Matter No. M10569

In the Matter of Nova Scotia Power's 2022 Load Forecast Report

EVIDENCE OF

JOHN D. WILSON

ON BEHALF OF

THE CONSUMER ADVOCATE

Resource Insight, Inc.

JULY 29, 2022

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I. Identification & Qualifications

Q: Mr. Wilson, please state your name, occupation, and business address.

A: I am John D. Wilson. I am the research director of Resource Insight, Inc., 10 Court Street, Arlington, Massachusetts.

Q: Summarize your professional education and experience.

A: I received a BA degree from Rice University in 1990, with majors in physics and history, and an MPP degree from the Harvard Kennedy School of Government with an emphasis in energy and environmental policy, and economic and analytic methods. I have been employed by Resource Insight since 2019.

Previously, I was deputy director of regulatory policy at the Southern Alliance for Clean Energy for more than twelve years, where I was the senior staff member responsible for SACE's utility regulatory research and advocacy, as well as energy resource analysis. I engaged with southeastern utilities through regulatory proceedings, formal workgroups, informal consultations, and research-driven advocacy.

My work has considered, among other things, the cost-effectiveness of prospective new electric generation plants and transmission lines, retrospective review of generation-planning decisions, conservation program design, ratemaking and cost recovery for utility efficiency programs, allocation of costs of service between rate classes and jurisdictions, design of retail rates, and performance-based ratemaking for electric utilities.

My professional qualifications are further summarized in Attachment 1.

Q: Have you testified previously in utility proceedings?

A: Yes. I have testified more than thirty times before utility regulators in California, Colorado, Nova Scotia and the Southeast U.S., and appeared numerous additional times before various regulatory and legislative bodies.

Q: Have you previously testified in other proceedings before this Board?

A: Yes. I have filed testimony in thirteen matters. I have also assisted the Consumer Advocate in preparing comments and developing positions in numerous proceedings and stakeholder processes.

Q: On whose behalf are you testifying?

A: My testimony is sponsored by the Nova Scotia Consumer Advocate.

II. Introduction

Q: Please summarize NS Power's application.

A: NS Power's 2022 Load Forecast Report represents a significant refinement of its prior load forecasts. Compared to the flat or declining forecast in 2021, NS Power now forecasts an annual increase of 0.3 percent in the net system requirement and a 1.6 percent annual increase in the system peak.[1]

The net impact of the 2022 load forecast will be to require several hundred megawatts of additional resources, mainly peaking capacity.

NS Power's refinements to its load forecast notably feature the use of a warming trend and an updated forecast for space heating and electric vehicle (EV) uptake, reflecting both the impact of global climate change and the province's efforts to reduce future carbon emissions.[2] My evidence will discuss these and several other revisions.

III. Directives from the 2021 Load Forecast Report Proceeding

Q: Please summarize NS Power's actions in response to Board directives related to the 2021 evidence filed by the Consumer Advocate.

A: In response to Mr. Jim Wilson's evidence, some of the key changes NS Power agreed to make include the following:

- Evaluate the peak design temperature based on historic data as a median or "1-in-2" forecast.
- Incorporate a warming trend into peak load and energy use forecast.
- Utilize weather from multiple stations for the residential model.
- Examine the impact of incremental cold on peak loads.

[1] Exhibit N-1, 2022 Load Forecast Report, pp. 8-9.

[2] *Id.*, pp. 13-15.

Q: Is NS Power's evaluation of the peak design temperature reasonable?

A: Yes. NS Power updated its peak design temperature as the "10 year average of the coldest evening (5-8pm) temperatures."[3] NS Power states that this "aligns with the annual HDD estimate and provides a better reflection of current weather trends."[4]

This update addresses the concerns expressed in Mr. Wilson's 2021 evidence.

Q: Did NS Power examine the impact of incremental cold on peak loads?

A: No. NS Power states that it will conduct further analysis of weather normalization and the impact of incremental cold on peak loads for the 2023 load forecast.[5] As I will discuss below, I recommend that this analysis also include the effect of wind speed.

Q: Is NS Power's incorporation of a warming trend into the forecast reasonable?

A: NS Power approached this issue in a reasonable manner, but the results are inconsistent with the methods used. NS Power recognized a trend in annual heating and cooling degree days (HDD and CDD, respectively) as well as a trend in the design peak temperature, which has been increasing at a rate of around 0.15 degrees per year.[6] While NS Power has not modeled a scenario without the trend variable, it has estimated that the trend variable impacts the load by about 59 GWh in the residential class and 16 GWh in the commercial class, or about 1% and 0.5%, respectively.[7]

The NS Power residential energy forecast per customer is the weighted sum of three components—heating, cooling and other loads—with adjustments for solar, EVs, COVID and DSM.[8]

However, I found a potential discrepancy between the model inputs and outputs. NS Power explains that "The HDD and CDD trends are included in the underlying XHeat and XCool variables which make up the regression model."[9] As shown in Figures 7 and 8 of the 2022 Load Forecast Report, NS Power identified declining and increasing trends in the HDD and CDD values, respectively.

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[3] Exhibit N-1, 2022 Load Forecast Report, p. 82.

[4] *Id.*

[5] Exhibit N-7, NS Power response to CA IR-17.

[6] Exhibit N-1, 2022 Load Forecast Report, pp. 19-24.

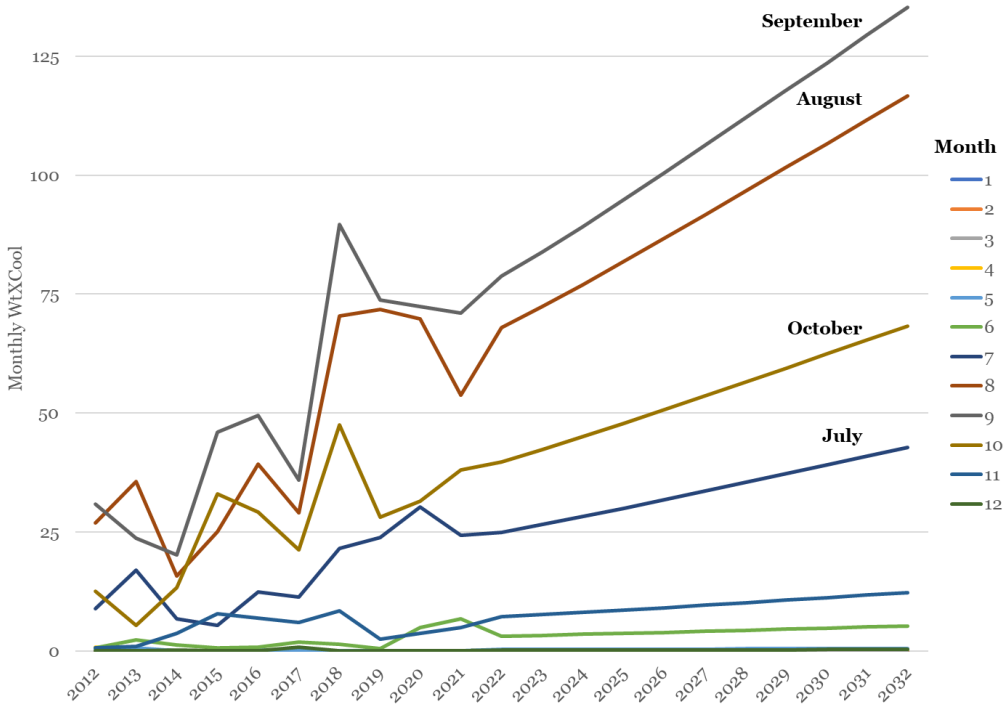
[7] Exhibit N-7, NS Power response to CA IR-1(c-d).

[8] Each of the major components is multiplied by a regression factor, which is close to 1.0 for heating and other, but only 0.6 for cooling.

[9] Exhibit N-7, NS Power response to CA IR-1(c-d).

As shown in Figure 1, the increasing trend in CDD values is an input and is, as expected, reflected in the WtXCool residential model output (average monthly cooling kWh per customer). A similar trend is observed in the small general model output.

Figure 1: Residential Model Output for WtXCool Variable, by Month[10]



However, as shown in Figure 2, the WtXHeat residential model output (average monthly kWh heating per customer) does not clearly show the impact of a decreasing trend in HDD values. And, as shown in Figure 3, the small general model output shows an *increasing* amount of energy used for heating in the small general customer model.

One possible interpretation of these results is that the effect of the decreasing number of HDD is almost perfectly offset by additional heat pumps (with a number of other smaller factors also contributing) in the residential customer class and is more than offset by electrification in the small general customer class. As I will discuss in Section IV, NS Power has further work to do to validate its electrification load forecast.

[10] Exhibit N-1, 2022 Load Forecast Report, Attachment 05 Residential Model.

Figure 2: Residential Model Output for WtXHeat Variable, by Month[11]

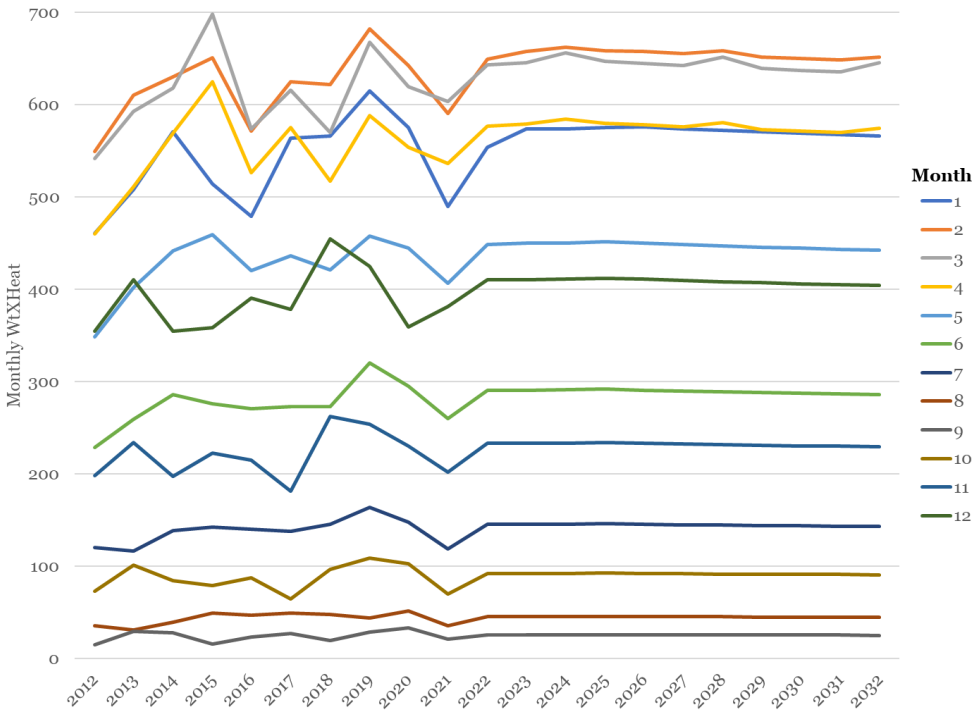
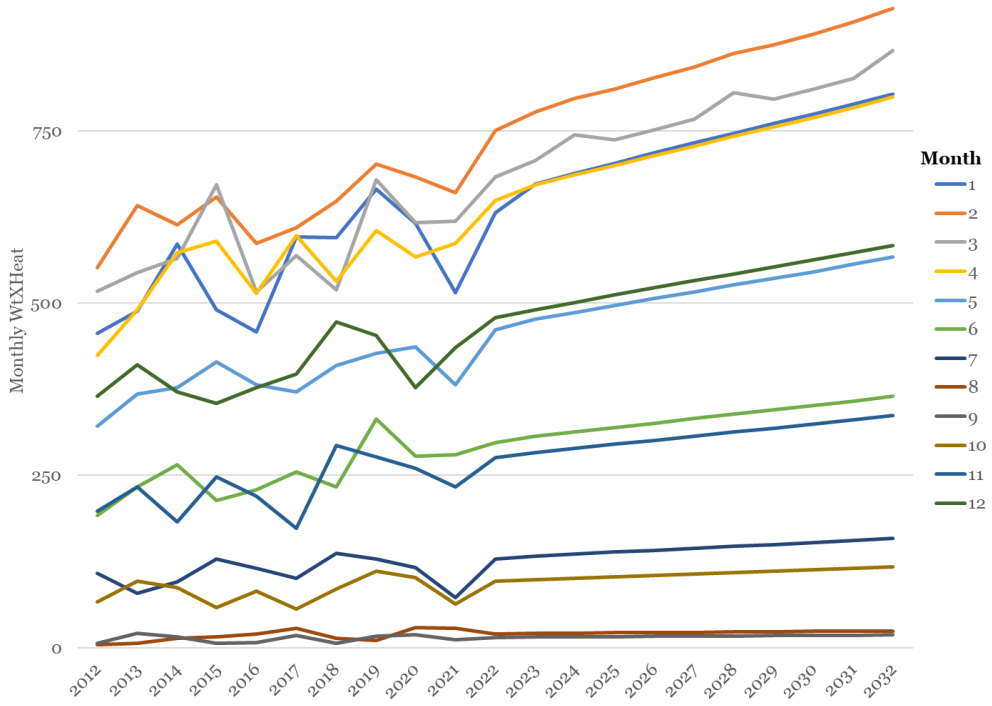


Figure 3: Small General Model Output for WtXHeat Variable, by Month[12]



[11] Exhibit N-1, 2022 Load Forecast Report, Attachment 05 Residential Model.

[12] Exhibit N-1, 2022 Load Forecast Report, Attachment 06 Small General Model.

Because NS Power's load forecast is modeled using proprietary software and is not available in spreadsheet format, I did not attempt to investigate alternative formulations of the warming trend. NS Power should continue to consider potential improvements to its methods for addressing climate change scenarios in its load forecast.

Q: Is NS Power's utilization of multiple weather stations in the residential forecast reasonable?

A: No. NS Power stated that it was unable to use load-weighted data and used a population-weighted approach instead. Its analysis of the population-weighted weather station data found "the differences are minimal with respect to the energy forecast."[13] The peak forecast is likely to be more sensitive to weather data than the monthly energy forecasts. Unfortunately, NS Power did not complete the analysis of the effect of multiple weather stations on the peak load analysis, so we do not know how sensitive the forecast may be to the treatment of geographically disaggregated weather station data.[14]

NS Power's energy analysis compared backcasts of 2021 monthly energy use using (a) the weighted average of monthly temperatures from eight stations and (b) the average monthly temperature from the Shearwater station.[15] It is unsurprising that an analysis of monthly averages found minimal differences, since any useful information about variability has been obscured by the averaging over the days of the month. A better approach would be to calculate the average hourly load-weighted temperature, calculate the monthly CDD and HDD metrics, and *then* determine whether the difference between the weighted weather station data is significantly different from the data from Shearwater station.

Another important issue is where NS Power can obtain the load data for weighting. In response to an information request, NS Power said that it had not evaluated load flows used for transmission planning as possible inputs, and that it is reviewing how to integrate AMI data in order to provide more granular analysis.[16] NS Power has hourly substation load data from the areas represented by the eight weather stations, those loads could be used to weigh the hourly temperature data.[17]

[13] Exhibit N-1, 2022 Load Forecast Report, p. 29.

[14] Exhibit N-1, 2022 Load Forecast Report, p. 29.

[15] Exhibit N-1, 2022 Load Forecast Report, pp. 28-29.

[16] Exhibit N-7, NS Power response to CA IR-3.

[17] NS Power provided loads at system peak for most substations in 2016, 2018, 2019, 2020, and 2021 in CA IR-56 of the 2022 GRA, M10431. Mapping those substations into the eight climate areas that NS Power used

In any event, NS Power should focus its multi-station weather analysis on the peak load. If a meaningful effect is found with respect to peak loads, then it should also re-evaluate whether monthly energy forecasts can be improved as well.

Q: Please summarize Mr. Wilson's 2021 recommendation with respect to multi-hour average temperatures and wind speed.

A: In his 2021 evidence, Mr. Wilson stated:

> The temperature in the same hour as the peak is not always a good measure of the cold as it impacts load; I have often found that multi-hour averages are more predictive of load levels.[18]

Mr. Wilson also recommended that the Board should require discussion of other weather measures, including wind speed and cloud cover.[19]

Q: Has NS Power responded to his recommendation on multi-hour average temperatures?

A: Not directly. However, in its discussion of the 2021 actual system firm peak of 1,875 MW, NS Power stated that the 2021 weather normalized peak of 2,002 MW is 71 MW lower than the 2021 forecast system firm peak of 2,073 MW. NS Power attributed this difference to the March 2 peak day not being "a particularly cold day" on which the temperature dropped rapidly to the daily minimum.

This event corroborates Mr. Wilson's 2021 evidence and suggests that a multi-hour temperature average should be evaluated for use in both weather normalization and peak load forecasting.

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should be straightforward. Even if those substation loads do not precisely total to system load, the relative loads could provide a reasonable basis for constructing a load-weighted average hourly temperature. While population distribution is a reasonable proxy for load distribution when viewed from a monthly or annual basis, it is not a reasonable proxy for load distribution on an *hourly* basis unless it is shown that hourly loads vary uniformly across the province.

[18] Exhibit N-8, Evidence of James F. Wilson, 2021 Load Forecast Report, Matter No. M10109, p. 14.

[19] *Id.*, pp. 5-6.

Q: Has NS Power responded to his recommendation on evaluating wind speed and cloud cover?

A: Not directly. In an information response, NS Power provided a regression analysis of temperature and load, and stated that temperature "is the predominant driver, so the impact of other factors may not be statistically significant when combined with temperature."[20]

Q: Is wind speed potentially a significant driver of load?

A: Yes. I performed a regression analysis of temperature and wind speed and found that both factors are statistically significant drivers of load. I found that high wind speeds could increase daily loads by more than 5% on cold days.

To reach this finding, I elaborated on NS Power's regression analysis provided in support of its assertion that temperature is the predominant driver. To be clear, I agree with NS Power that temperature is the predominant driver. Nonetheless, wind speed is also a significant driver and should be factored into NS Power's weather normalization equation.[21]

As shown in Table 1, adding wind speed to the regression equation slightly reduces the relationship of cold temperature with load and shows a small, but significant relationship of wind speed to load. The addition of wind speed to the model only increases the R square value by about 1%, so the amount of the variance in load that is explained by a model with wind speed is not much higher than without. Because the p-value for both variables is practically zero, the model results indicate that adding wind speed results in a better model.

Table 1: Load Regression Statistics

	Without Wind Speed	With Wind Speed
Intercept	35,375 MWh	33,957 MWh
Daily Average Temperature	- 660 MWh per degree	-637 MWh per degree
Daily Average Wind Speed	n/a	95 MWh per km/hr
R Square	85.5%	86.4%
P-value, Temperature	0.000%	0.000%
P-value, Wind Speed	n/a	0.000%

The range of average daily wind speeds for days with temperatures below 18 degrees is 4 – 33 km/hr. Over this range, wind speed could add up to 2,769 MWh to the daily load.

[20] Exhibit N-7, NS Power response to IR-13(a),(g).

[21] It may also be useful for NS Power to consider this factor when calculating the effective load carrying capability (ELCC) of wind power resources. It may be appropriate to recognize that daily average wind speed is correlated with both load and generation in that calculation.

On the coldest days, the average wind speed is about 17 km/hr, with a maximum of 27 km/hr. This additional 10 km/hr of wind could add about 980 MWh to daily load, which represents 2.5% of the average daily load of 39,933 MWh on days with temperatures below -5 degrees.

Taking wind speed into consideration could improve NS Power's weather normalization of both monthly loads and peak load events. If it is not already considered, including wind speed in short-term load forecasts for operational dispatch planning could also improve forecast accuracy.

Q: What are your recommendations with respect to these six load forecast improvement issues?

A: The Board should direct NS Power to prioritize peak loads in a re-evaluation of geographically differentiated load data to understand whether load-weighted temperature data may offer an improvement to load forecasting.

The Board should also direct NS Power to evaluate the use of a multi-hour temperature average and wind speed in both weather normalizing and forecasting peak loads.

Currently, NS Power provides stakeholders with an opportunity to review its load forecast findings in advance of filing, but after the work is substantially complete. This does not provide an opportunity for stakeholders to suggest alternative methods. Accordingly, I recommend that the Board direct NS Power to engage stakeholders around its proposed methods for load-weighted temperature data, weather normalization (including multi-hour temperature averages and wind speed) and the impact of incremental cold (and wind speed) on peak loads.

IV. Electrification Forecast

Q: What is your opinion of the electrification forecast?

A: Overall, the electrification forecast appears to be a credible effort given the early stage of policies and programs to achieve electrification goals. As NS Power acknowledges, the forecast will need to be refined as policies and programs become more specific and as more is known about the performance of technologies in the NS Power service territory. For

example, NS Power currently includes all EV load in the residential model but will be shifting commercial EV load to the commercial model for the 2023 forecast.[22]

Nonetheless, I have identified three significant issues with the electrification forecast. The first two relate to winter electric load for residential and small general heating. As discussed in Section III, NS Power forecasts that electric load for heating will be flat for residential customers (see Figure 2) and increasing for commercial customers (see Figure 3). I suggested that these results may reflect a modeling error.

The second issue is the heat pump adoption trajectory. The forecast heat pump adoption levels rely on a "trajectory that would be required to align with carbon emission reduction targets."[23] NS Power's forecast for residential heat pump installations appears to assume that customers installing residential heat pumps will remove (or retire) existing heating sources.[24]

However, NS Power's recent report for its heat pump on-bill financing report suggests that customer installations are not straightforward replacement projects. Itron found that heat pump installations were not only displacing existing heating system loads, but also resulting in higher loads because customers were keeping their homes warmer in the winter, cooler in the summer, and increasing the floorspace coverage in both seasons.[25] Not only is there an increase in load for customers whose heating sources were previously not all electric, but there can also be an increase in load for customers whose heating sources were previously all electric. Even though heat pumps are more efficient than the baseboard or other resistance heating sources that many customers previously relied upon, it appears that customers take advantage of the heat pumps to improve comfort, resulting in annual load that is "consistent with or slightly greater than" customers who have not yet installed heat pumps.[26]

NS Power has acknowledged that even though additional market interventions are necessary to achieve the level of electrification indicated in its load forecast, "The process by which NS Power will consider such [electrification] measures has not yet been

[22] Exhibit N-5, NS Power response to SBA IR-14(b-c).

[23] Exhibit N-5, NS Power response to SBA IR-10.

[24] Exhibit N-1, 2022 Load Forecast Report, pp. 35-40.

[25] Itron, *Cold Climate Heat Pump Load Study* (July 2022), p. 17. Submitted as Appendix A to NS Power, On-Bill Financing Final Report, M09321 (July 21, 2022).

[26] *Id.*, p. 18.

determined."[27] NS Power should identify the gap between existing electrification measures and trends and those included in its load forecast as necessary to achieve federal and provincial policy goals for electrification. Explicit acknowledgement of this difference will enable NS Power and the Board to properly focus on the scale of potential measures.

In the short term, NS Power should investigate its weather-dependent load forecast models and verify that the warming trend and electrification trends are properly implemented, correcting any errors that may be found. In the longer term, NS Power should update those same load forecast models to reflect the findings from Itron with respect to real-world impacts of heat pumps and identify the gap between realistic projections of the impacts of heat pump adoption and policy goals for electrification.

The third issue with NS Power's modeling of electrification is a simplistic view of EV charging during peak load events. NS Power forecasts between 55 and 81 MW of charging demand during peak load events in 2030.[28]

Both commuter and commercial vehicle use would be reduced during weather-related business or institutional closures. If that extreme weather is associated with peak loads, NS Power's forecast of peak charging demand would tend to overstate EV charging during peak load events. NS Power (with its consultant E3) could evaluate this possibility by reviewing available traffic data associated with peak load events in recent years. This qualitative indication of vehicle use during peak load events could inform assumptions regarding EV charging demand during peak load events.

Fourth, it is unclear whether NS Power has updated its forecast for heat pump water heaters since 2020;[29] NS Power should expect increased penetration of those appliances.

V. Load Research Sample (LRS) and Line Loss Determination Models

Q: What is the status of NS Power's LRS model?

A: NS Power states that its load research sample achieved a reliable sample size in 2018. In contrast, NS Power has only a "degraded sample of load research data prior to 2017."[30] NS

[27] Exhibit N-4, NS Power response to EfficiencyOne IR-4(c)-(d).

[28] Exhibit N-1, 2022 Load Forecast Report, p. 45.

[29] Exhibit N-1, 2022 Load Forecast Report, p. 41.

[30] Exhibit N-6, NS Power response to Synapse IR-29(b).

Power has implemented AMI at 78% of industrial customers, 84% of commercial customers, and 89% of domestic customers as of April 2022.[31]

The LRS model is important to the load forecast in a number of respects, particularly with respect to estimating line losses. NS Power has not updated its line loss estimates since 2013.

Q: Should this be sufficient to update its line loss determination model?

A: Yes. In response to an information request, NS Power confirmed that its original expectation was that the line loss determination model could be updated within 1–3 months after receiving one calendar year of load research data.[32]

NS Power has produced peak-day and monthly line-loss estimates but is still validating those numbers "as being representative of losses."[33] NS Power has not provided any timeline for completion of the validation.

Q: What are your recommendations with respect to the line loss determination model?

A: As recommended in evidence I prepared with Paul Chernick for NS Power's General Rate Application, the Board should renew its directive to NS Power to complete the line loss determination model. NS Power should report on its progress on a quarterly basis until the project is complete to the satisfaction of the Board. NS Power should bear any costs of completing the model since it failed to complete this work as directed and because it has already placed the load research sample project in service.

Q: Does this conclude your testimony?

A: Yes.

[31] Exhibit N-6, NS Power response to Synapse IR-29(c).

[32] Exhibit N-34, NS Power response to CA IR-41(b), Matter No. M10431.

[33] Exhibit N-6, NS Power response to Synapse IR-29(e)-(f).

JOHN D. WILSON

Resource Insight, Inc.
5 Water Street
Arlington, Massachusetts 02476

SUMMARY OF PROFESSIONAL EXPERIENCE

2019–Present **Research Director, Resource Insight, Inc.** Provides research, technical assistance, and expert testimony on electric- and gas-utility planning, economics, and regulation. Reviews electric-utility rate design. Designs and evaluates conservation programs for electric utilities, including conservation cost recovery mechanisms and performance incentives. Evaluates performance of renewable resources and designs performance evaluation systems for procurement. Designs and assesses resource planning and procurement strategies for regulated and competitive markets.

2007-19 **Deputy Director for Regulatory Policy, Southern Alliance for Clean Energy.** Managed regulatory policy, including supervision of experts in areas of energy efficiency, renewable energy, and market data. Provided expert witness testimony on topics of resource planning, renewable energy, energy efficiency to utility regulators. Directed litigation activities, including support of expert witnesses in the areas of rate design, resource planning, renewable energy, energy efficiency, and resource procurement. Conducted supporting research and policy development. Represented SACE on numerous legislative, utility, and private committees across a wide range of climate and energy related topics.

2001–06 **Executive Director, Galveston-Houston Association for Smog Prevention.** Directed advocacy and regulatory policy related to air pollution reduction, including ozone, air toxics, and other related pollutants in the industrial, utility, and transportation sectors. Served on the Regional Air Quality Planning Committee, Transportation Policy Technical Advisory Committee, and Steering Committee of the TCEQ Interim Science Committee.

2000–01 **Senior Associate, The Goodman Corporation.** Provided transportation and urban planning consultant services to cities and business districts across Texas.

1997–99 **Senior Legislative Analyst and Technology Projects Coordinator, Office of Program Policy Analysis and Government Accountability, Florida Legislature.** Author or team member for reports on water supply policy, environmental permitting, community development corporations, school district financial management and other issues – most recommendations implemented by the 1998 and 1999 Florida Legislatures. Edited statewide government accountability newsletter and coordinated online and internal technical projects.

1997 **Environmental Management Consultant, Florida State University.** Project staff for Florida Assessment of Coastal Trends.

1992-96 **Research Associate, Center for Global Studies, Houston Advanced Research Center.** Coordinated and led research for projects assessing environmental and resource issues in the Rio Grande / Rio Bravo river basin and across the Greater Houston region. Coordinated task force and edited book on climate change in Texas.

EDUCATION

BA, Physics (with honors) and history, Rice University, 1990.

MPP, John F. Kennedy School of Government, Harvard University, 1992. Concentration areas: Environment, negotiation, economic and analytic methods.

PUBLICATIONS

"Urban Areas," with Judith Clarkson and Wolfgang Roeseler, in Gerald R. North, Jurgen Schmandt and Judith Clarkson, *The Impact of Global Warming on Texas: A Report of the Task Force on Climate Change in Texas*, 1995.

"Quality of Life and Comparative Risk in Houston," with Janet E. Kohlhase and Sabrina Strawn, *Urban Ecosystems*, Vol. 3, Issue 2, July 1999.

"Seeking Consistency in Performance Incentives for Utility Energy Efficiency Programs," with Tom Franks and J. Richard Hornby, *2010 American Council for an Energy-Efficient Economy Summer Study on Energy Efficiency in Buildings*, August 2010.

"Monopsony Behavior in the Power Generation Market," with Mike O'Boyle and Ron Lehr, *Electricity Journal*, August-September 2020.

REPORTS

"Policy Options: Responding to Climate Change in Texas," Houston Advanced Research Center, US EPA and Texas Water Commission, October 1993.

Houston Environmental Foresight Science Panel, *Houston Environment 1995*, Houston Advanced Research Center, 1996.

Houston Environmental Foresight Committee, *Seeking Environmental Improvement*, Houston Advanced Research Center, January 1996.

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Office of Program Policy Analysis and Government Accountability, *Best Financial Management Practices for Florida School Districts*, Report No. 97-08, October 1997.

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Office of Program Policy Analysis and Government Accountability, *Review of the Expedited Permitting Process Coordinated by the Governor's Office of Tourism, Trade, and Economic Development,* Report No. 98-17, October 1998.

Office of Program Policy Analysis and Government Accountability, *Florida Water Policy: Discouraging Competing Applications for Water Permits; Encouraging Cost-Effective Water Development,* Report No. 99-06, August 1999.

"Smoke in the Water: Air Pollution Hidden in the Water Vapor from Cooling Towers – Agencies Fail to Enforce Against Polluters," Galveston Houston Association for Smog Prevention, February 2004.

"Reducing Air Pollution from Houston-Area School Buses," Galveston Houston Association for Smog Prevention, March 2004.

"Who's Counting: The Systematic Underreporting of Toxic Air Emissions," Environmental Integrity Project and Galveston Houston Association for Smog Prevention, June 2004.

"Mercury in Galveston and Houston Fish: Contamination by Neurotoxin Places Children at Risk," Galveston Houston Association for Smog Prevention, October 2004.

"Exceeding the Limit: Industry Violations of New Rule Almost Slid Under State's Radar," Galveston Houston Association for Smog Prevention, January 2006.

"Whiners Matter! Citizen Complaints Lead to Improved Regional Air Quality Control," Galveston Houston Association for Smog Prevention, June 2006.

"Bringing Clean Energy to the Southeastern United States: Achieving the Federal Renewable Energy Standard," Southern Alliance for Clean Energy, February 2008.

"Cornerstones: Building a Secure Foundation for North Carolina's Energy Future," Southern Alliance for Clean Energy, May 2008.

"Yes We Can: Southern Solutions for a National Renewable Energy Standard," Southern Alliance for Clean Energy, February 2009.

"Green in the Grid: Renewable Electricity Opportunities in the Southeast United States," with Dennis Creech, Eliot Metzger, and Samantha Putt Del Pino, World Resources Institute Issue Briefs, April 2009.

"Local Clean Power," with Dennis Creech, Eliot Metzger, and Samantha Putt Del Pino, World Resources Institute Issue Briefs, April 2009.

"Energy Efficiency Program Impacts and Policies in the Southeast," Southern Alliance for Clean Energy, May 2009.

"Recommendations for Feed-In-Tariff Program Implementation In The Southeast Region To Accelerate Renewable Energy Development," Southern Alliance for Clean Energy, March 2011.

"Renewable Energy Standard Offer: A Tennessee Valley Authority Case Study," Southern Alliance for Clean Energy, November 2012.

"Increased Levels of Renewable Energy Will Be Compatible with Reliable Electric Service in the Southeast," Southern Alliance for Clean Energy, November 2014.

"Cleaner Energy for Southern Company: Finding a Low Cost Path to Clean Power Plan Compliance," Southern Alliance for Clean Energy, July 2015.

"Analysis of Solar Capacity Equivalent Values for Duke Energy Carolinas and Duke Energy Progress Systems," prepared for and filed by Southern Alliance for Clean Energy, Natural Resources Defense Council, and Sierra Club in North Carolina NCUC Docket No. E-100, Sub 147, February 17, 2017.

"Seasonal Electric Demand in the Southeastern United States," Southern Alliance for Clean Energy, March 2017.

"Analysis of Solar Capacity Equivalent Values for the South Carolina Electric and Gas System," Southern Alliance for Clean Energy, March 2017.

"Solar in the Southeast, 2017 Annual Report," with Bryan Jacob, Southern Alliance for Clean Energy, February 2018.

"Energy Efficiency in the Southeast, 2018 Annual Report," with Forest Bradley-Wright, Southern Alliance for Clean Energy, December 2018.

"Solar in the Southeast, 2018 Annual Report," with Bryan Jacob, Southern Alliance for Clean Energy, April 2018.

"Tracking Decarbonization in the Southeast, 2019 Generation and CO_2 Emissions Report," with Heather Pohnan and Maggie Shober, Southern Alliance for Clean Energy, August 2019.

"Seasonal Electric Demand in the Southeastern United States," with Maggie Shober, Southern Alliance for Clean Energy, April 2020.

"Making the Most of the Power Plant Market: Best Practices for All-Source Electric Generation Procurement," with Mike O'Boyle, Ron Lehr, and Mark Detsky, Energy Innovation Policy & Technology LLC and Southern Alliance for Clean Energy, April 2020.

PRESENTATIONS

"Clean Energy Solutions for Western North Carolina," presentation to Progress Energy Carolinas WNC Community Energy Advisory Council, February 7, 2008.

"Energy Efficiency: Regulating Cost-Effectiveness," Florida Public Service Commission undocketed workshop, April 25, 2008.

"Utility-Scale Renewable Energy," presentation on behalf of Southern Alliance for Clean Energy to the Board of the Tennessee Valley Authority, March 5, 2008.

"An Advocates Perspective on the Duke Save-a-Watt Approach," ACEEE 5th National Conference on Energy Efficiency as a Resource, September 2009.

"Building the Energy Efficiency Resource for the TVA Region," presentation on behalf of Southern Alliance for Clean Energy to the Tennessee Valley Authority Integrated Resource Planning Stakeholder Review Group, December 10, 2009.

"Florida Energy Policy Discussion," testimony before Energy & Utilities Policy Committee, Florida House of Representatives, January 2010.

"The Changing Face of Energy Supply in Florida (and the Southeast)," 37th Annual PURC Conference, February 2010.

"Bringing Energy Efficiency to Southerners," Environmental and Energy Study Institute panel on "Energy Efficiency in the South," April 10, 2010.

"Energy Efficiency: The Southeast Considers its Options," NAESCO Southeast Regional Workshop, September 2010.

"Energy Efficiency Delivers Growth and Savings for Florida," testimony before Energy & Utilities Subcommittee, Florida House of Representatives, February 2011.

"Rates vs. Energy Efficiency," 2013 ACEEE National Conference on Energy Efficiency as a Resource, September 2013.

"TVA IRP Update," TenneSEIA Annual Meeting, November 19, 2014.

"Views on TVA EE Modeling Approach," presentation with Natalie Mims to Tennessee Valley Authority's Evaluating Energy Efficiency in Utility Resource Planning Meeting, February 10, 2015.

"The Clean Power Plan Can Be Implemented While Maintaining Reliable Electric Service in the Southeast," FERC Eastern Region Technical Conference on EPA's Clean Power Plan Proposed Rule, March 11, 2015.

"Renewable Energy & Reliability," 5th Annual Southeast Clean Power Summit, EUCI, March 2016.

"Challenges to a Southeast Carbon Market," 5th Annual Southeast Clean Power Summit, EUCI, March 2016.

"Solar Capacity Value: Preview of Analysis to Date," Florida Alliance for Accelerating Solar and Storage Technology Readiness (FAASSTeR) meeting, Orlando, FL, November 2017.

"Making the Most of the Power Plant Market: Best Practices for All-Source Electric Generation Procurement," Southeast Energy and Environmental Leadership Forum, Nicholas Institute for Environmental Policy Solutions, August 2020.

EXPERT TESTIMONY

2008 **South Carolina PSC** Docket No. 2007-358-E, surrebuttal testimony on behalf of Environmental Defense, the South Carolina Coastal Conservation League, Southern Alliance for Clean Energy and the Southern Environmental Law Center. Cost recovery mechanism for energy efficiency, including shareholder incentive and lost revenue adjustment mechanism.

2009 **North Carolina NCUC** Docket No. E-7, Sub 831, direct testimony on behalf of Environmental Defense Fund, Natural Resources Defense Council, Southern Alliance for Clean Energy, and Southern Environmental Law Center. Cost recovery mechanism for energy efficiency, including shareholder incentive and lost revenue adjustment mechanism.

Florida PSC Docket Nos. 080407-EG through 080413-EG, direct testimony on behalf of Southern Alliance for Clean Energy and the Natural Resources Defense Council. Energy efficiency potential and utility program goals.

South Carolina PSC Docket No. 2009-226-E, direct testimony in general rate case on behalf of Environmental Defense, the Natural Resources Defense Council, the South Carolina Coastal Conservation League, Southern Alliance for Clean Energy and the Southern Environmental Law Center. Cost recovery mechanism for energy efficiency, including shareholder incentive and lost revenue adjustment mechanism.

2010 **North Carolina NCUC** Docket No. E-100, Sub 124, direct testimony on behalf of Environmental Defense Fund, the Sierra Club, Southern Alliance for Clean Energy, and Southern Environmental Law Center. Adequacy of consideration of energy efficiency in Duke Energy Carolinas and Progress Energy Carolinas' 2009 integrated resource plans.

Georgia PSC Docket No. 31081, direct testimony on behalf of Southern Alliance for Clean Energy. Adequacy of consideration of energy efficiency in Georgia Power's 2010 integrated resource plan, including cost effectiveness, rate and bill impacts, and lost revenues.

Georgia PSC Docket No. 31082, direct testimony on behalf of Southern Alliance for Clean Energy. Adequacy of consideration of energy efficiency in Georgia Power's 2010 demand side management plan, including program revisions, planning process, stakeholder engagement, and shareholder incentive mechanism.

2011 **South Carolina PSC** Docket No. 2011-09-E, allowable ex parte briefing on behalf of Southern Alliance for Clean Energy, South Carolina Coastal Conservation League, and Upstate Forever. Adequacy of South Carolina Electric & Gas's 2011 integrated resource plan, including resource mix, sensitivity analysis, alternative supply and demand side options, and load growth scenarios.

South Carolina PSC Docket Nos. 2011-08-E and 2011-10-E, allowable ex parte briefing on behalf of Southern Alliance for Clean Energy, South Carolina Coastal Conservation League, and Upstate Forever. Adequacy of Progress Energy Carolinas and Duke Energy Carolinas' 2011 integrated resource plans, including resource mix, sensitivity analysis, alternative supply and demand side options, cost escalation, uncertainty of nuclear and economic impact modeling.

2013 **Georgia PSC** Docket No. 36498, direct testimony on behalf of Southern Alliance for Clean Energy. Adequacy of consideration of energy efficiency in Georgia Power's 2013 integrated resource plan, including cost effectiveness, rate and bill impacts, and lost revenues, economics of fuel switching and renewable resources.

South Carolina PSC Docket No. 2013-392-E, direct testimony with Hamilton Davis in Duke Energy Carolinas need certification case on behalf of the South Carolina Coastal Conservation League and Southern Alliance for Clean Energy. Need for capacity, adequacy of energy efficiency and renewable energy alternatives, and use of solar power as an energy resource.

2014 **South Carolina PSC** Docket No. 2014-246-E, direct testimony generic proceeding on behalf of the South Carolina Coastal Conservation League and Southern Alliance for Clean Energy. Methods for calculating dependable capacity credit for renewable resources and application to determination of avoided cost.

2015 **Florida PSC** Docket No. 150196-EI, direct testimony in Florida Power & Light need certification case on behalf of Southern Alliance for Clean Energy. Appropriate reserve margin and system reliability need.

2016 **Georgia PSC** Docket No. 40161, direct testimony on behalf of Southern Alliance for Clean Energy. Adequacy of consideration of renewable energy in Georgia Power's 2016 integrated resource plan, including portfolio diversity, operational and implementation risk, analysis of project-specific costs and benefits (including location and technology considerations), and methods for calculating dependable capacity credit for renewable resources.

2019 **Georgia PSC** Docket Nos. 42310 and 42311, direct testimony with Bryan A. Jacob in Georgia Power's 2019 integrated resource plan and demand side management plan on behalf of Southern Alliance for Clean Energy. Adequacy of consideration of renewable energy in IRP, retirement of uneconomic plants, and use of all-source procurement process. Shareholder incentive mechanism for both renewable energy and DSM plan.

2020 **Nova Scotia UARB** Matter No. M09519, direct testimony with Paul Chernick in Nova Scotia Power's application for approval of the Smart Grid Nova Scotia Project on behalf of the Nova Scotia Consumer Advocate. Cost classification, decommissioning costs, justification for software vendor selection, and suggested changes to project scope.

Nova Scotia UARB Matter No. M09499, direct testimony with Paul Chernick in Nova Scotia Power's 2020 annual capital expenditure plan on behalf of the Nova Scotia Consumer Advocate. Potential to decommission hydroelectric systems, review of annually recurring capital projects, use of project contingencies, and cost minimization practices.

Nova Scotia UARB Matter No. M09579, direct testimony with Paul Chernick in Nova Scotia Power's application for the Gaspereau Dam Safety Remedial Works on behalf of the Nova Scotia Consumer Advocate. Alternatives to proposed project, project contingency factor, estimation of archaeological costs, and replacement energy cost calculation.

Nova Scotia UARB Matter No. M09609, direct testimony with Paul Chernick in Nova Scotia Power's application for the Advanced Distribution Management System Upgrade on behalf of the Nova Scotia Consumer Advocate. Need for the ADMS and integration with the Distributed Energy Resources Management System.

Nova Scotia UARB Matter No. M09707, direct testimony with Paul Chernick on Nova Scotia Power's 2020 Load Forecast on behalf of the Nova Scotia Consumer Advocate. Impacts of recession, application of end-use studies, improvements to forecast components, and impact of time-varying pricing.

California PUC Docket A.19-10-012, direct and rebuttal testimony with Paul Chernick in San Diego Gas & Electric's application for the Power Your Drive Electric Vehicle Charging Program on behalf of the Small Business Utility Advocates. Ensuring that utility-installed chargers advance California goal for electric vehicles. Budget controls. Reporting requirements. Evaluation, monitoring and verification processes. Outreach to small business customers.

California PUC Docket A.19-08-012, direct testimony in Southern California Edison's 2021 general rate case (track 2) on behalf of the Small Business Utility Advocates. Reasonableness of remedial software costs to be included in authorized revenue requirement.

Georgia PSC Docket Nos. 4822, 16573 and 19279, direct, rebuttal and surrebuttal testimony in Georgia Power Company's PURPA avoided cost review on behalf of the Georgia Large Scale Solar Association. Reviewing compliance with prior Commission orders. Application of capacity need forecast in projection of avoided capacity cost. Calculation of cost of new capacity. Proposal of standard offer contract.