energy Savings Associated with Clothes Washers' New MEPS
in the Nova Scotia Market**

Product Class	Nova Scotia Market in 2017	Percentage of Nova Scotia Market Affected by the Standard in 2017	Annual Energy Savings (kWh/yr/unit)	Total Energy Savings at the Meter in 2017 (GWh)
Top-loading	16,278	51%	263	2.183
Front-loading	4,781	54%	102	0.263
Total	21,059			2.447

3.4.7 At the Meter Peak Demand Savings

The peak demand savings were calculated by applying an on-peak demand-to-energy ratio of 0.138 MW/GWh to the energy savings at the meter shown in Table 31. This ratio was calculated using the on-peak demand-to-energy ratios developed by Navigant in the 2016-2018 DSM Plan. These ratios were established for various measure categories, based on modelled system-coincident peak demand savings and energy savings for a projected deployment of measures. Navigant used local data to establish the ratios for 2017. The Evaluator considers Navigant's approach to establishing the on-peak demand-to-energy ratios valid. Therefore, this ratio was used to estimate peak demand savings for clothes washers. The Evaluator estimates that the introduction of the regulation generated 0.337 MW in peak savings in Nova Scotia in 2017, as summarized in Table 31.

**Table 31: Peak Demand Savings Associated with the Introduction
of Clothes Washers Standards in the Nova Scotia Market**

Product Class	Total Energy Savings at the Meter in 2017 (GWh)	Demand-to-Energy Ratio	Total Peak Demand Savings at the Meter in 2017 (MW)
Top-loading	2.183	0.138	0.301
Front-loading	0.263	0.138	0.036
Total	2.447		0.337

3.5 Refrigerators

3.5.1 Product Description

Residential refrigerators are common household appliances. Refrigerators are classified in Canada mainly according to the freezer component's position (top, bottom, or side) in the unit and the defrost capabilities (automatic, semi-automatic or manual). NRCAN⁵⁵ focuses on four primary types: (1) Type 3 refrigerator-freezers have automatic defrost with top-mounted freezers; (2) Type 5 refrigerator-freezers have automatic defrost with bottom-mounted freezers; (3) Type 7 refrigerator-freezers have automatic defrost with side-mounted freezers; and (4) Type 11 compact refrigerators and refrigerator-freezers with semi-automatic or manual defrost. This classification is used in this report (see also Table 32).

3.5.2 Regulation Description

Amendment 13 to the Energy Efficiency Regulations was registered on December 9, 2016, published on December 28, 2016 and came into force on June 28, 2017. The MEPS for refrigerators are designed to increase the efficiency of Types 3, 5, 7 and 11 by approximately 15 percent for product models that have not yet met the standard. Manufacturers often make product improvements by increasing the insulation and/or by improving the fan design to remove heat and cool the inside air. The regulation is aimed at reducing GHG emissions and aligning the requirements with the U.S. standard to minimize manufacturers' burden of regulatory compliance.

Table 32: Overview of Refrigerator Types

Product Class	Type Description
Type 3	Refrigerator-freezers with automatic defrost and top-mounted freezer without through-the-door ice service. All-refrigerators with automatic defrost.
Type 5	Refrigerator-freezers with automatic defrost and bottom-mounted freezer without through-the-door ice service.
Type 7	Refrigerator-freezers with automatic defrost and side-mounted freezer with through-the-door ice service.
Type 11	Compact refrigerators and refrigerator-freezers with semi-automatic or manual defrost.

⁵⁵ Natural Resources Canada, *Refrigerators, Refrigerator-Freezers and Wine Chillers Energy Efficiency Regulations*, <http://www.nrcan.gc.ca/energy/regulations-codes-standards/products/6877> (Last accessed February 2, 2018).

3.5.3 Market Size Estimate

The AHAM Canada provided information about refrigerator shipments to Atlantic Canada from 2014 to 2017, and this information was converted into estimates for Nova Scotia based on its share of Atlantic Canada's total population. The NRCan cost-benefit analysis report on the standards covered by Amendment 13 (NRCan, 2016) provided a breakdown of shipments according to four types (Types 3,5,7, and 11).⁵⁶ According to a report prepared for NRCan in 2015⁵⁷, these four types accounted for 93 percent of all shipments in Canada. The Evaluator assumes that these four types accounted for the same percentage in the 2017 Atlantic Canada shipments. Table 33 below lists the market size in 2017 for each refrigerator type.

Table 33: Refrigerator Market Size Estimates for Nova Scotia, 2017

Product Class	Atlantic Market in 2017	Nova Scotia Market in 2017
Type 3	21,294	8,483
Type 5	30,017	11,958
Type 7	995	396
Type 11	12,544	4,997
Total	64,850	25,834

3.5.4 Portion of the Market Impacted by the Regulation

The NRCan cost-benefit analysis report on the standards covered by Amendment 13 provided the non-compliance rate for refrigerators in Canada prior to the application of the new MEPS. Since no province-specific statistics are available, the non-compliance rate for Nova Scotia has been assumed to be the same as for Canada. Table 34 shows the estimated portion of the market impacted by the regulation governing refrigerators.

Table 34: Percentage of Total Shipments to Nova Scotia Affected by the Regulation in 2017

Product Class	Percentage of Total Shipments to Nova Scotia Affected by the Regulation in 2017
Type 3	2%
Type 5	0%
Type 7	22%
Type 11	10%

⁵⁶ Natural Resources Canada, *Refrigerators, Refrigerator-Freezers and Wine Chillers Energy Efficiency Regulations*, <http://www.nrcan.gc.ca/energy/regulations-codes-standards/products/6877> (Last accessed February 2, 2018).

⁵⁷ Dunsky Energy Consulting, *Update - Market and Technology Assessment for Residential Clothes Washers in Canada*, Final Report submitted to Natural Resources Canada, 2015.

3.5.5 Unitary Savings Values

In Amendment 13, NRCan specifies the average unitary savings values for the categories of refrigerators, as shown in Table 35.

Table 35: Unitary Savings Values for Refrigerators

Product Class	Annual Energy Savings (kWh/unit)
Type 3	33
Type 5	0
Type 7	31
Type 11	86

3.5.6 At the Meter Energy Savings

By applying these unitary savings values, the market size estimates for refrigerators in Nova Scotia and the estimates of the total shipments to Nova Scotia affected by the regulation in 2017, the Evaluator estimates that the introduction of the regulation governing refrigerators has resulted in energy savings of 0.052 GWh at the meter (see Table 36).

Table 36: Energy Savings Associated with Refrigerators New MEPS in the Nova Scotia Market

Product Class	Projected Nova Scotia Market in 2017	Percentage of Nova Scotia Market Affected by the Standard in 2017	Annual Energy Savings (kWh/yr/unit)	Total Energy Savings at the Meter in 2017 (GWh)
Type 3	8,483	2%	33	0.006
Type 5	11,958	0%	0	0.000
Type 7	396	22%	31	0.003
Type 11	4,997	10%	86	0.043
Total	25,834			0.052

3.5.7 At the Meter Peak Demand Savings

The peak demand savings were calculated using an on-peak demand-to-energy ratio of 0.138 MW/GWh. This ratio was calculated using the on-peak demand-to-energy ratios developed by Navigant in the 2016-2018 DSM Plan. These ratios were established for various measure categories, based on modelled system-coincident peak demand savings and energy savings for a projected deployment of measures. Navigant used local data to establish the ratios for 2017. The Evaluator considers Navigant's approach to establishing the on-peak demand-to-energy ratios valid. Therefore, this ratio was used to estimate peak demand savings for refrigerators. The Evaluator estimates that the introduction of the regulation generated 0.007 MW in peak savings in Nova Scotia in 2017, as summarized in Table 37 below.

Table 37: Peak Demand Savings Associated with the Introduction of Refrigerators Standards in the Nova Scotia Market

Product Class	Total energy Savings at the Meter in 2017 (GWh)	Peak Demand-to-Energy Ratio	Total Peak Demand Savings at the Meter in 2017 (MW)
Type 3	0.006	0.138	0.001
Type 5	0.000	0.138	0.000
Type 7	0.003	0.138	0.000
Type 11	0.043	0.138	0.006
Total	0.052		0.007

3.6 Total Savings at the Generator

Incremental annual energy savings at the meter were calculated by taking into account all product categories, for which the necessary information about the market size, non-compliance rates and unitary savings values was available. As for the savings calculations at the generator level, the Evaluator used a line loss factor of 1.100 for the residential sector, 1.063 for the commercial sector and 1.046 for the municipal sector, as provided by NSP, to account for transmission and distribution losses.

The 2017 overall energy and peak demand savings for C&S have been estimated at 21.914 GWh and 4.028 MW at the generator respectively, as summarized in Table 38 below. Overall, using the Nova Scotia-specific factor⁵⁸ of GHG generated by electricity production, i.e., 0.6531 kg CO₂ eq/kWh, it was estimated that the net energy savings resulted in 14,312 tonnes of avoided CO₂ eq annually.

⁵⁸ At the time of writing, 2017 data was not yet available. The Nova Scotia-specific factor was obtained from Nova Scotia Power's 2016 total system emissions data (7,079,268 CO₂ eq tonnes) and total electricity generation (10,839 GWh). These were found in the following two sources:

Nova Scotia Power, *Total System Emissions*, <http://www.nspower.ca/en/home/about-us/environmental-commitment/air-emissions-reporting/total-system-emissions-all-plants.aspx> (Last accessed December 17, 2017).

Emera Inc., *Management's Discussion & Analysis As at February 10, 2017*, <http://investors.emera.com/Cache/1500095769.PDF?Y=&O=PDF&D=&fid=1500095769&T=&iid=4072693> (Last accessed December 17, 2017).

**Table 38: Codes and Standards Overall Incremental Annual Energy and
Peak Demand Savings, 2017**

Product Category	Incandescent Lamps	LED Street-lighting	New Energy Code for Residential	New Energy Code for Commercial and Industrial	Clothes Washers	Refrigerators	Total
Energy Savings							
Number of Units	439,761	21,685	1,740	107	21,059	25,834	
Total Energy Savings at the Meter (GWh)	8.425	4.966	1.290	3.091	2.447	0.052	20.270
Line Loss Factor	1.1	1.046	1.1	1.063	1.1	1.1	
Total Energy Savings - at the Generator (GWh)	9.268	5.194	1.419	3.285	2.691	0.057	21.914
Peak Demand Savings							
Total Peak Demand Savings- at the Meter (MW)	0.988	1.236	0.365	0.816	0.337	0.007	3.750
Line Loss Factor	1.1	1.046	1.1	1.063	1.1	1.1	
Total Peak Demand Savings- at the Generator (MW)	1.087	1.293	0.402	0.867	0.371	0.008	4.028

LIST OF APPENDICES

The following is presented in the C&S– Appendices.

Codes and Standards

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ECONOLER

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APPENDIX I

2017 RECOMMENDATIONS

This appendix summarizes all the recommendations made by the Evaluator as part of the 2017 evaluation. There were no incomplete 2016 recommendations at the time of writing.

Sections	Recommendations
Executive Summary	1 Include some Amendment 13 standards in the 2018 evaluation. The new standards set forth in Amendment 13 came into force at the end of June 2017. Most of these new standards were not included in the 2017 evaluation since their impact was expected to be limited until January 2018 while retailers sell their existing stocks. For the 2018 evaluation, these new standards should be considered for inclusion. However, a review of Amendment 13 shows that many of the new MEPS will only have a limited impact in terms of savings, since the new MEPS either bring very little change to the standard level or target products with small markets. The Evaluator therefore recommends selecting two or three products from the Amendment 13 standards based on their savings potential and a consideration of how much effort will be needed to estimate their market sizes. The 2017 evaluation showed that clothes washers (Amendment 13) provided considerable savings and should still be included in the 2018 evaluation, whereas refrigerators (Amendment 13), due to their low savings, should no longer be included. The Evaluator recommends continuing to evaluate the impacts associated with lighting, street-lighting and building codes in 2018 since they provide significant savings.



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