**TOWN OF berwick**

**Feasibility Study - Factorydale Hydropower Plant Refurbishment Project**

**HSV-2024-043-SREP02 – Ver.1**

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## INTRODUCTION

The main dam of Factorydale Hydropower Plant under the management of Berwick Electric Commission (BEC), is a concrete and earthen embankment structure raised to provide approximately 80 ft of head for the turbine/generator system.

In 2023, an incident occurred at the Factorydale Power Site, resulting in a complete shutdown of the water turbine and consequently a permanent loss of power generation. To investigate the event, BEC conducted a Condition Assessment and Costed Option Analysis to establish a logical starting point for the refurbishment project. This report focuses on critical components of the plant, including the turbine, generator, governor, circuit breakers, and civil structures, following the HydroAMP (Hydropower Asset Management Project) methodology.

Additionally, a Root Cause Analysis (RCA) was conducted, determining that the failure originated from a large solid object passing through and initially damaging one or more wicket gates. This event led to catastrophic damage affecting the wicket gates, control arms, control rings, and turbine runner.

This study evaluates the technical and financial feasibility of the Factorydale hydropower plant refurbishment project. The project's objective is to upgrade existing equipment and infrastructure to enhance efficiency, reliability, and long-term sustainability. The scope includes the supply, installation, and commissioning of a new Francis-type hydro turbine optimized for the plant's existing hydraulic conditions, as well as necessary upgrades to the generator, new trash rack in penstock entry, control and automation systems, monitoring and protection systems, governor, switchgear, excitation system, power transformer and all associated mechanical and electrical infrastructure.

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## SECTION 1 – PREVIOUS STUDIES

For the incident, following a Condition Assessment and Costed Option Analysis, BEC conducted a Root Case Analysis to evaluate refurbishment feasibility. The proposed refurbishment includes installing a new, optimized Francis-type hydro turbine and all related mechanical and electrical infrastructure, aiming to improve efficiency, reliability, and sustainability.

### 1.1 Conditions Assessment Analysis: Conclusions

- The condition assessment of the Factorydale Hydropower Plant indicates that while some components remain operational, the plant's overall health is compromised by aging infrastructure and significant damage to critical components, particularly the turbine. Therefore, a complete replacement of all electromechanical components using the existing civil infrastructure is required for continued plant operation.
- Given the plant's age and current state of its equipment, immediate actions are necessary to address critical issues, specifically the replacement of all electromechanical components. The cost analysis outlines three potential paths forward: a like-for-like replacement of damaged components, the installation of modern electromechanical equipment optimized for current conditions, or a complete facility decommissioning. Each option presents different financial and operational implications, and this Condition Assessment report provides a basis for informed decision-making regarding the Factorydale plant's future.
- The recommended course of action involves replacing all electromechanical components on the existing civil infrastructure, allowing the plant to continue generating power efficiently and reliably, supported by ongoing maintenance to ensure long-term sustainability.

### 1.2 Root Case Analysis: Conclusions

- The most likely scenarios were reviewed based on evidence gathered on-site, laboratory analyses, and computer simulations. The evaluation strongly indicates that a large object passed through the turbine, causing catastrophic failure. This object damaged the wicket gates, turbine runner, and scroll case, leading to irreversible damage to the entire turbine unit.

- Secondary issues were identified related to turbine design, notably the inappropriate use of cast iron, resulting in brittle fractures and broken attachments. Visual inspection revealed that the cast iron used was a non-weldable, non-ductile material, exhibiting approximately 30% of the ultimate tensile strength expected for typical gate castings. The substandard casting structure means these gates would likely fail under any significant impact load. Additionally, the wicket gates' design did not achieve a complete seal, making flow stoppage unreliable. The runner blade attachment method is weak by current engineering standards, posing a risk of blade detachment and potential failure if reconstructed similarly.

- Further inspection revealed deficiencies indicating the need for more rigorous maintenance and routine inspections. Although runner blades had been previously treated against corrosion and cavitation, no recent condition assessments were available. Seal and pipe joint leakages were also observed, along with inadequate evidence of corrosion protection measures such as epoxy paint or regular coating maintenance. Future replacement parts should be selected using appropriate engineering methods and strict quality controls.

# SECTION 2 – TECHNICAL INFORMATION

## 2.1 Site Conditions

The powerhouse building is constructed with reinforced concrete and brick. It includes concrete and metal pathways, passages, stairs, entrance/exit doors, and other common features typical of industrial applications.

The Berwick Factorydale Hydroelectric Power Plant is located at 2545 Harmony Rd, Aylesford, Nova Scotia. Figure 1 provides a location diagram, including the penstock route.

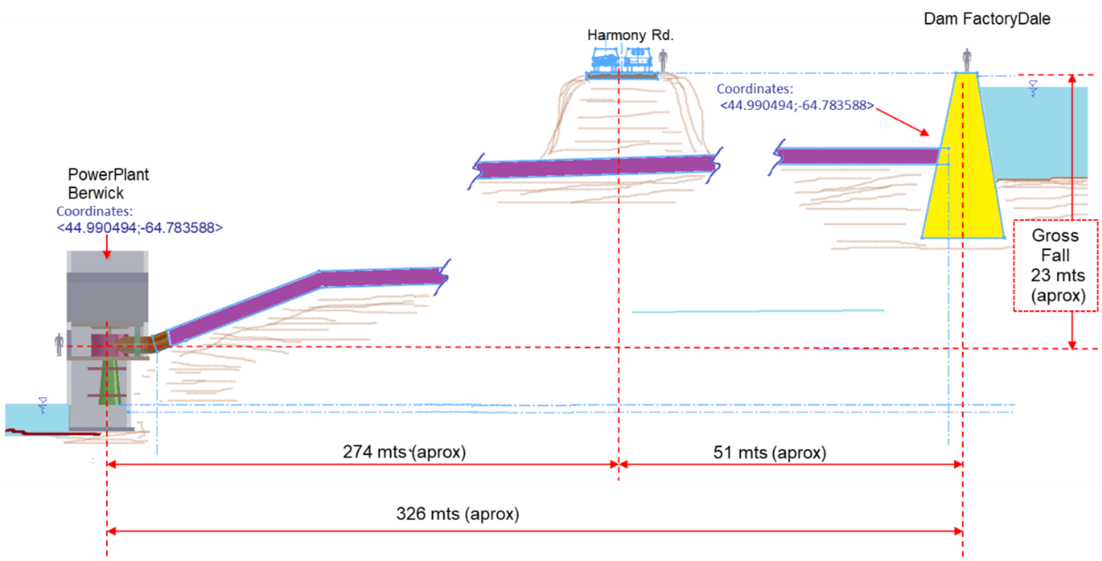


*Figure 1: General diagram of the intake pipe from the dam to the plant*

The Factorydale Hydroelectric Power Station has the following key infrastructure features:

- It operates as a reservoir-based plant.
- The main dam is a concrete embankment structure with elevated earth, providing a height of approximately 80 feet (24.384 m) for the turbine/generator system.
- The net head is 22.654 meters, accounting for a tailwater effect of 1.82 meters (6 feet).
- **The design flow rate is 3.39 cubic meters per second (120 cubic feet per second).** Seasonal variations are to be evaluated to account for changes in flow and height throughout the year.
- Penstock Details:
  - Type: Reinforced fiberglass.
  - Length: Approximately 320 meters.
  - Diameter: 1.21 meters (48 inches) (internal).
  - Condition: Excellent, fully refurbished in 2016.

The rock structure around this site consists of large cliffs of fractured slate.

*Figure 2: Slate slabs located around the powerhouse.*

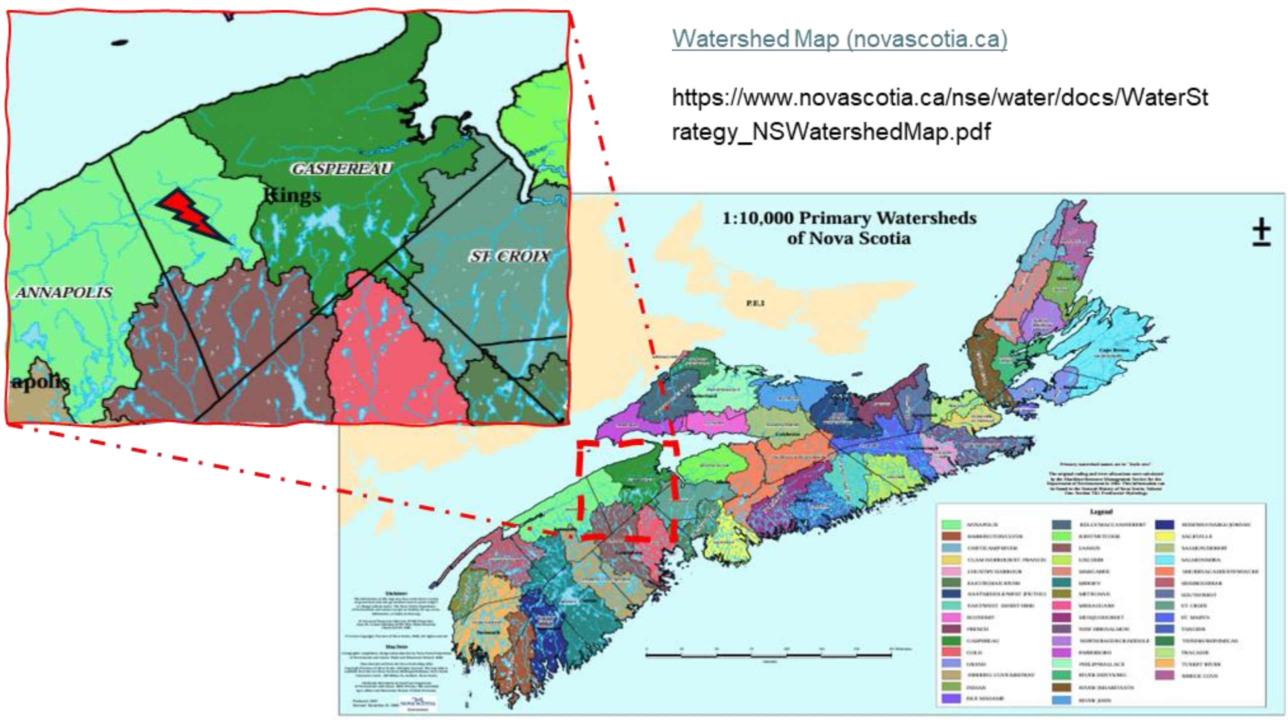


*Figure 3: The river that feeds the Berwick Power Plant within King's County is a tributary of the Annapolis River.*

The plant is located in Kings County. This river belongs to the hydrographic basin of the Annapolis River and is a tributary to the east on the south side.

Water is contained by a concrete dam with overflow gates and rip rap to protect the edges from washout. A rudimentary control system measures the water level and opens and closes the overflow gates to provide continuous flow through the draft tube. A manually operated hydraulic (lift) intake gate at the draft tube entrance provides safety protection to stop the flow of water through the draft tube and into the Turbine.

*Figure 4: Head Pond views looking upstream from the dam.*

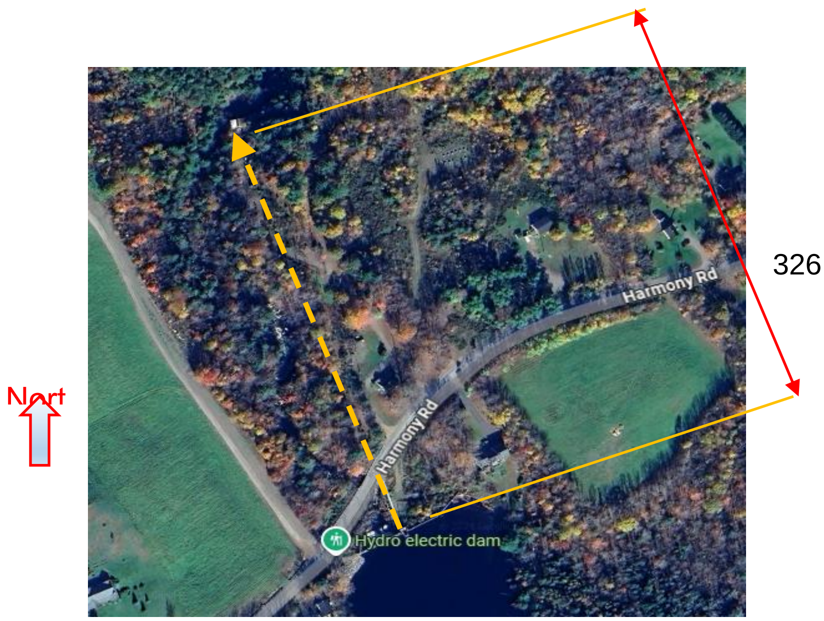


*Figure 5: Aerial view of the surroundings.*

The surge valve piping from the valve to the powerhouse is constructed from welded steel pipe.

*Figure 6: Draft Tube leading down from Surge Valve Building into the Powerhouse.*

*Figure 7: Powerhouse upper level.*

Continuing down to the turbine room entrance revealed the open scroll case and damaged turbine.

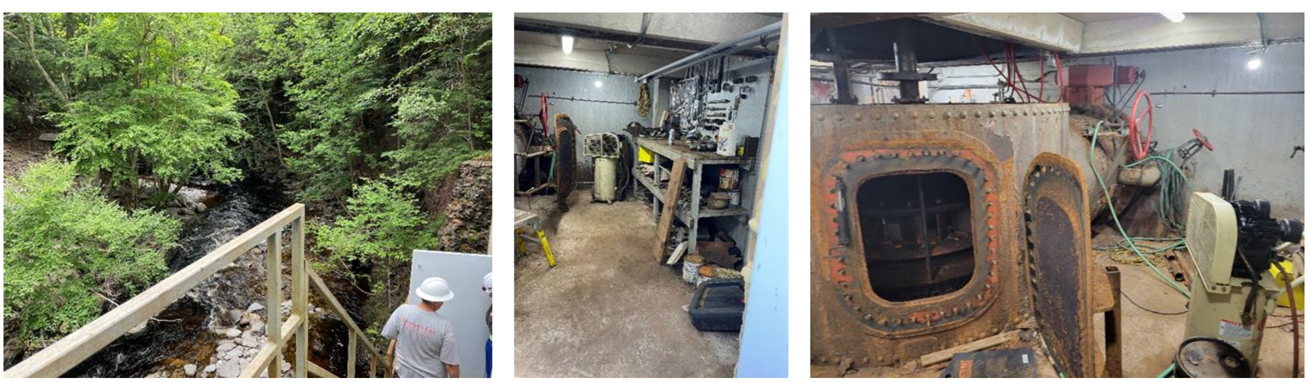

*Figure 8: Turbine floor.*

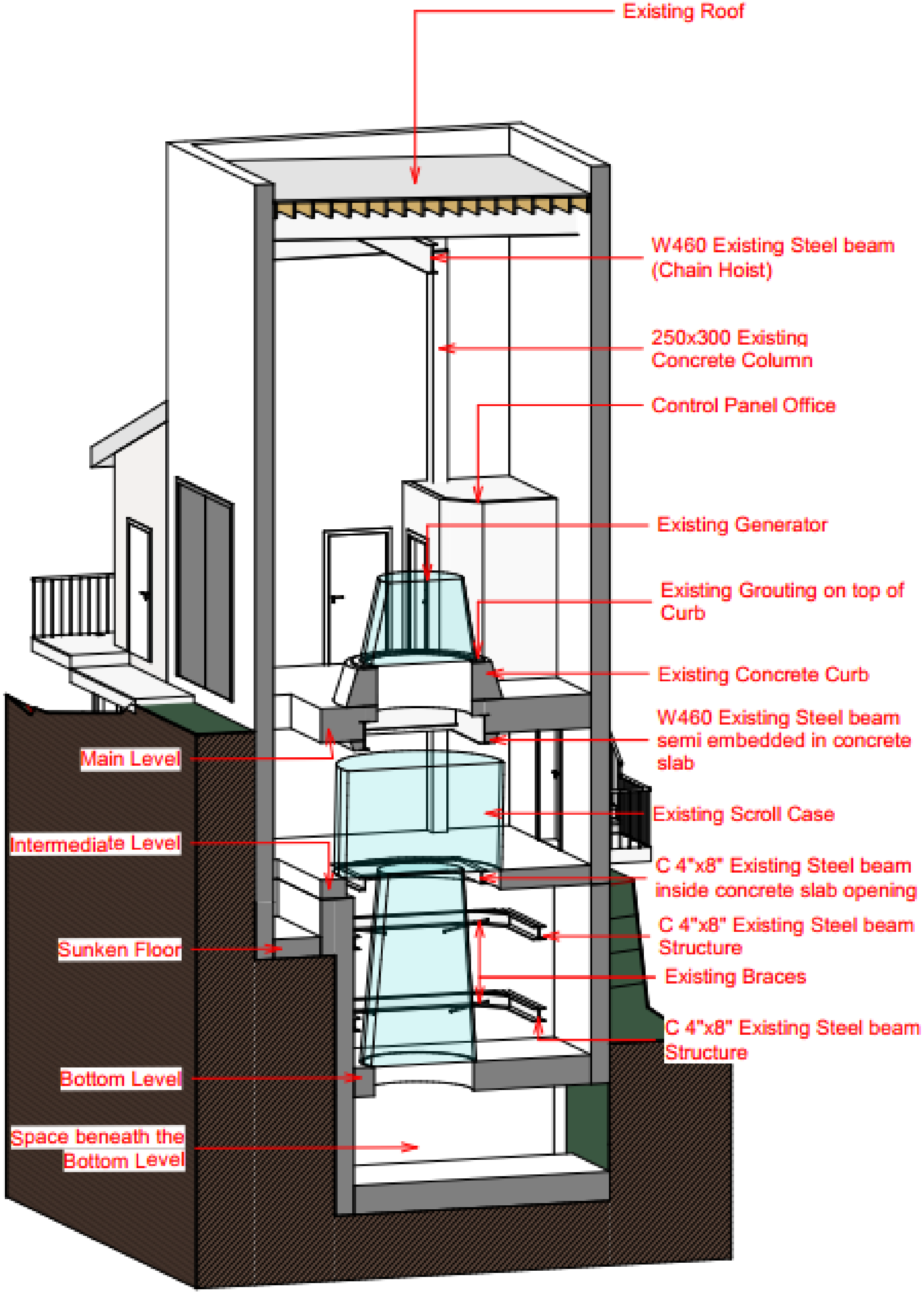


*Figure 9: Powerhouse drawing extract supplied. Drawing: HSV-2024-043-05 – Existing Building.*

## 2.2 Current Equipment

The electric generator for replacement, operates at a constant speed of 514 rpm, synchronous AC, 416 kW (520 kVA – PF: 80%), 2300 V, 131 A, 14 poles, 60 Hz. Canadian General Electric, No. 140147.


*Figure 10: Description of Generator installed.*

The Turbine Francis type, 12 blades, 692 hp, 614 rpm, Manufactured by Barber Turbine & Foundries, 1968. The turbine system is controlled by a mechanical governor using flyball weights to fix the RPM at a constant speed for the generator.

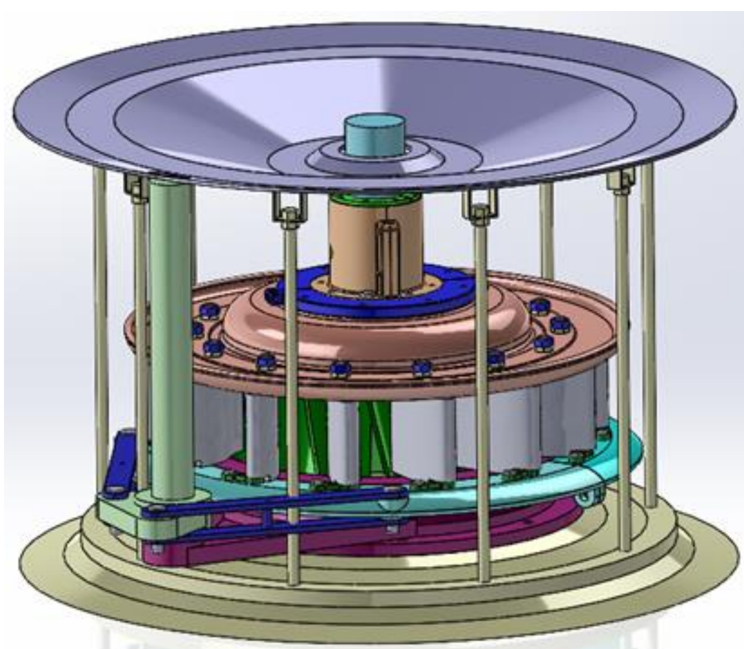

*Figure 11: Original description of Barber Hydraulic Turbine controlled by Mechanical Governor*

The Governor is Hydraulic, Woodward, type HR, torque: 6700 ft.lb. The governor and wicket gate controls are mechanically linked so the operator can increase the generated load by opening the gates and the governor keeps the rpm steady. The head and volume of the river fix the design to be of the Francis style of water turbine, so the runner blades are fixed to the runner.

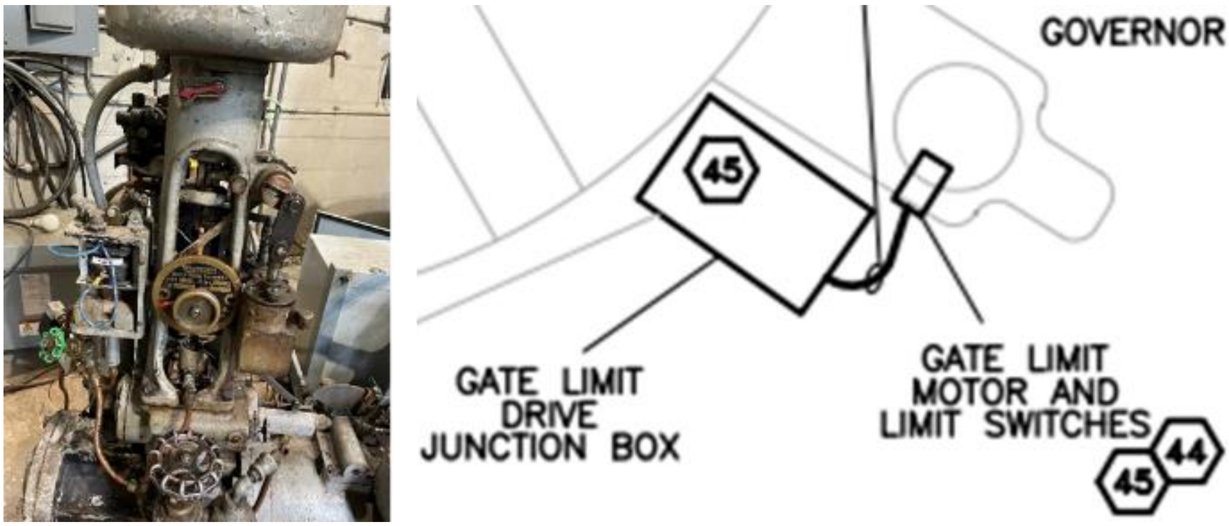


*Figure 12:* Governor and limit switch diagram

# Turbine assembly breakdown and disassembly order

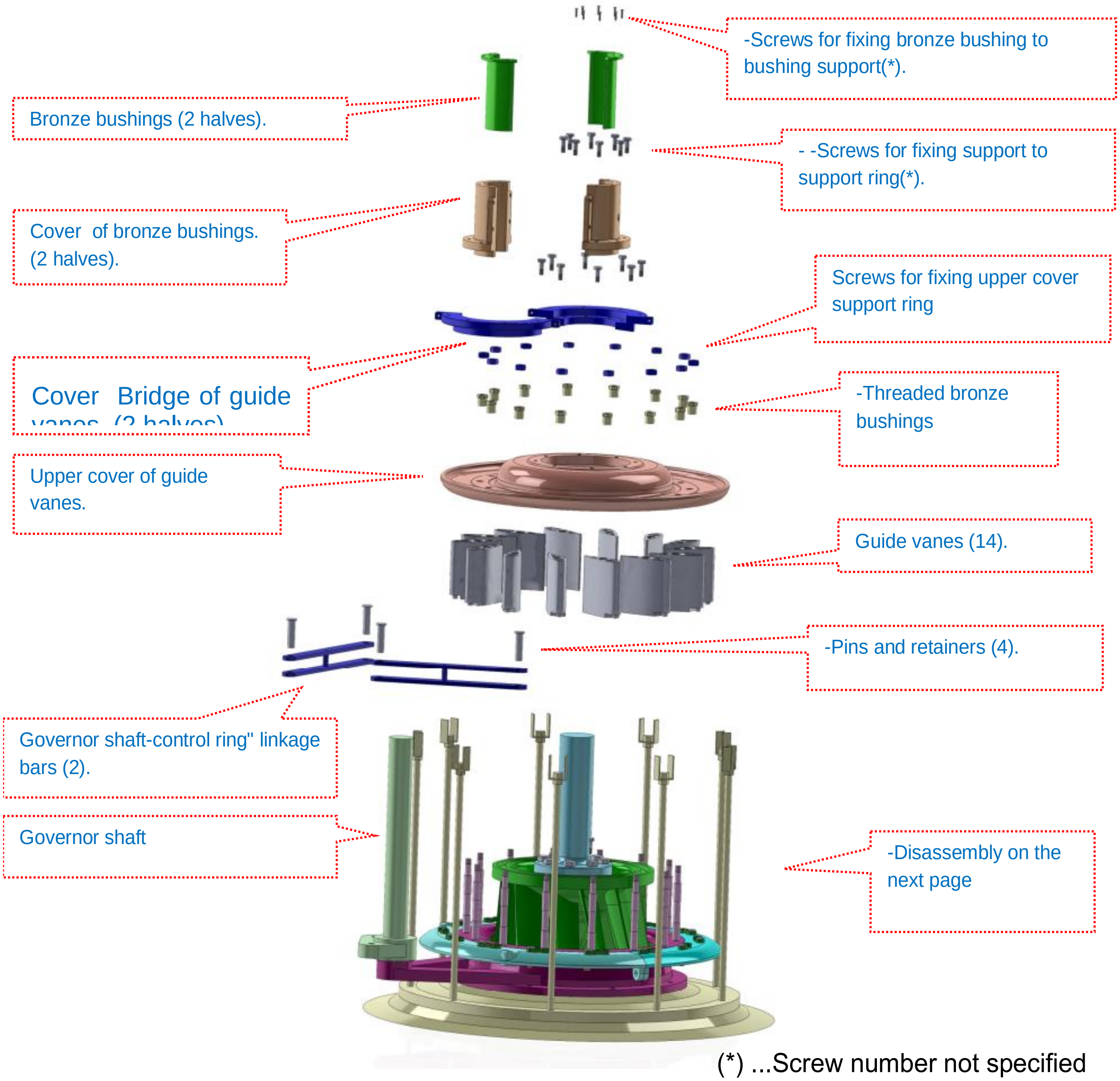


*Figure 13: Current turbine disassembly A*

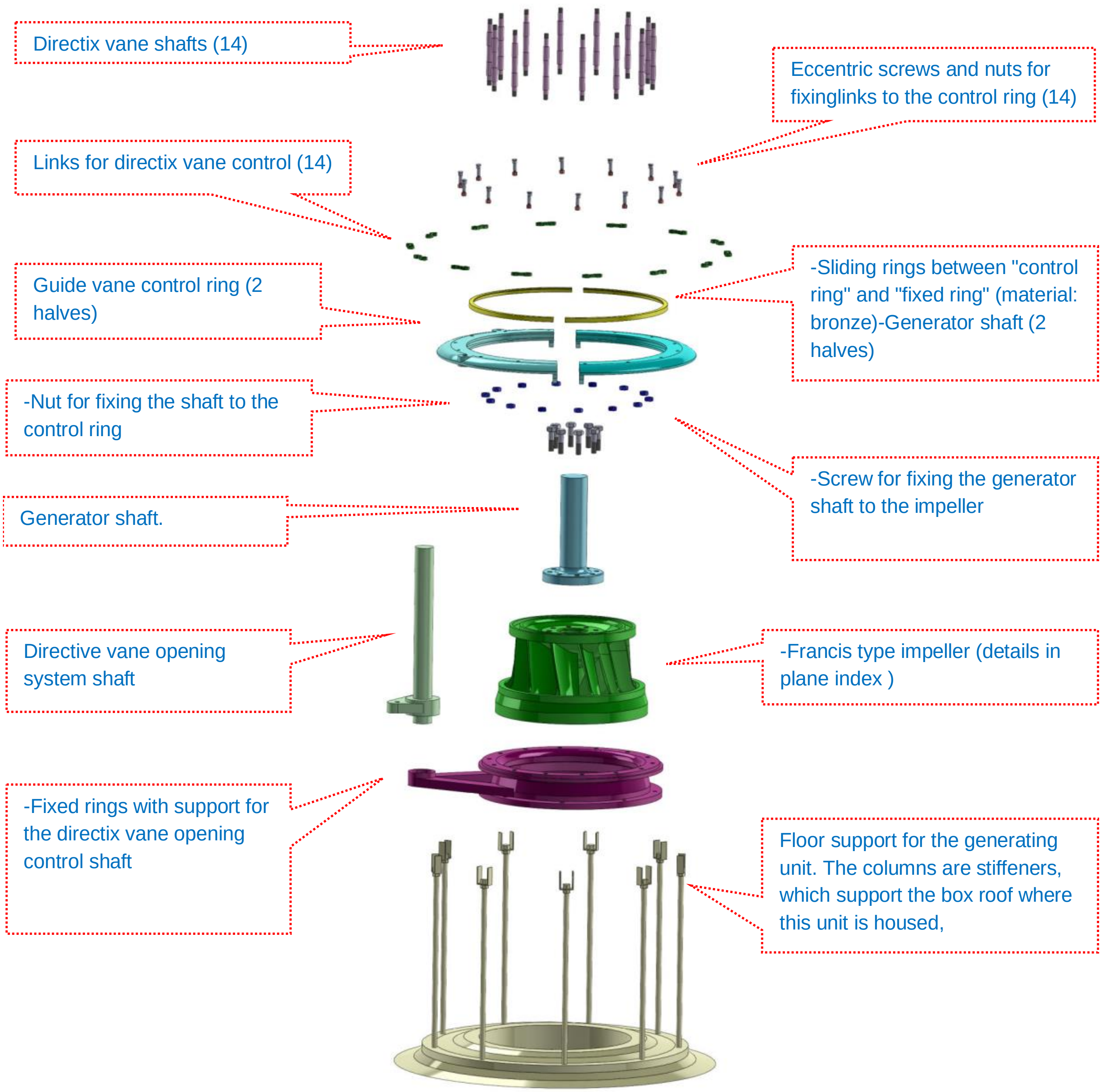


*Figure 14: Current turbine disassembly B.*

The intake gate controls the entry of water into the draft tube and on to the turbine. It is hydraulically operated with a portable power pack and is not used to control water flow on a continuous monitored basis. This intake gate's primary function is to prevent water flowing into the draft tube when the generator is not producing power.


*Figure 15: Intake gate in closed position.*

The trash rack at the penstock entry captures debris to keep it from entering the draft tube and mechanical equipment below. This style of trash rack is cleaned manually and requires maintenance personnel to tend to it.

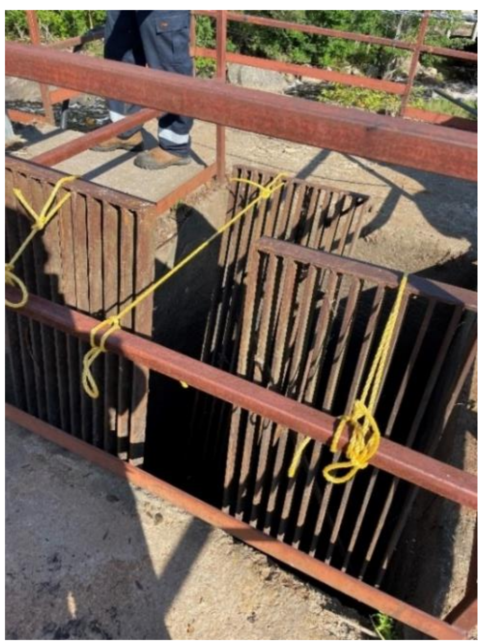

*Figure 16: Segmented Trash rack - lifted for inspection.*

The penstock is a multi-construction pipe made from CFP and steel. It leads downhill to the main shutoff valve room and connects to the turbine house scroll case.

*Figure 17: FRP section of draft tube looking downstream from dam.*

The plant, instead of having a surge tank, has a pressure relief valve installed, with surge anticipation. This is a common system that is used in small hydro plants to avoid the construction of a surge tank. This protects the penstock and the powerhouse of the water-ram effect in the event of a sudden closure of the intake valve, or the wicket gates in this case.

*Figure 18: Surge Valve Building and valve.*

*Figure 19: Discharge area at the river.*

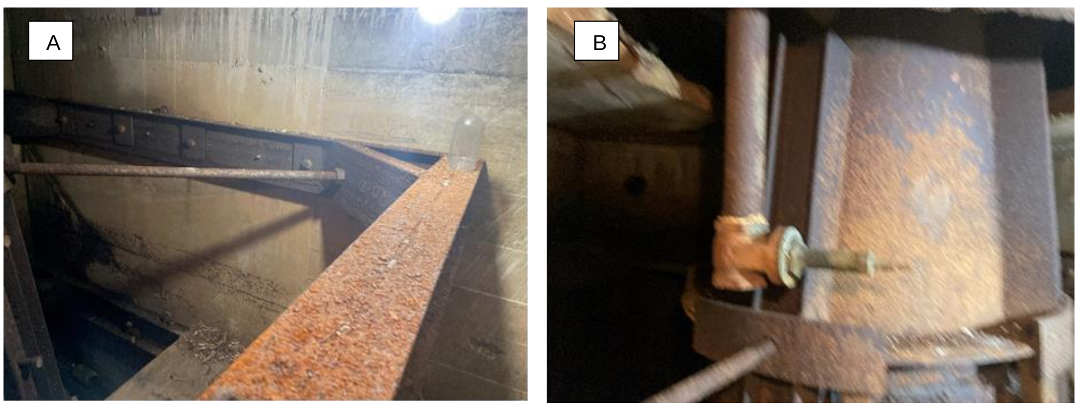


*Figure 20: Inspection of draft tube chamber. A: Detail of support anchored to the walls. B: Detail of conical discharge pipe.*

## 2.3 Proposed Equipment

The project aims to fully upgrade all electromechanical systems, including the turbine, generator, balance of plant (BOP), transformer, and all associated systems at the Factorydale hydroelectric plant, increasing its capacity from 416 kW to a range between 650 kW and 750 kW. It also seeks to enhance reliability through new control systems and advanced condition-monitoring systems with machine learning capabilities, enabling predictive maintenance and providing suggested maintenance actions.

The new generator must be fully adapted and coupled to integrate seamlessly with the complete power system of the Hydrogenerator. **This includes the intake valve, turbine, upgrading the generator, control and automation systems, monitoring and protection systems, governor,**

**switchgear, excitation system, power transformer, as well as all associated mechanical and electrical components of the plant**.

Figure 21 shows a comparison between the old installation and the Modernization Plan that is initially proposed with better performance in the same space, it is a general scheme to develop the proposal.

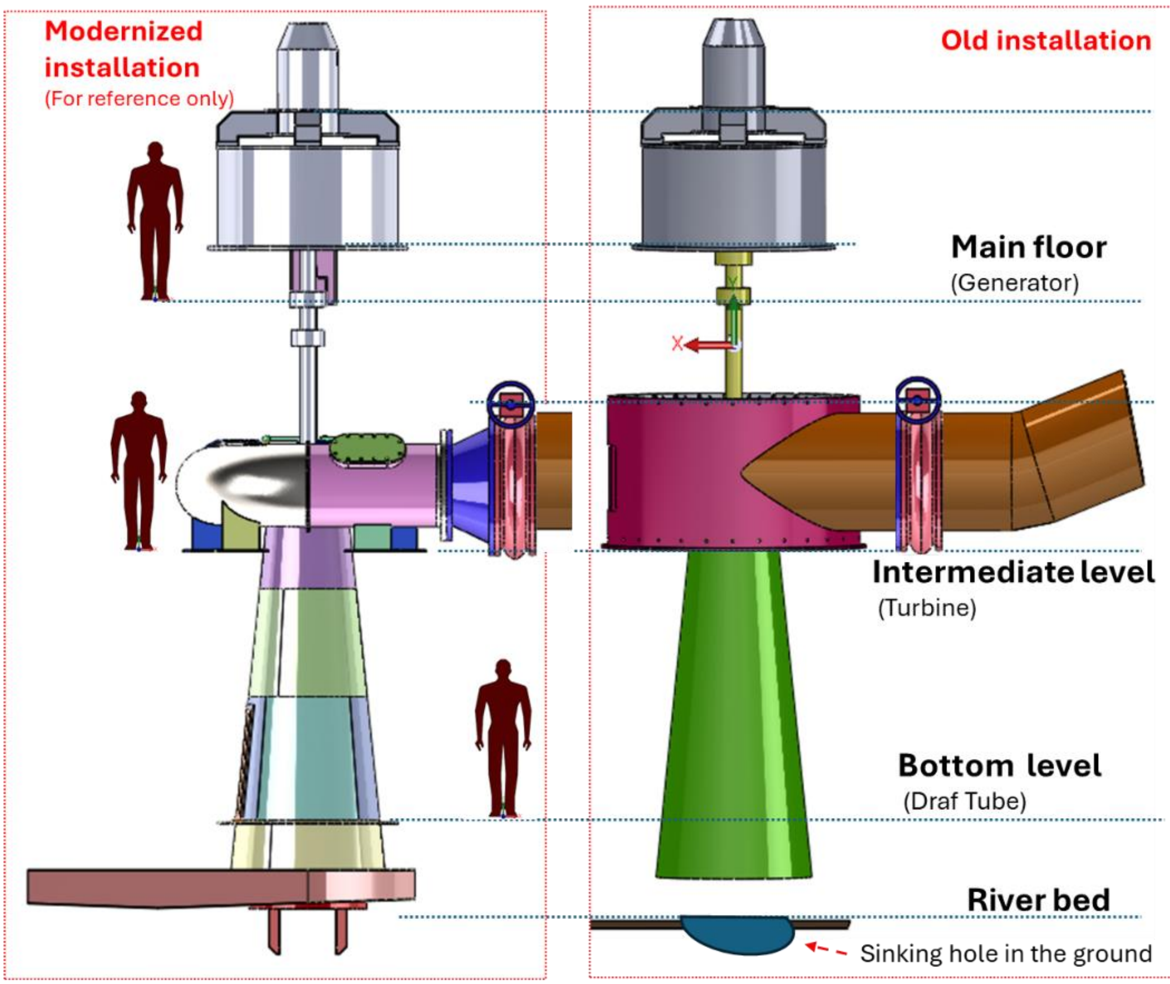


*Figure 21: "Old installation" vs. reference of "Modernized installation".*

### 2.3.1 Draft Tube

The draft tube design follows a practical and commonly used configuration in vertical-shaft Francis-type hydraulic turbines. Located directly beneath the turbine runner, this draft tube gradually expands downward in a conical shape, gently widening to efficiently recover residual water energy. This intuitive design readily adapts to specific conditions such as available flow rates and hydraulic head for the project.

Its smooth, conical shape progressively increases in cross-sectional area toward the water discharge outlet, significantly reducing the flow velocity after passing through the turbine. This thoughtful design transforms the remaining kinetic energy into static pressure, thereby improving overall system efficiency. The length of the draft tube is dictated by existing infrastructure constraints, ensuring a gradual reduction in water velocity to prevent turbulence or flow separation.

Given its constant submersion and exposure to water flow, this component is susceptible to wear, sediment accumulation, and potential structural damage, necessitating periodic inspections. The new design incorporates an accessible inspection door to simplify internal evaluations. Considering its current advanced deterioration, this component urgently requires intervention to enhance performance.

The proposed assembly is segmented into three parts (pipe, conical diffuser, and discharge diffuser), allowing easier internal transport and on-site assembly. Furthermore, the conical diffuser features robust anchoring to mitigate soil erosion at the discharge point, while the discharge diffuser optimizes the water exit velocity, thus maximizing hydroelectric system efficiency.

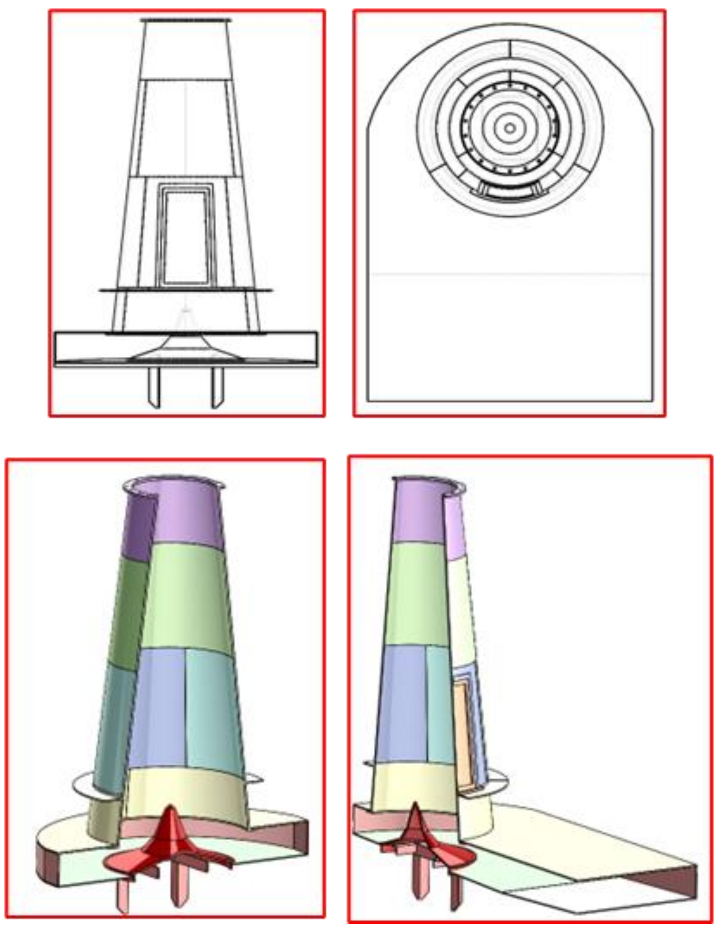

*Figure 22: Reference of the design of Draft Tube.*

### 2.3.2 Scroll Case

The proposed scroll case design adopts a spiral-shaped geometry concentrically surrounding the turbine, ensuring uniform flow distribution to each guide vane. This uniformity minimizes vibrations, torque fluctuations, and enhances hydraulic efficiency. Structurally anchored to the facility's foundations, it withstands internal pressures and operational loads effectively.

It must be manufactured according to international standards (IEC, ASME), the scroll case consists of welded steel with precisely calculated thicknesses and internal epoxy coating for reduced friction losses. Hydraulic performance must comply with IEC 60193 standards. The segmented design, comprising two or three sections, enables manageable on-site assembly, incorporating removable lids for inspection and maintenance.

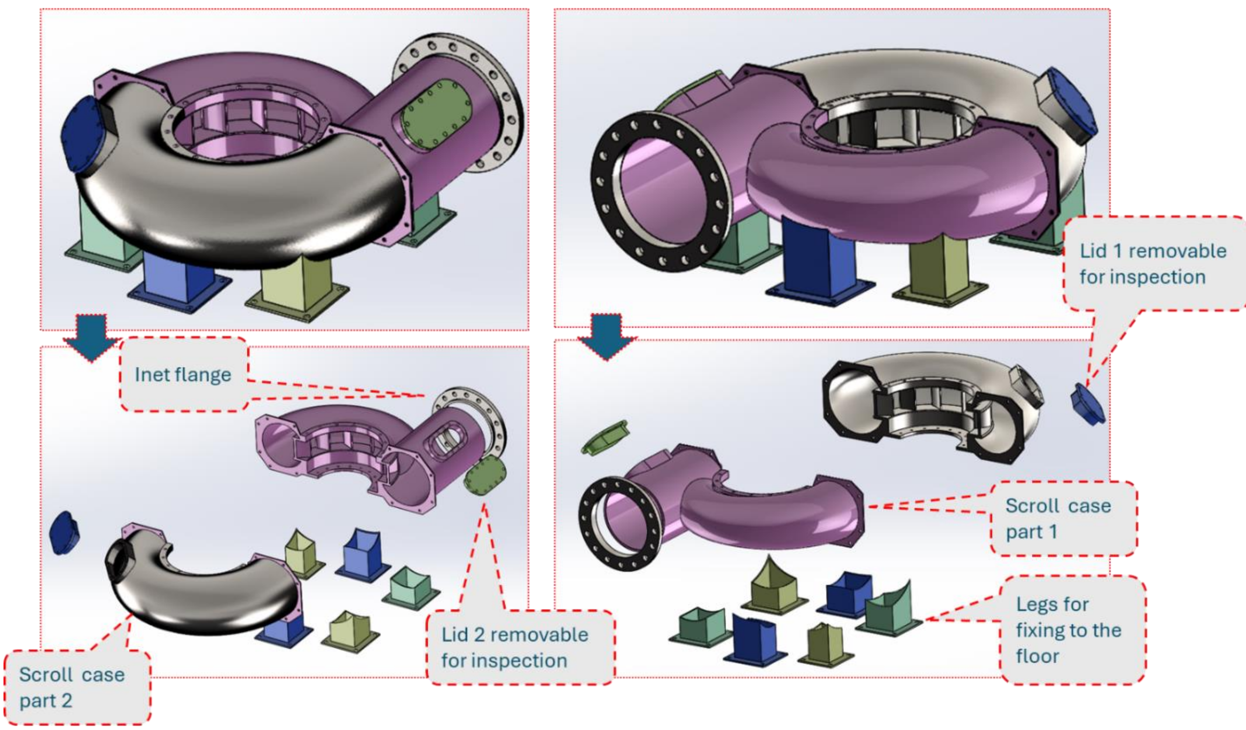


*Figure 23: For reference only, Scroll case disassembly mode*.

### 2.3.3 Turbine

The proposed project involves the installation of a new Francis-type hydro turbine, designed to deliver a power output ranging between 650 and 750 kW, intended to replace the existing unit at the Factorydale hydroelectric plant. The turbine must operate efficiently under variable flow conditions, utilizing both impounded water and run-of-the-river flows managed by the upstream dam system. Full integration with existing plant infrastructure, including manual, automated, and SCADA systems, is required.

The turbine design must consider specific site conditions, including exposure to humid coastal climates with potential salt influence, temperature extremes between -20°C and 40°C, and the presence of sediment in the water. To ensure a minimum service life of 50 years, corrosion protection using epoxy coatings, which may require reapplication approximately every ten years, is mandated. Additionally, the turbine should be robust enough to manage hydraulic fluctuations and sediment-laden flows efficiently.

Manufacturing of the turbine will strictly adhere to international IEC and ASME standards, using materials resistant to impact, corrosion, and cavitation, such as type 410 stainless steel or equivalent for critical components. The design will include effective sealing systems for wicket gates to minimize leakage, and bearings preferably oil-free or environmentally safe alternatives, equipped with continuous monitoring through sensors for vibration, temperature, and pressure.

Logistically, all components must comply with precise dimensional constraints (maximum diameter of 1806 mm and maximum weight of 9,991 kg) to facilitate handling and installation using the existing overhead gantry crane. Furthermore, the current 48-inch butterfly intake gate system will be retained but upgraded for automated and remote operation, fully integrated with the plant's SCADA system.

Finally, comprehensive Factory Acceptance Testing (FAT) and Site Acceptance Testing (SAT) will be required, ensuring a minimum efficiency of 90% under nominal conditions and operational availability of at least 98%. The manufacturer must provide a detailed preventive and corrective maintenance plan, including critical spare parts lists, specialized tools, operator and technician training, and a comprehensive warranty covering materials, performance, and workmanship.

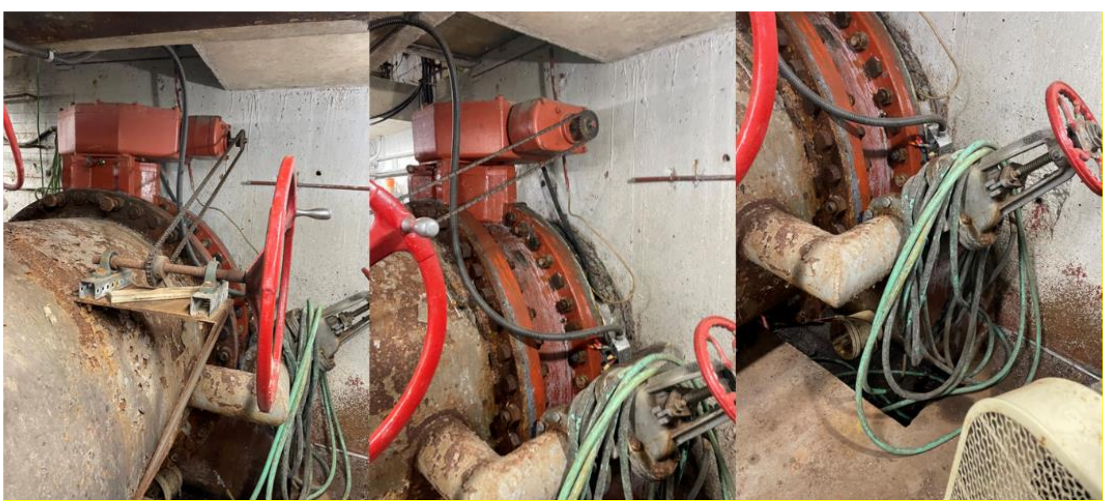

*Figure 24: Intake valve.*

*Figure 25: Pressure relief valve.*

### 2.3.4 Governor

The Factorydale project involves installing a sophisticated governor control system for the new 650-750 kW Francis-type water turbine. This governor system is essential for managing turbine speed and load under varying operational conditions, ensuring prompt and reliable startup within 10 minutes of initiation, typically scheduled with a 1-hour advance notice. Given the remote operation of the facility, the system must integrate seamlessly with the existing SCADA infrastructure, enabling real-time monitoring and remote management.

Due to environmental sensitivity, the governor design should avoid hydraulic oils or, if necessary, employ biodegradable oils with stringent containment measures to prevent contamination. The preferred actuator for wicket gates is the ball screw actuator, although other environmentally friendly options will be considered. Proposals must outline clearly the approach to minimize ecological impact while maintaining high operational reliability.

Technically, the governor system must include at least two configurable analog inputs supporting critical functions such as pond/tail level monitoring, gate position feedback, and remote adjustments for speed or load. Additionally, it should accommodate discrete inputs like run/stop commands, emergency shutdown signals, and synchronization checks, alongside configurable relay outputs for operational and alarm states. System expansion capabilities through additional analog and digital I/O modules (such as LINKnet HT) are required to ensure future scalability.

Hardware requirements specify robust, modular components capable of continuous operation in humid coastal conditions, resistant to vibration, temperature variations, and electrical disturbances. Redundant sensors for speed measurement, actuator drivers, and precise load sensors are mandatory. The governor system should include comprehensive diagnostics, redundant power supply options, and extensive communication capabilities (LAN, USB, optional serial ports), ensuring reliable operations even during power disruptions.

Proponents must deliver comprehensive training for operators on system diagnostics and operations, ensuring field service support availability within 72 hours of notice. Detailed Factory Acceptance Testing (FAT) and Site Acceptance Testing (SAT) protocols must validate system functionality and integration, both at manufacturing facilities and on-site. The proposal phase requires a high-level description of the governor system design, including cost estimates, configuration details, and compatibility assurances with existing plant infrastructure.

### 2.3.5 Generator

The proposed project involves the replacement of the existing electric generator at Factorydale with a new synchronous AC generator, rated between 650 kW and 750 kW, operating at 2300 V, 514 rpm, with 14 poles and 60 Hz frequency. This replacement aims to enhance overall operational efficiency, reliability, and sustainability, applying advanced technologies and complying strictly with environmental and regulatory standards. The new generator will incorporate updated safety features, advanced protection mechanisms against electrical disturbances, and robust corrosion-resistant materials suited to the site's humid environmental conditions.

Operational and maintenance considerations for the new generator will include comprehensive documentation, training plans, and detailed inspection and maintenance schedules. Preventive maintenance, condition monitoring, and troubleshooting plans will be outlined clearly, with special attention given to spare parts management, particularly those prone to wear during normal operations. Critical spare parts required for continuous and safe operation during the initial ten years must be identified, along with a lifecycle analysis and replacement strategies.

The new generator installation must adhere strictly to international (IEC) and Canadian (CSA) standards, ensuring compliance with the most rigorous requirements. These include standards related to electromagnetic compatibility, rotating electric machinery, protective relays, and medium-voltage switchgear, among others. Special attention must be paid to network integration and remote monitoring capabilities, aligning with SCADA system requirements to facilitate operational decisions, remote monitoring, and control actions.

Additional technical requirements include robust humidity control and insulation resistance certification, vibration monitoring, grounding systems, and protective features such as overload, short-circuit, frequency deviations, and differential protection. The generator must also guarantee operational stability under transient network conditions and load rejection scenarios. Finally, environmental adaptability, specifically designed for operation in temperatures ranging from -20°C to 40°C, and high ingress protection (IP rating) for critical electrical and electronic components are mandatory, along with appropriate fire protection measures in all installation areas.

### 2.3.6 Switchgear

The Factorydale hydropower project includes the replacement and upgrade of the existing switchgear system, ensuring comprehensive protection, control, and isolation of electrical systems associated with the new hydro-generator unit. The new installation will feature specialized enclosures designed with effective ventilation and humidity control systems to safeguard against environmental degradation. Detailed functional drawings and documentation outlining AC and DC circuit arrangements and protective measures will accompany the installation.

Operational and maintenance requirements will involve providing extensive documentation, including original manufacturer manuals, descriptive reports, and training plans. The switchgear system will incorporate detailed procedures for routine inspections, condition monitoring, preventive maintenance, and emergency response protocols. Particular attention will be given to the provision and management of critical spare parts, especially those susceptible to wear within the first decade of operation, supported by lifecycle analysis and replacement strategies.

Compliance with international (IEC) and Canadian (CSA) standards is mandatory, with adherence to rigorous requirements related to protective relays, electrical machine safety, electromagnetic compatibility, and medium-voltage switchgear operations. The switchgear will integrate advanced protection mechanisms such as overcurrent, overvoltage, undervoltage, frequency deviations, differential protection, power reversal, ground fault detection, and internal arc protection. It must also include operational commands for main switches and disconnectors, equipped with counters for local display and remote SCADA integration.

A comprehensive grounding system assessment and enhancement will ensure equipment safety and operational stability. This includes verifying the existing grounding configuration, evaluating ground resistance (targeting < 5 ohms), and assessing surge protection through lightning arresters and transient suppressors. Equipotential bonding of all exposed metal components and ensuring the neutral generator connection's integrity to the grounding system are critical for system reliability and protection against electrical disturbances.

*Figure 26: Description of Switchgear.*

### 2.3.7 SCADA, Control, Automatization, Protection and Measurement

The proposed Factorydale hydropower project involves upgrading the existing SCADA, Control, Automation, Protection, and Measurement systems. The upgrade will include a complete replacement of the current PLC-based Control and Automation Panel, incorporating advanced remote communication capabilities to enhance operational efficiency and reliability. The new system must support comprehensive control, including unit start-up/shutdown, setpoint adjustments, and remote monitoring of critical operational events and alarms. Additionally, the automation scheme will incorporate machine learning-based condition monitoring for predictive maintenance, ensuring increased availability and reduced downtime.

Protection, Control, and Measurement systems will be thoroughly updated, integrating multifunctional protective relays capable of handling overcurrent, undervoltage, overvoltage, frequency anomalies, ground faults, and differential protection. Advanced power quality meters will be installed to precisely measure and communicate electrical parameters, such as voltage, current, power factor, and harmonics, via standard protocols like IEC 61850, Modbus TCP/IP, and DNP3. Enhanced protection will include internal arc protection and reverse power detection, significantly increasing operational safety.

A robust and highly reliable SCADA infrastructure will be established, featuring main servers with redundancy to guarantee high availability and continuity. These servers will be equipped with extensive storage capacity, real-time data management capabilities, and intuitive graphical user interfaces for simplified monitoring and control. Workstations with dual high-definition monitors and advanced SCADA client software will ensure efficient operational oversight and decision-making support. Network infrastructure will be upgraded with industrial-grade managed switches, secure routers, firewalls, and communication equipment capable of maintaining secure, redundant connections.

Critical equipment will be supported by an Uninterruptible Power Supply (UPS) system with a minimum capacity of 5 kVA, ensuring continuous operation of servers, control stations, and essential instruments. All SCADA components, including local control panels and cabinets, will meet IP65 protection standards for industrial environments. Comprehensive documentation, operator training, technical support, and a minimum two-year maintenance commitment will accompany the upgraded system. Full compliance with applicable IEC standards governing electrical safety, automation, and communications will ensure international standard adherence and interoperability with existing and future plant systems.


*Figure 27: Current panel of the PLC Control and Automation System to be Replaced.*

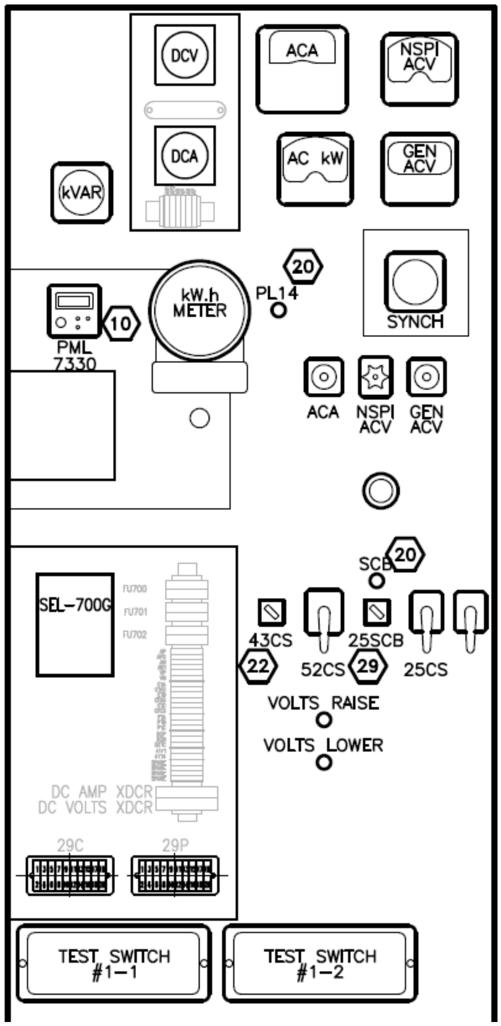


*Figure 28: Current panel of the Protection, Control and Measurement System Automation by PLC to be Replaced.*

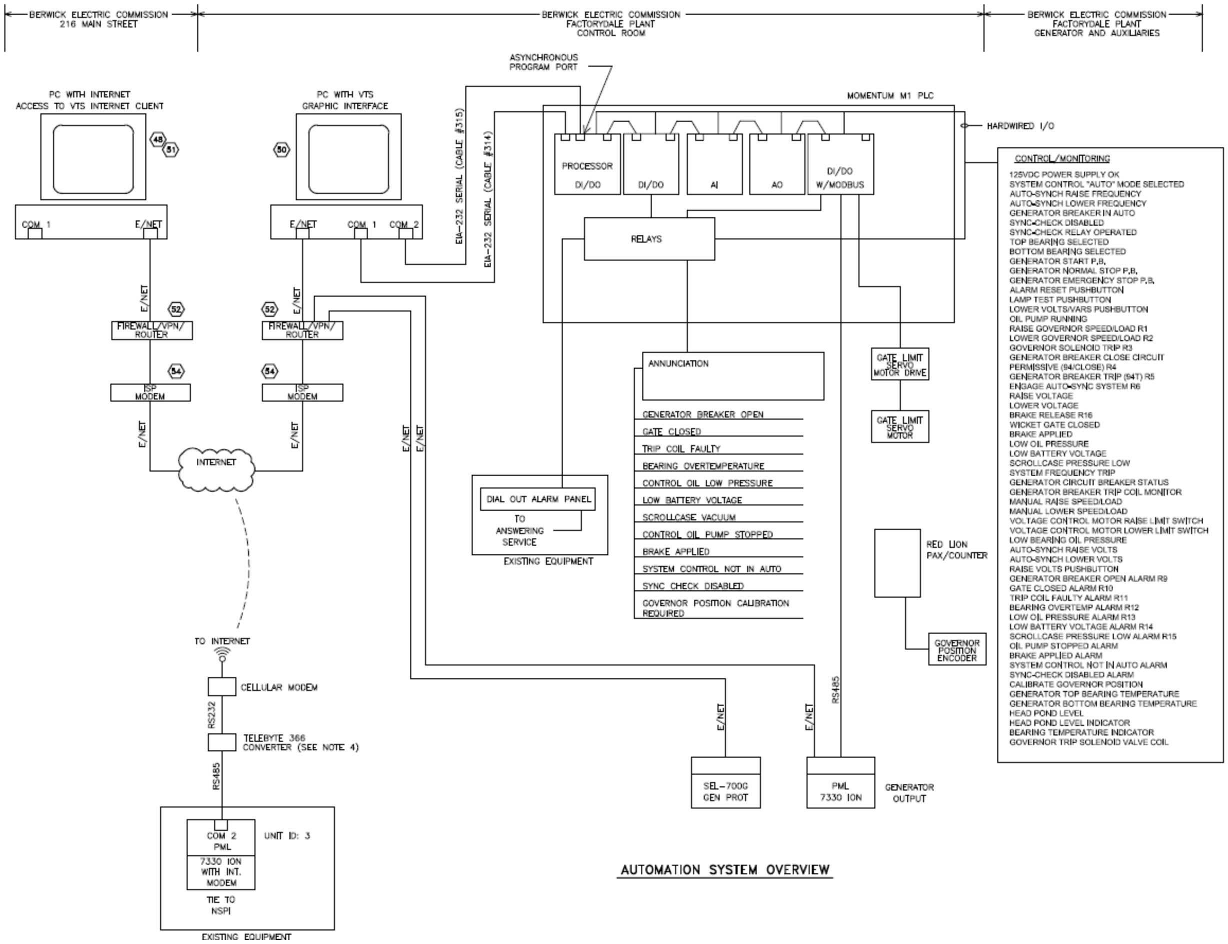


*Figure 29: Current Operating Diagram of the Control, Automation and Communication System*

## 2.3.8 Power Transformer

The complete and detailed proposal for this equipment will be defined following the closing of submissions by the Hydrogenerator System manufacturers. The proposed project involves replacing the existing 600 kVA padmount transformer at the Berwick Factorydale hydropower facility with a new unit designed to meet enhanced operational efficiency requirements. The current transformer is an ONAN (Oil Natural Air Natural) type, operating at 2300 V (Delta connection) on the generator side and 12470 V (Wye connection) on the distribution side. It operates at a frequency of 60 Hz and has an impedance of 4.3% at 85°C. Its dielectric insulation utilizes mineral oil with a capacity of 1075 liters, compliant with environmental regulations (NON PCB < 2 ppm).

Externally, the transformer installation site is outdoor and easily accessible, situated approximately 115 meters from the hydropower plant. The area includes adequate safety barriers and protective fences that adhere to Canadian Electrical Code (CEC) and IEC international standards. The installation features a concrete pedestal base anchored securely, with gravel surroundings for oil spill containment, and is equipped with an oil trap system capable of holding the transformer's full oil volume.

The grounding system currently installed has been specifically designed considering local soil resistivity, ensuring a safe and effective grounding path compliant with established safety standards. This includes connections to the transformer's neutral terminal, tank, and metallic chassis. All existing infrastructures, including perimeter fences, concrete base, and oil containment systems, will be retained unless modifications are deemed necessary for compatibility with the new transformer.

For the new transformer, recalculations for cabling connections to both the underground and overhead power grid networks will be required, ensuring safe and efficient integration into the existing electrical infrastructure. Complete new sets of controls, instrumentation, protections, and measurement systems will also accompany the new transformer. These systems will enhance operational reliability and facilitate comprehensive condition monitoring and predictive maintenance, ensuring compliance with modern standards for safety, efficiency, and environmental sustainability.


*Figure 30: Location and approximate distance of the Transformer to the plant.*

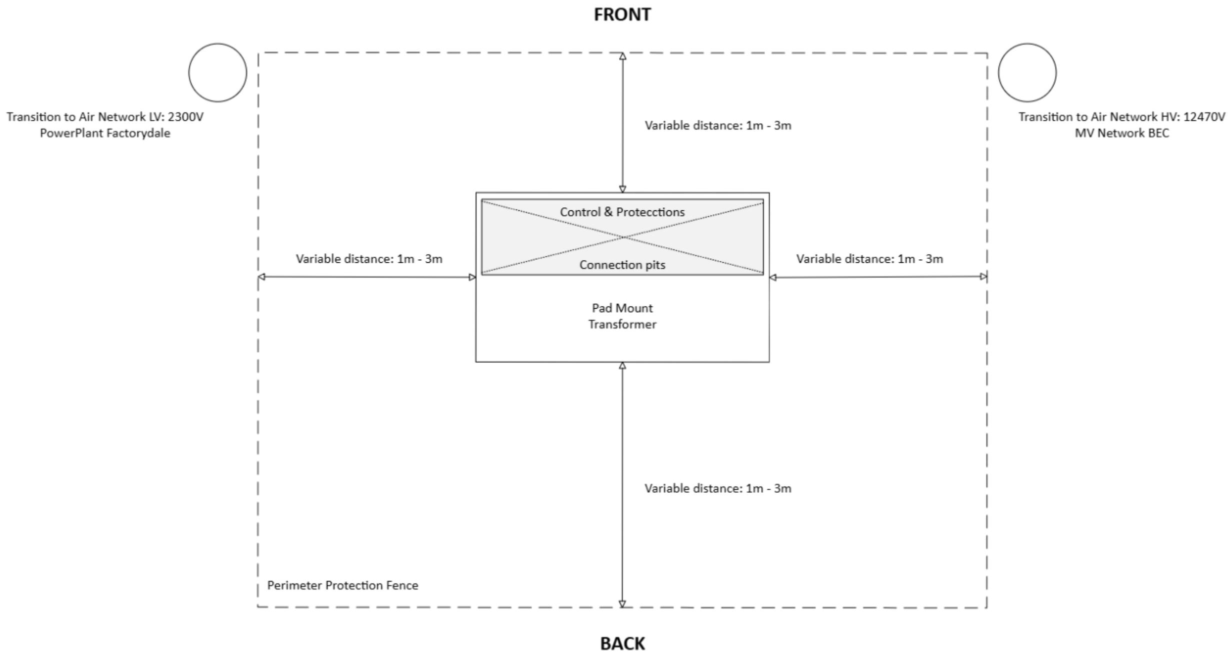


*Figure 31: Arrangement inside the perimeter protection fence for the transformer.*

LV: 2300V
PowerPlant Factorydale

HV: 12470V
MV Network BEC

*Figure 32: Transition to Air Network.*

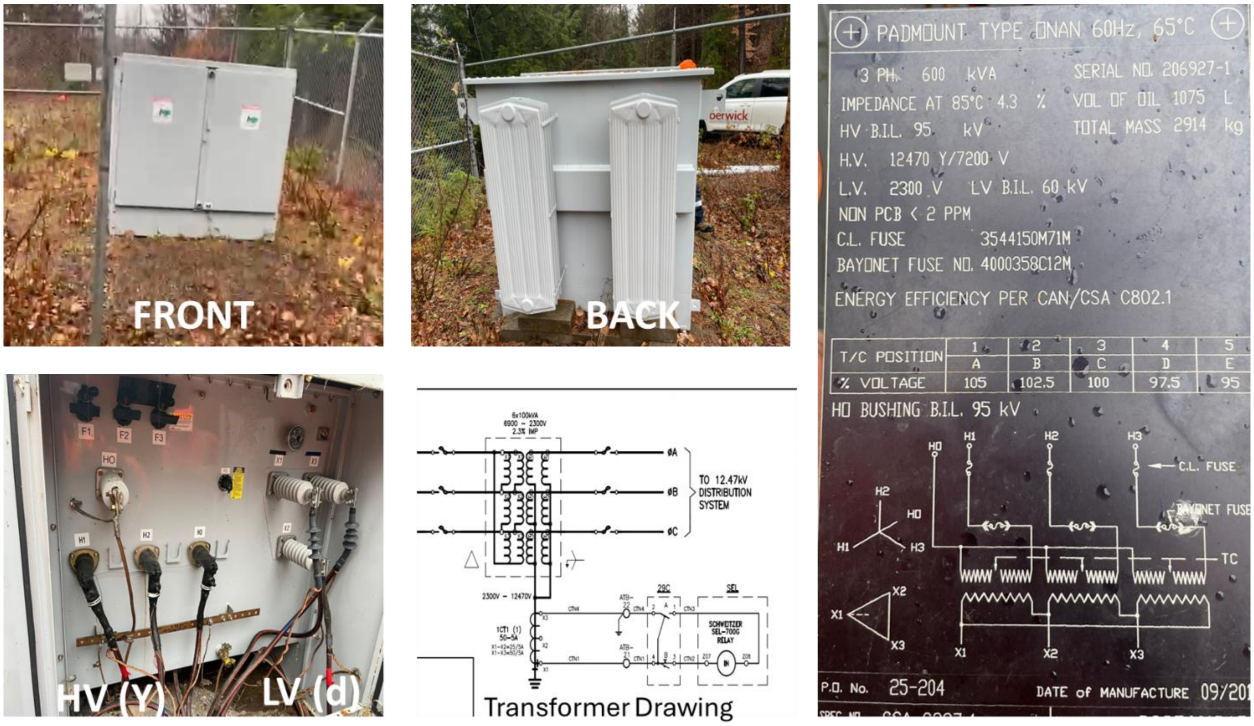


*Figure 33: Description of the installed transformer.*

### 2.3.9 Excitation System

The proposed project involves supplying and installing a new Static Excitation System (SES) to support the new generating unit rated between 650 kW and 750 kW. The SES will be designed to ensure structural compatibility with existing infrastructure, mounted directly atop the generator to optimize space and functionality. It will feature advanced forced-air cooling with temperature-controlled redundant fans, effectively maintaining operational reliability within the environmental temperature range of -20°C to +40°C.

Operationally, the SES will incorporate a microprocessor or high-speed DSP-controlled rectifier bridge, employing either three-phase thyristor (SCR) or high-performance IGBT technology. This system will feature multiple control modes, including Automatic Voltage Regulation (AVR), Manual Excitation Control, Power Factor Control, Reactive Current Control, and a dedicated Tracking Mode for safe synchronization with the electrical grid. Comprehensive safety protections, including overcurrent, overvoltage limiters, and rectifier fault protections, will safeguard against operational anomalies and ensure reliable performance.

Integration into the plant's SCADA system is critical, with real-time remote monitoring and control capabilities provided through standard industrial communication protocols. This capability will allow operators to efficiently manage and adjust critical variables such as current, voltage, and temperature remotely. A detailed documentation package, including functional diagrams, descriptive reports, training plans, and both digital and physical records, will be provided to facilitate effective operation, maintenance, and condition monitoring of the SES.

The SES installation will comply rigorously with international IEC standards and Canadian CSA standards, emphasizing electromagnetic compatibility, protective relays, electrical machine safety, and energy system communication protocols. The system will undergo extensive Factory Acceptance Testing (FAT) and Site Acceptance Testing (SAT) to certify performance, safety compliance, and integration effectiveness, thus ensuring the SES meets or exceeds all specified operational criteria.

### 2.3.10 New Trash rack in penstock entry

With the current trash rack in poor condition as mentioned on Section 2.2, we decided to add to the scope of work a new trash rack, in this case made not made in steel but in HMWPE – high molecular weight polyethylene. This material has been proven in hundreds of small and big hydro plants on their trash racks, as well as other applications where a barrier in a body of water is needed. It has several advantages:

- Head loss reduction (Rounded edges and the smooth surface finish)
- Low thermal conductivity
- Light weight (20% of steel trash racks weight)
- Less expensive for small spacing
- No corrosion, no deformation, long term durability.

As well, a mechanically assisted system to clean the trash rack will be added, with the following constraints: no hydraulics, locally operated, simple controls, low to no maintenance.

## 2.3.11 Summary - Proposed Equipment

The following Table 1 shows a summary of the proposed equipment (continues in next page)

*Table 1: Summary - Proposed Equipment*

| Equipment Name | Description of Equipment | Capacity/ Design Rating |
|---|---|---|
| Draft Tube | A **draft tube** is a conically shaped tube installed beneath a hydraulic turbine, designed to gradually reduce the velocity of discharged water, converting kinetic energy into static pressure and thereby increasing overall turbine efficiency. | The draft tube's design capacity or rating is determined by the specific flow rate and hydraulic head conditions of the system, optimized to maximize flow efficiency and minimize energy losses. |
| Scroll Case | A **scroll case** is a spiral-shaped casing around a hydraulic turbine designed to evenly distribute pressurized water to the turbine runner, ensuring uniform flow conditions for efficient energy conversion. | The scroll case's design capacity or rating is determined by the turbine's specific flow rate and operating pressure, optimized to ensure uniform water distribution and efficient hydraulic performance. |
| Turbine | A **turbine** is a mechanical device that converts the kinetic and potential energy of a flowing fluid (such as water, steam, or air) into mechanical energy, typically used to generate electricity. | The turbine's design capacity or rating is defined by its maximum power output (in kW or MW) under specified flow and hydraulic head conditions, optimized for efficient energy conversion. |
| Governor | A **governor** is an automatic control device used in turbines to regulate speed and power output by adjusting flow conditions, ensuring stable and efficient operation. | The governor's design capacity or rating is defined by its ability to accurately control turbine speed and load within specified operational conditions, ensuring reliable and stable performance. |
| Generator | A **generator** is an electrical machine that converts mechanical energy into electrical energy, typically by rotating a conductor within a magnetic field. | The generator's design capacity or rating is defined by its maximum electrical power output (kW or MW), voltage, frequency, and operating conditions under specified mechanical inputs. |
| Switchgear | **Switchgear** is electrical equipment that controls, protects, and isolates electrical circuits and equipment, ensuring safe and reliable operation. | The switchgear's design capacity or rating is defined by its maximum voltage, current, short-circuit withstand capability, and operational parameters, ensuring safe protection and control of electrical systems. |

| Equipment Name | Description of Equipment | Capacity/ Design Rating |
|---|---|---|
| SCADA, Control, Automatization, Protection and Measurement | **SCADA, Control, Automation, Protection, and Measurement** refers to an integrated system that remotely monitors, manages, automates, protects, and measures operational parameters of industrial processes, ensuring efficiency, reliability, and safety. | The design capacity or rating of the SCADA, Control, Automation, Protection, and Measurement system is defined by its capability to accurately monitor, control, protect, and automate processes, handling specific quantities of inputs/outputs, data points, and communication protocols effectively. |
| Power Transformer | A **power transformer** is an electrical device used to transfer electrical energy between circuits, typically changing voltage levels while maintaining frequency for efficient transmission and distribution. | The power transformer's design capacity or rating is defined by its maximum apparent power (kVA or MVA), primary and secondary voltages, frequency, cooling type, and thermal limits under specified operating conditions. |
| Trash Rack in Penstock Entry | A **trash rack** at the penstock entry is a protective structure consisting of a grid or screen designed to prevent debris from entering the penstock and turbine, ensuring safe and efficient operation. | The trash rack's design capacity or rating is defined by its maximum allowable flow rate, debris load, structural strength, and permissible pressure drop under specified operating conditions. |
| Excitation System | An **excitation system** is an electrical system that provides regulated direct current (DC) to a generator's rotor winding, creating the necessary magnetic field to produce electricity. | The excitation system's design capacity or rating is defined by its maximum DC current and voltage output, control accuracy, and operational stability required to maintain the generator's voltage and reactive power within specified limits. |

## SECTION 3 – FINANCIAL ANALYSIS AND FUNDING OPPORTUNITIES

The financial strategy for the Factorydale Hydropower Plant revolves around capital investment, revenue generation, and operational sustainability, based on reduced maintenance cost via a simplified design of the entire hydropower machinery.

The cost of upgrading the plant is financed through:

- The Green Municipal Fund (GMF) through a loan covering 80% of project costs, with a 15% grant on the loan.
- Insurance funds recovered from the claim made to the insurer related to the event on December 2023 that destroyed the turbine (HSV-2024-043-RCA01). This amount is still under negotiation, and even though we know we will obtain funds from that, we don't know the amount or when we will get them, so we are not using it into the financial model. Once the funds area available, we will use it to help the contingency funds, and/or repay in advance the loan obtained.
- SREP – Smart Renewables and Electrification Pathways: we are applying for this program as well, but as a tool to help to implement an advanced monitoring and control system for the plant, as an add-on to the current proposed system on this main application, and as well to strength our contingency capabilities. We were already accepted to submit an application. As well, because this is a competitive funding application, we are not including it into the financial model. Whatever resources we can get from this funding source, for now, we are covering it through utility's equity.
- Berwick Electric Commission own equity. At this time, will represent 20% of the total costs of the project.

The financial model relies on electricity sales and operational savings. With the plant being fully owned by the BEC, and the energy going directly to the BEC's grid, the revenue model is as simple as continuing to charge the BEC's grid customers for the energy use, as it is being done today, and maintain the operation and maintenance costs of the powerplant under control. There is no need to change this simple approach.

A comprehensive costed option analysis was performed, and it is show on the section 6 of the Condition Assessment Report (HSV-2024-043-CA01) and on the Additional Costed Option Scenarios report (HSV-2024-043-CA02). On the first report (HSV-2024-043-CA01) the methodology to do the analysis is explained and scenarios were outlined, first as paths, and then in depth on each path. On the second report (HSV-2024-043-CA02), the refurbishment path is being analysed more in-depth, with the energy modeling of different scenarios using water flow-duration curves extrapolated from rivers and water bodies with similar behaviour than Factorydale's.

To avoid to repeat information, please refer to Section 6 on the Condition Assessment Report (HSV-2024-043-CA01), and the entirety of the Additional Costed Option Scenarios report (HSV-2024-043-CA02). As well, we are including all the energy models developed for the project in PDF, and RETScreen models are available upon request.

## 3.1 Funding Opportunities – Green Municipal Fund

The Green Municipal Fund (https://greenmunicipalfund.ca/) offers several programs to municipalities and utilities owned by municipalities to get federal funding for their renewable energy projects. In this case, we believe this project will enter into the program called "**Capital project: Community Energy Systems"**, understanding that the renewable energy generated on site at Forbes Lake to reduce the GHG emissions of the water treatment plant, in fact benefits the whole local grid. Plus, being BEC a municipality owned utility it makes it a perfect candidate for funding.

Information about the program can be found here: Capital project: Community Energy Systems

Some highlights:

**Maximum Award:**

- Combined grant and loan for up to 80% of eligible costs.
- Combined grant and loan up to a maximum of $10 million.
- Grant up to 15%** of project costs.

Additional 5% grant available if the project involves the remediation of a brownfield site. *Note: The grant contribution is determined as a function of the loan and cannot be separate.*

**Open To:**

The following organizations are eligible for GMF funding:

- Canadian municipal governments (e.g., towns, cities, regions, districts, and local boards).
- Municipal partners, which include:
  - private sector entities
  - municipally-owned corporations
  - regional, provincial or territorial organizations delivering municipal services
  - non-governmental organizations
  - not-for-profit organizations
  - research institutes (e.g., universities)
- An Indigenous community is an eligible lead applicant if they are partnering with a Canadian municipal government on an eligible project, or if they have a shared service agreement with a Canadian municipal government related to municipal infrastructure, climate change or adaptation.

**Expected Output:**

A capital project to construct a 100% renewable community energy system.

**Application Deadline:**

Applications are accepted year-round, though this offer may close when all funding has been allocated.

That being said, we will assume on our financial models that:

- we are getting the financing from this program for 80% of the total capital cost,
- as well as 15% of that financing portion as a grant,
- and an interest rate of 4.95%, which may vary at the moment of the final loan approval.

## 3.2 Financial models per Scenario

The Berwick Electric Commission (BEC) sells its energy directly to customers in their grid. The rates established by the Nova Scotia Utility Regulator are as follows (in summary):

- Domestic Service: $0.1789 / kWh
- Small General: $0.1802 / kWh
- General: $0.1276 / kWh

To be conservative, and to account to the diversity of the type of customers, we are using the highest kWh rate, and apply a discount of 25%, and that will be the Electricity Export Rate in our energy models, in this case, $0.1749 x 0.75 = 0.1311

Estimated annual energy production varies depending on the turbine replacement possible scenario. During the first phase of this project, we developed a costed option analysis, and requested very high-level quotes to three OEMs to have a sense of the costs of the project, then we aligned those costs and estimates to energy models developed by us, using extrapolated water flow duration curves from rivers with similar configurations here in Nova Scotia. The summary of the results is as follows on Table 2:

*Table 2: Summary of costs, revenue, ROI and ROE for new units*

| Option to analyze | Capacity (kW) | Electricity (kWh) | Initial costs (CAD) | Electricity export revenue (CAD) | O&M costs (savings) (CAD) | Simple payback (YEARS) | Equity Payback (YEARS) |
|---|---|---|---|---|---|---|---|
| Factorydale - Beaverbank Ext - NEW - 3.39 m3/s (10%) - NORCAN | 1,012 | 1,452,189 | $5,168,750 | $190,382 | $91,656 | 44.5 | 49.5 |
| Factorydale - Beaverbank Ext - NEW - 3.39 m3/s (30%) - NORCAN | 1,012 | 3,264,446 | $5,168,750 | $427,968 | $91,656 | 13.1 | 3.1 |
| Factorydale - Beaverbank Ext - NEW - 3.39 m3/s (70%) - NORCAN | 1,012 | 5,669,246 | $5,168,750 | $743,238 | $91,656 | 6.7 | 0.65 |

| Option to analyze | Capacity (kW) | Electricity (kWh) | Initial costs (CAD) | Electricity export revenue (CAD) | O&M costs (savings) (CAD) | Simple payback (YEARS) | Equity Payback (YEARS) |
|---|---|---|---|---|---|---|---|
| Factorydale - Cornwallis Ext - NEW - 3.39 m3/s (10%) - NORCAN | 1,012 | 1,439,509 | $5,168,750 | $188,719 | $91,656 | 45.3 | 49.6 |
| Factorydale - Cornwallis Ext - NEW - 3.39 m3/s (30%) - NORCAN | 1,012 | 2,920,921 | $5,168,750 | $382,932 | $91,656 | 15.1 | 5.8 |
| Factorydale - Cornwallis Ext - NEW - 3.39 m3/s (70%) - NORCAN | 1,012 | 6,131,119 | $5,168,750 | $803,789 | $91,656 | 6.2 | 0.56 |
| Factorydale - Beaverbank Ext - NEW - 3.39 m3/s (10%) - CANYON | 750 | 1,315,779 | $5,883,466 | $172,498 | $67,892 | 47.8 | +50 |
| Factorydale - Beaverbank Ext - NEW - 3.39 m3/s (30%) - CANYON | 750 | 2,857,437 | $5,883,466 | $374,610 | $67,892 | 16.3 | 8.7 |
| Factorydale - Beaverbank Ext - NEW - 3.39 m3/s (70%) - CANYON | 750 | 4,857,558 | $5,883,466 | $636,825 | $67,892 | 8.8 | 1.1 |
| Factorydale - Cornwallis Ext - NEW - 3.39 m3/s (10%) - CANYON | 750 | 1,287,308 | $5,883,466 | $168,766 | $67,892 | 49.6 | +50 |
| Factorydale - Cornwallis Ext - NEW - 3.39 m3/s (30%) - CANYON | 750 | 2,756,477 | $5,883,466 | $361,374 | $67,892 | 17 | 11 |
| Factorydale - Cornwallis Ext - NEW - 3.39 m3/s (70%) - CANYON | 750 | 4,999,464 | $5,883,466 | $655,429 | $67,892 | 8.5 | 1 |
| Factorydale - Beaverbank Ext - NEW - 3.39 m3/s (10%) - DIVE | 614 | 1,286,552 | $3,500,000 | $168,667 | $55,550 | 26.3 | 34.3 |
| Factorydale - Beaverbank Ext - NEW - 3.39 m3/s (30%) - DIVE | 614 | 2,570,863 | $3,500,000 | $337,040 | $55,550 | 10.6 | 1.6 |

| Option to analyze | Capacity (kW) | Electricity (kWh) | Initial costs (CAD) | Electricity export revenue (CAD) | O&M costs (savings) (CAD) | Simple payback (YEARS) | Equity Payback (YEARS) |
|---|---|---|---|---|---|---|---|
| Factorydale - Beaverbank Ext - NEW - 3.39 m3/s (70%) - DIVE | 614 | 3,965,820 | $3,500,000 | $519,919 | $55,550 | 6.4 | 0.6 |
| Factorydale - Cornwallis Ext - NEW - 3.39 m3/s (10%) - DIVE | 614 | 1,243,047 | $3,500,000 | $162,963 | $55,550 | 27.7 | 35.6 |
| Factorydale - Cornwallis Ext - NEW - 3.39 m3/s (30%) - DIVE | 614 | 2,468,555 | $3,500,000 | $323,627 | $55,550 | 11.1 | 1.8 |
| Factorydale - Cornwallis Ext - NEW - 3.39 m3/s (70%) - DIVE | 614 | 4,070,239 | $3,500,000 | $533,608 | $55,550 | 7.7 | 2.7 |

These are high level scenarios. All of them were done in RETScreen. The report (HSV-2024-043-CA02) is available for your review and attached to this application, as well as the energy models.

Then, in the Additional Costed Option Scenarios report (HSV-2024-043-CA02) we demonstrated that a unit with an energy output in the range of 650 kW to 750 kW was a realistic approach to take, and one that offers a still attractive ROI for a hydro project. On Table *2* the summary is shown.

Having said that, we think that the most conservative approach in terms of costs is the one where a unit of 750kW is using a water flow of 3.39 m3/s available 30% of the time. The cost is the highest of all three preliminary quotes received, but it is in fact the most realistic approach.

*Table 3: Analysis of 750 kW option.*

| Option to analyze | Capacity (kW) | Electricity (kWh) | Initial costs (CAD) | Electricity export revenue (CAD) | O&M costs (savings) (CAD) | Simple payback (YEARS) | Equity Payback (YEARS) |
|---|---|---|---|---|---|---|---|
| Factorydale - Beaverbank Ext - NEW - 3.39 m3/s (30%) - CANYON | 750 | 2,857,437 | $5,883,466 | $374,610 | $67,892 | 16.3 | 8.7 |
| Factorydale - Cornwallis Ext -NEW - 3.39 m3/s (30%) - CANYON | 750 | 2,756,477 | $5,883,466 | $361,374 | $67,892 | 17 | 11 |

With the RFP process on going (All RFP documents will be available for you for your review and as support to our application) we expect that the numbers will change, in fact slightly lowering the costs but as well probably lowering the total amount of estimated annual energy production, but still we estimate that the total project costs will be on the $6,000,000 CAD range.

Having said that, we are going to be even more conservative. We think that a unit on the lower end of the power output range, a 650 kW machine, will be closer to the final design approved (conservative scenario). With all the ancillary systems, including a new transformer, a new draft tube, and a new trash rack, including contingency, the financial models with the two flow duration curve scenarios, will be as follows:

*Table 4: Analysis of 650 kW option.*

| Option to analyze | Capacity (kW) | Electricity (kWh) | Initial costs (CAD) | Electricity export revenue (CAD) | O&M costs (savings) (CAD) | Simple payback (YEARS) | Equity Payback (YEARS) |
|---|---|---|---|---|---|---|---|
| Factorydale - Beaverbank Ext -NEW - 3.39 m3/s (30%) – 650 KW | 650 | 2,688,943 | $6,000,000 | $352,520 | $58,852 | 17.1 | 11.9 |
| Factorydale - Cornwallis Ext -NEW - 3.39 m3/s (30%) – 650 KW | 650 | 2,799,784 | $6,000,000 | $367,051 | $58,852 | 18 | 14.5 |

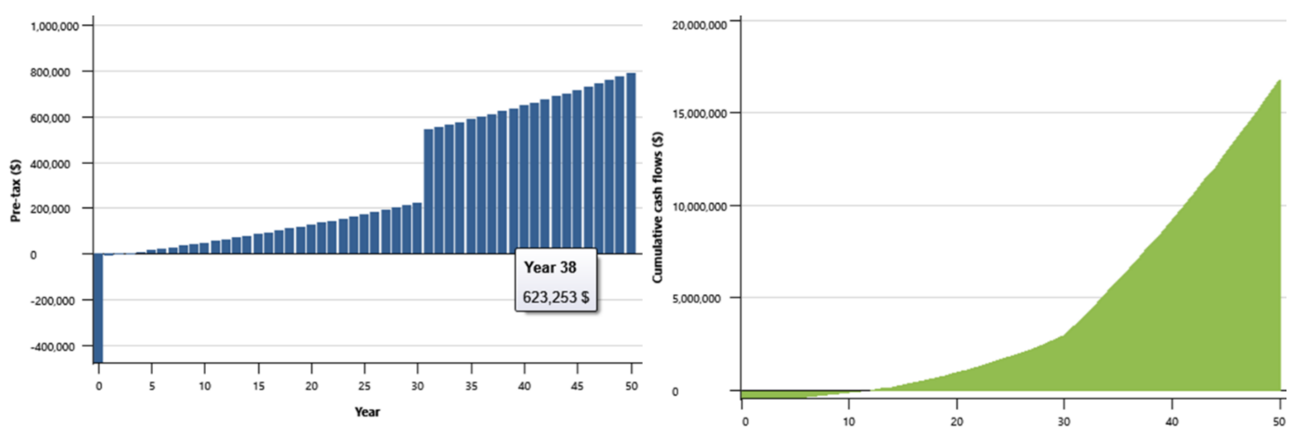


*Figure 34: Financial model for 650 kW unit, using Cornwallis flow duration curve*

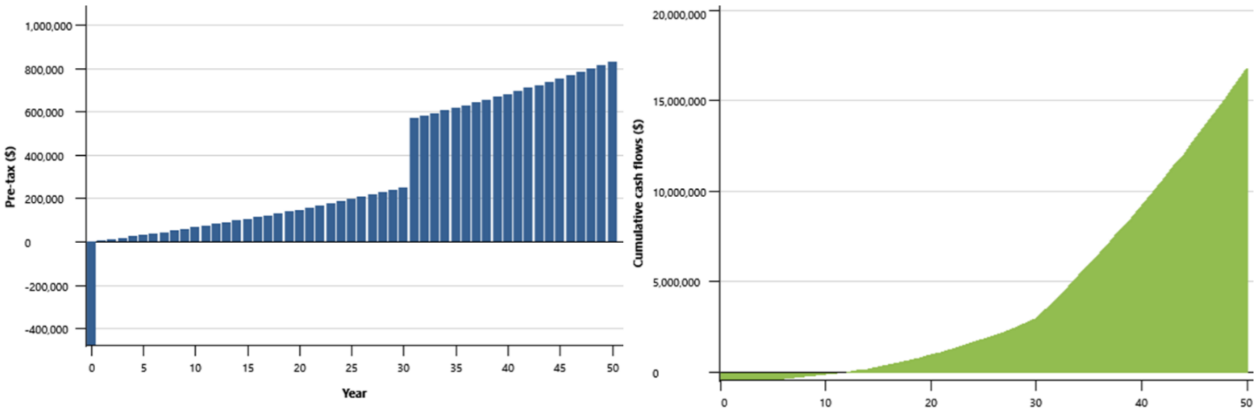


*Figure 35: Financial model for 650 kW unit, using Beaverbank*

As you can notice, both financial models are virtually identical. The life expectancy of the project is 50 years, as a common practice for hydropower projects. With a focus on simplicity during the design phases we are aiming to accomplish that goal.

## SECTION 4 – PROJECT IMPACT

### 4.1 Grid Modernization

- **Improving the utilization and efficiency of existing assets.** The project modernizes a hydropower facility, enhancing the efficiency of existing infrastructure. Upgrades to the turbine, generator, and draft tube optimize water flow and energy conversion, reducing energy losses and maximizing output. Advanced SCADA systems and monitoring equipment improve operational management, ensuring assets are used effectively and maintained proactively to extend their lifespan.
- **Increasing the Reliability, Resiliency, and Flexibility of the Power System.** The project enhances system reliability by integrating modern protection systems and redundant controls, reducing the risk of unplanned outages. Resiliency is increased through the deployment of real-time monitoring tools that detect faults and allow rapid response to disturbances. Enhanced operational flexibility enables the plant to adjust quickly to fluctuating grid demands, ensuring stable energy delivery.
- **Increasing the Integration and Use of Renewable Resources.** By modernizing the hydropower plant, the project increases renewable energy production and displaces fossil fuel-based generation. The integration of advanced controls enables seamless interaction with the grid and other renewable resources. This reduces reliance on non-renewable sources while contributing to Nova Scotia's renewable energy and decarbonization goals.

### 4.2 Customer Value

The Factorydale Hydropower Plant Refurbishment delivers significant value to ratepayers by improving affordability, reliability, and environmental sustainability while supporting broader community benefits.

- **Affordability**
  - Upgraded turbine and generator systems increase energy efficiency, reducing operational costs and ensuring stable, competitive electricity rates. By extending the plant's operational life by 50 years, the project minimizes long-term capital expenditures compared to constructing new facilities.
  - The AMI upgrades will provide customers with options to affordable renewables during periods when excess renewable energy is being produced by multiple clean generation facilities: wind, solar and hydro.
- **Improved Reliability and Resiliency**
  - Modern controls, SCADA integration, and advanced protection systems enhance operational reliability, reducing the risk of outages. Real-time monitoring enables proactive maintenance, ensuring uninterrupted energy delivery and improved grid stability. Substation upgrades future provide resiliency and capacity for redirecting load, increased renewable energy on the grid and reducing the risk of outages.
- **Increased Renewable Energy Access**
  - The refurbishment increases renewable energy production, displacing fossil fuel generation and reducing greenhouse gas emissions. Ratepayers benefit from a cleaner energy supply that aligns with provincial decarbonization goals.

- **Non-Energy Benefits**
  - The project supports local economic development by creating jobs during construction and maintenance. Environmental enhancements, such as oil-free systems and better water management, improve sustainability and protect local ecosystems, contributing to community well-being.

## 4.3 Job Creation

- The proposed project aligns directly with the program's objectives by significantly increasing employment opportunities within the electricity sector. It is anticipated to generate approximately 20-25 temporary jobs during the construction and implementation phases, providing meaningful short-term employment and stimulating economic activity within the community.
- In addition to the temporary construction roles, the project's long-term operational impact includes creating 2-3 permanent employment positions throughout its useful life. The estimates provided for job creation are based on a robust, methodologically sound analysis, ensuring that the figures are realistic, achievable, and supported by documentation included in the mandatory attachments outlined in the Project Proposal Package Checklist.

## 4.4 Emissions Reduction

The Factorydale Hydropower Plant Refurbishment will directly reduce greenhouse gas (GHG) emissions by increasing the efficiency and reliability of renewable energy generation. The upgraded turbine, generator, and supporting systems will maximize the plant's energy output, displacing fossil fuel-based electricity generation in Nova Scotia.

- **Direct Emission Reductions**
  - By increasing annual energy production to 2,400 MWh, the project displaces fossil fuel-generated electricity with an average emission intensity of 0.660 kg $CO_2$/kWh. This results in avoided emissions of approximately 1,600 metric tons of $CO_2$ equivalent annually. Over the 50-year lifespan of the plant, cumulative avoided emissions are estimated at 80,000 metric tons of $CO_2$ equivalent.
- **Enabling Future Emission Reductions**
  - This project also establishes a modernized, renewable energy asset capable of integrating with a more decarbonized grid in the future. The upgraded SCADA system and controls enable seamless coordination with other renewable resources, such as wind and solar, further reducing reliance on non-renewable energy sources.

To avoid repeating information, it is important to note that all the energy, financial and emissions models are attached. Now, following what has been said on Section 3.2, we can see the different emissions' reduction estimates on both similar scenarios (Cornwallis and Beaverbank flow duration curves) for a 650 kW unit.

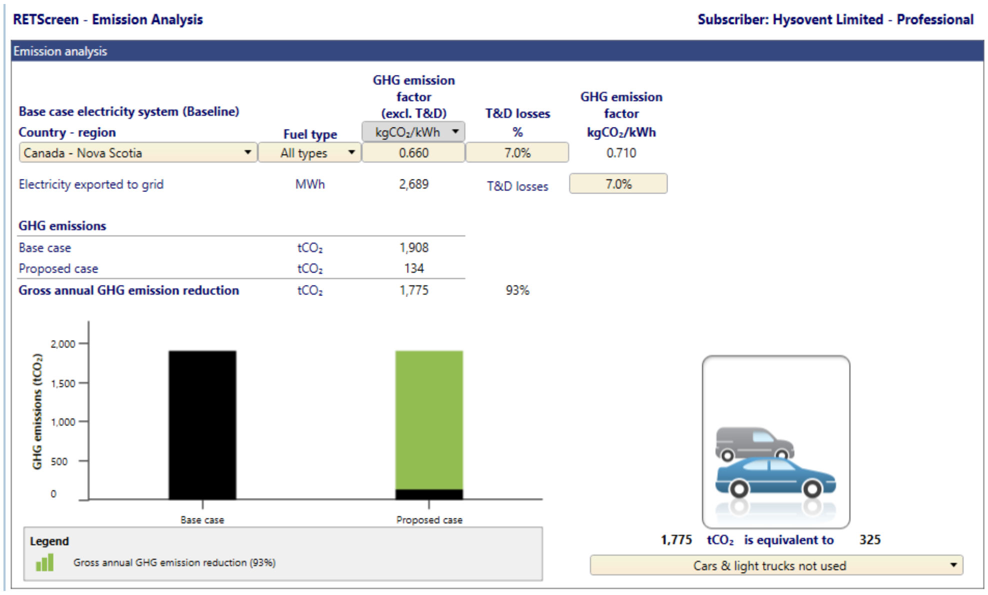


*Figure 36: Emissions Reduction Estimation using Cornwallis Flow Duration Curve*

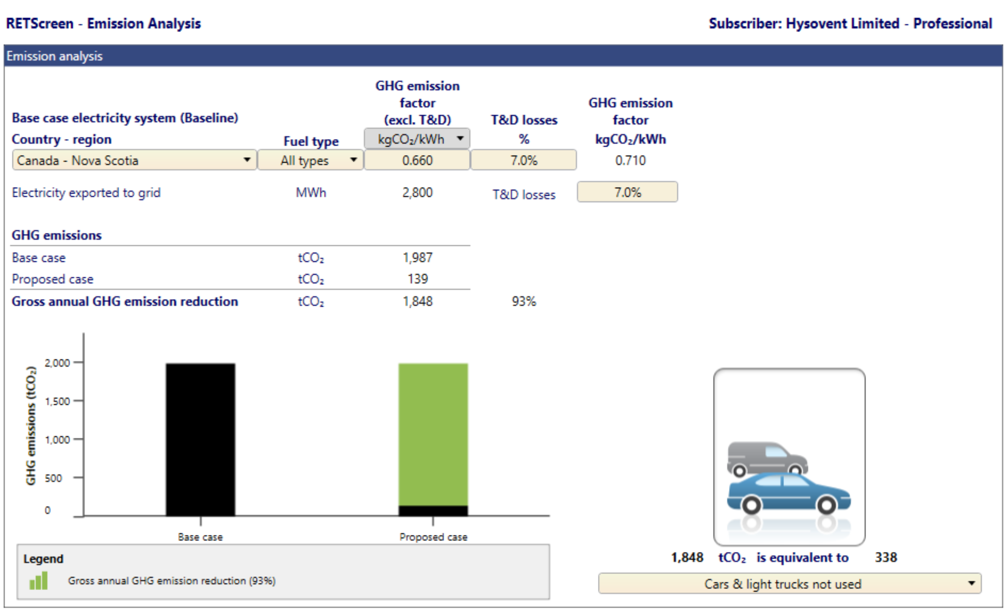


*Figure 37: Emissions Reduction Estimation using Beaverbank Flow Duration Curve*

As you can notice, the RETScreen models are in fact more optimistic on emissions reductions than our first high level estimates.

## 4.5 Societal Benefits

The Factorydale Hydropower Plant Refurbishment delivers societal benefits by enhancing energy affordability, reliability, and accessibility for Nova Scotians, especially those that are part of the Berwick Electric Commission (BEC) grid in rural Nova Scotia. Hydropower contributes to stable electricity rates, reducing the burden of energy costs on vulnerable households. The additional renewable source of energy increases the probability of excess renewables available to customers of BEC at affordable prices.

The modernized grid infrastructure will improve reliability for rural and end-of-line customers who historically face higher outage risks. Enhanced system capacity and real-time data will facilitate future initiatives, such as community solar gardens or local battery storage, further supporting affordability and resilience. The project's infrastructure modernization directly enables BEC to implement innovative community-based renewable energy projects in the future, significantly reducing energy poverty and improving quality of life for vulnerable populations in the region.

- **Addressing Energy Affordability and Security**
    - By modernizing the Factorydale plant, the project ensures the continued supply of renewable, cost-effective energy to the grid, directly benefiting communities that rely on affordable electricity, as well as providing opportunities to purchase renewables at lower prices during period when excess renewables are being generated. Increased reliability reduces the risk of outages, ensuring consistent energy delivery to end-of-line and rural customers who may face higher vulnerabilities to disruptions.
- **Economic and Employment Opportunities**
    - The project creates local job opportunities during construction and ongoing operations, with training programs aimed at equipping local workers with skills in renewable energy technologies. Indirect employment in supply chains and maintenance services will also support regional economic growth.
- **Community Engagement**
    - The project will foster community involvement through public information sessions during the planning phase, ensuring transparency and opportunities for feedback. Environmental enhancements, such as improved water management, will protect ecosystems and benefit local communities that depend on the river for recreation.

## Section 5 – Methodology to measure project results and performance

### 5.1 Grid Modernization

- **Improving the utilization and efficiency of existing assets.**
  - **Turbine-Generator Efficiency:** Increase from 60% to 90% using hydropower efficiency tests (power output vs. hydraulic input).
  - **Unplanned Downtime Reduction:** Decrease forced outage hours by 95% (from 200 to 10 hours/year), measured via SCADA logs.
- **Increasing the Reliability, Resiliency, and Flexibility.**
  - **Outage Duration (SAIDI):** Reduce by **30%** (1.5 to 1.05 hours/customer) via SCADA and grid event logs.
  - **Real-Time Grid Monitoring:** Achieve **100% system visibility**, measured via SCADA/AMI analytics.
- **Increasing Renewable Integration.**
  - **Renewable Penetration:** Increase to >55% of BEC's grid supply, tracked via generation reports.
  - **Fossil Fuel Displacement:** Reduce fossil-based energy imports by 2,400 MWh/year, based on PPA data.

### 5.2 Customer Value

- **Reliability & Service Quality.**
  - **Outage Reduction (SAIDI):** Reduce customer outage duration.
    - **Target:** 30% reduction in outage hours (1.5 to 1.05 hrs/customer annually).
    - **Measurement:** Utility event logs, SCADA tracking.
  - **Power Quality Improvements:** Reduce voltage fluctuations and grid disruptions.
    - **Target:** 95% compliance with voltage regulation standards.
    - **Measurement:** SCADA voltage readings, customer complaint tracking.
- **Customer Experience & Satisfaction**
  - **Customer Satisfaction Score:** Improve perception of reliability and service quality.
    - **Target:** Increase satisfaction from 85% to 92%.
    - **Measurement:** Annual customer surveys.

## 5.3 Job Creation

- The Factorydale Hydropower Plant Refurbishment is expected to create approximately **20-25 temporary construction jobs** during the intense **3-month** on-site construction phase, contributing an estimated **9,600 to 12,000 person-hours.** Additional manufacturing, preparation, and assembly work outside the site and province will support skilled jobs at partner facilities over the 18-month project timeline.
- **Post-commissioning**, the plant will support **2-3 long-term direct employment positions** for operation, maintenance, and monitoring. Indirectly, the project will generate jobs in supply chains, equipment manufacturing, and ongoing technical support, benefiting local and regional economies.

## 5.4 Emissions Reduction

- The methodology to calculate emission reductions involves using the RETScreen energy modeling tool, which quantifies energy generation based on flow-duration curves representative of similar rivers in Nova Scotia. Specifically, the energy output increment (2,400 MWh annually) is determined by analyzing historical hydrological data and performance benchmarks from comparable facilities. This projected energy production is then multiplied by **the provincial grid's average emission intensity factor of 0.660 kg $CO_2$/kWh**, resulting in an accurate estimation of displaced fossil fuel-generated emissions.
- To further enhance precision, the calculated annual emission reduction figure **(approximately 1,600 metric tons of $CO_2$ equivalent)** is validated by comparing modeled results with historical operational data from similar hydropower projects. Cumulative emission reductions over the plant's 50-year lifespan **(estimated at 80,000 metric tons of $CO_2$ equivalent)** are then derived by extrapolating the annual reductions, considering plant efficiency improvements and expected operational availability. This systematic and verifiable approach ensures robust quantification and transparency of environmental benefits.
- To measure the emissions reduction after commissioning, we will just multiply the amount of energy generated by the plant on an annual basis by the Nova Scotia emissions factor of that year, and report it on the annual operational report of the power plant.

## 5.5 Societal Benefits

- **Improved Energy Affordability**
  - **Metric**: Percentage of BEC customers benefiting from stable or reduced energy rates due to increased renewable generation.
    - **Target:** At least 80% of BEC customers see stable or reduced electricity rates post-project implementation (by Year 3). No increase in rates due to capital investment.
    - **Measurement Method:** Annual customer billing analysis pre/post project implementation.

- **Job Creation & Local Economic Impact**
  - **Temporary Jobs:** Create 20-25 local temporary construction jobs over 3 months.
    - **Measurement Method:** Employment records and contractor reports tracked monthly during construction.
  - **Long-Term Employment:** 2-3 permanent positions created for long-term operations and maintenance.
    - **Measurement Method:** BEC internal HR records and annual employment reports post-commissioning.
- **Energy Accessibility & Affordability (End-of-Line & Vulnerable Customers)**
  - **Reliability Improvement for Vulnerable Customers:** Reduce outage hours by 30% annually for rural and end-of-line customers.
    - **Measurement Method:** SCADA-based outage logs and service reports.
- **Community Engagement**
  - **Community Participation & Feedback:** Conduct at least 3 public information sessions throughout project lifecycle.
    - **Measurement Method:** Attendance logs, meeting minutes, and participant feedback forms.
    - **Targeted Results:** Increase community awareness and involvement, with a goal of achieving participation from at least 10% of BEC's customer base.

## Section 6 – Risk Evaluation

*Table 5: Risk Evaluation.*

| Key Risks | Probability | Impact | Risk Mitigation Strategies |
|---|---|---|---|
| **Technical Risks** | | | |
| Integration of new turbine with existing civil infrastructure | Medium | High | Detailed civil and structural assessment already completed; design validation through OEM and engineering firm. On-site measurement and re-measurements part of the plan. |
| Design considering a too optimistic / too pessimistic head and flow | Low | Medium | We are assuming a water head based on current and old drawings, and are conservative in our design parameters. We are directing the OEMs to prefer a higher head (25 m aprox.) and a standard water flow (3.39 m3/s) to be able to have a machine with a capability to respond to higher water levels and higher flows, if necessary, in case of a climate event. |
| Availability of components in the future (spares) | Medium | Low | We are encouraging the OEMs to use off-the shelf equipment as much as they can, understanding that the only components that will be 100% custom are the turbine mechanical components, the generator, and the draft tube. |
| SCADA – intercommunication between devices | Low | High | Design quality control measures will avoid communication issues at the design table, way before commissioning. |
| Cooling System Performance (Generator, Bearings, Transformer) | Medium | Medium | Thermal modeling, specifying robust air or water cooling, temperature alarms, and N+1 redundancy where feasible. This is in fact a requirement on the design. The current bearing had no cooling, and potentially the new one may not need it either. We will review the proposed designs and recommend any necessary change/modification/upgrade to avoid this issue. |
| Vibration and Resonance in New Turbine Installation | Low | High | Modal and structural dynamic analysis; use of dampers or isolation pads. A full simulation of the machine running is possible and required, which will help to reduce the |
| Cybersecurity | Low | High | This is a risk that has been already expressed to the OEMs, and we are requiring to minimize any exterior access to the control systems, and implement firewalls and VPNs with the most current cybersecurity approach available, following, if possible and feasible, NERC standards. |

| Key Risks | Probability | Impact | Risk Mitigation Strategies |
|---|---|---|---|
| Inadequate Factory Acceptance Testing (FAT) or Commissioning Plans | Low | High | Include FAT and SAT in procurement scope; simulate real operating conditions during testing. FAT and SAT are already requested on the RFP and are part of the evaluation of proposals. |
| **Regulatory and Permitting Risks** | | | |
| Delays in obtaining Nova Scotia Utility and Review Board (NSUARB) approvals for capital expenditure | Low | High | Early engagement with NSUARB; use of prior precedent (2023 approvals); staged filings aligned with project milestones. On this specific project, we will not require to increase the rates outside the planned increase following inflation, which will make the approval for construction straightforward. Being BEC a municipally owned utility helps as well with the final approval process. |
| Environmental permitting delays or requirements changes | Low | Medium | Historical plant operation with no environmental issues; maintain open communication with regulators; early submission of any new environmental documents. In this case, because the main infrastructure already exists, and we will use in fact less water for the operation of the plant, environmental permitting is unnecessary. What it is necessary is to renew the permitting related to the use of water, but again, we are not increasing the use to the approval will be straightforward. |
| **Budget and Financing Risks** | | | |
| Cost overruns during project execution | Medium | High | Budget includes contingency; use of firm quotes where possible; regular cost tracking and change control processes will be in place. |
| Failure to secure non-SREP funding in time | Low | High | Internal approval obtained; SREP is the final gap funding; contingency plan to shift timelines within allowable window if needed. |
| Currency fluctuation affecting equipment import costs | Medium | Medium | Currency risk accounted for in contingency; contracts in CAD where possible; staged payments negotiated with suppliers. |
| Inaccurate Cost Estimates Due to Scope Creep | Medium | High | Establish strict scope control; conduct design reviews at 30/60/90% milestones; include contingency (10–15%). |

| Key Risks | Probability | Impact | Risk Mitigation Strategies |
|---|---|---|---|
| Escalation in Material or Equipment Prices (e.g., steel, copper) | Medium | Medium | Include escalation clauses in budget; request fixed-price contracts where feasible; pre-purchase long-lead materials. |
| Exchange Rate Fluctuations for Imported Equipment | Low | Low | Use CAD-denominated contracts; hedge currency risk where possible; allow margin in budget for exchange rate buffer (typically 5–10%). |
| Delay in Reimbursement or SREPs Funding Disbursement | Low | High | Maintain working capital reserve; track milestones closely to trigger disbursements; maintain regular communication with NRCan on reporting. |
| Overreliance on SREPs Funding to Proceed with Project | Medium | High | Confirm internal approvals and contingency financing; plan phased implementation in case of partial SREPs contribution. |
| **Project Plan and Timeline Risks** | | | |
| Construction delays due to weather or unforeseen site conditions | Low | Medium | Schedule buffer included; seasonal timing considerations built into project schedule. With the construction happening inside the plant, weather is not a key factor. |
| Long lead time for key equipment (e.g., turbine components) | Medium | High | Early procurement and defined supplier agreements; advance engineering completed; phased delivery considered. This is in fact probably the biggest risk of the project, due to current supply chain conditions on the hydro industry. We have on our favor that the proposed design is simple, and can be manufactured 100% in Canada. |
| Supply chain delays (e.g., electrical switchgear, custom components) | Medium | Medium | Pre-qualified vendors identified; use of alternative suppliers; inventory of spares for standardized components. Made in Canada approach across the project. |
| Contractor Scheduling Conflicts or Resource Shortages | Low | Medium | Prequalify and secure contractor early with clear start dates; require resource commitment in contract; include contractor penalty clauses. |

| Key Risks | Probability | Impact | Risk Mitigation Strategies |
|---|---|---|---|
| Unrealistic Initial Schedule Commitments | Low | High | Perform detailed schedule development during engineering; validate timelines with suppliers and contractors; include float in critical path. |
| Delays in Design Review or Owner Approvals | Medium | Medium | Set predefined design review periods; appoint dedicated internal technical reviewers; use collaborative review tools. |
| Supply Chain Disruptions (e.g., logistics, shipping, border delays) | Medium | Medium | Include delivery buffer in schedule; track shipments with vendors; favor domestic suppliers where possible. |
| **Business Model and Business Plan Risks** | | | |
| Unfavorable cost recovery decision from regulator (NSUARB) | Low | Medium | Strong business case presented; precedent for capital projects in rate base; alternative recovery mechanisms assessed. Because we are not asking the regulator for an increase in rates to cover the additional capital costs, this is a very low probability risk. |
| Inaccurate demand forecasts or low generation output | Low | Medium | RETScreen modeling completed; historic flow data used for validation; sensitivity analysis confirms viability at conservative scenarios. |
| Overestimation of Annual Energy Production (AEP) | Medium | High | Use 30+ year hydrological records; conduct conservative RETScreen modeling; include +/-10% uncertainty in revenue forecasts. Our estimates are in fact very conservative. |
| Lack of Asset Management Strategy Post-Refurbishment | Medium | Medium | Develop asset registry and lifecycle maintenance plan; implement CMMS system; integrate with capital budgeting process. Training of personnel is critical and included in the RFP as part of the costs. |
| Inaccurate Forecast of Long-Term Operations & Maintenance (O&M) Costs | Medium | Medium | Use benchmarking from similar plants; apply conservative O&M escalation factors (e.g., 2–3% annually); update forecasts annually. |
| **Environmental Risks:** | | | |
| Potential pollution or contamination | Low | High | Implement strict pollution control measures, spill response plans, and regular environmental audits. Use only biodegradable oil on hydraulic systems. |

| Key Risks | Probability | Impact | Risk Mitigation Strategies |
|---|---|---|---|
| Impact on local wildlife | Medium | Medium | Conduct wildlife assessments, mitigation planning, establish protective barriers, and regular monitoring. |
| Regulatory changes or new requirements | Low | Medium | Maintain regular communication with regulatory bodies, build flexibility into project design. |
| Soil erosion or sedimentation | Medium | Medium | Employ erosion control measures, frequent site inspections, and rapid corrective actions. |
| Noise and vibration impacts | Low | Medium | Schedule noisy activities during non-sensitive hours, use noise-reducing technologies. |
| **Stakeholder/Resident Engagement Risks:** | | | |
| Community opposition | Medium | Medium | Develop proactive engagement plans, regular public meetings, clear communication of project benefits. |
| Miscommunication or misinformation | Medium | Medium | Provide consistent updates through verified channels, promptly address misinformation. |
| Stakeholder expectation misalignment | Medium | Medium | Clearly define project goals and scope, manage expectations through ongoing dialogue. |
| **Social Risks:** | | | |
| Negative public perception | Low | Medium | Clearly communicate positive impacts, engage community leaders, demonstrate social responsibility. |
| Disruption to local services | Medium | Medium | Plan activities minimizing disruption, communicate clearly with local services and communities. |
| Inequitable community benefits | Low | Medium | Ensure transparent and fair distribution of project benefits, involve community input. |
| **Operational Risks:** | | | |
| Equipment failure or downtime | Medium | High | Regular preventive maintenance, redundancy planning, availability of critical spare parts. |
| Human error | Medium | Medium | Ongoing staff training, clear operational procedures, regular audits. |
| Cybersecurity threats | Medium | High | Implement robust cybersecurity measures, regular system audits, employee training. |
| **Planning Risks:** | | | |

| Key Risks | Probability | Impact | Risk Mitigation Strategies |
|---|---|---|---|
| Inaccurate initial schedules | Medium | High | Thorough schedule validation, include contingencies, regular progress reviews. |
| Delays in regulatory approvals | Medium | Medium | Early engagement with regulators, clear documentation, proactive follow-ups. |
| Unclear project scope or changes | Medium | High | Strict scope control, defined project governance, and milestone reviews. |
| **Time and Cost-Related Risks:** | | | |
| Cost escalation due to market conditions | Medium | High | Fixed-price contracts, cost contingencies, regular financial monitoring. |
| Procurement delays | Medium | High | Early supplier engagement, identify alternative suppliers, contractual delay provisions. |
| Currency exchange fluctuations | Medium | Medium | Hedge currency risks, negotiate contracts in local currency, maintain contingency buffers. |
| **Additional Risks Identified:** | | | |
| Supply chain disruptions | Medium | Medium | Diversify suppliers, inventory critical spares, regular supplier risk assessments. |
| Safety risk during demolition or installation phases | Medium | High | Use of certified contractors; compliance with Nova Scotia occupational health and safety regulations; daily safety meetings and supervision. Safety plans required and reviewed before mobilization. |
| Lack of formal asset management and maintenance records | Medium | Medium | CMMS system to be implemented as part of project; O&M manuals updated; staff training and maintenance procedures established. |
| Cybersecurity risk from new control systems (e.g., AMI or SCADA) | Low | Medium | Control systems follow cybersecurity protocols; network isolation for critical systems; IT audit conducted post-commissioning. |
| Natural Disaster (e.g., flood, extreme weather event during construction) | Medium | High | Schedule critical works outside high-risk weather seasons; obtain appropriate insurance; have emergency response plan in place. |

| Key Risks | Probability | Impact | Risk Mitigation Strategies |
|---|---|---|---|
| Public or Stakeholder Opposition | Low | Low | Project already approved to continue by Town Council. Because we are not altering the external structure, or the dam, we are not impacting the public. The entire project happens inside the powerplant. |
| Loss of Institutional Knowledge (e.g., retirement of key personnel) | Medium | Medium | Cross-train staff; document systems and procedures; retain external technical advisors through transition. |
| Cyberattack or Ransomware on New Digital Systems (e.g., SCADA, AMI) | Low | High | Implement IEC 62443 cybersecurity best practices; use firewalls, VPNs, and multi-factor authentication; conduct penetration testing. |
| Delays in Decision-Making from Governing Authorities or Council | Medium | Medium | Build in approval time into schedule; engage elected officials early; prepare briefing materials and decision packages in advance. |

## Section 7 – Regulatory and Legal Considerations

One of the most interesting aspects of this project is that, because it is being executed inside the structure of the powerhouse, and there is no modification to the civil structure, no reduction or increase of the footprint of any of the assets, and no increase in the water usage, there is virtually no additional permitting or additional regulatory aspects that could impact the project advancement.

Regardless, there are a few aspects that are important and that we will keep close attention.

- Water usage: the Berwick Electric Commission has a permit by the Province of Nova Scotia to use the water of the Factorydale reservoir to generate energy. The permit is already valid, but will need to be renovated before commissioning starts in late 2026. We don’t see an issue on this aspect, it is a straightforward application.
- NSUARB: the utility regulator approves any capital expenditure that requires an adjustment on the energy rates that can affect the customers, could be an increase or a reduction. In this case, the BEC will notify the regulator at the annual rates review application that this project is on-going, but that no increase on rates is derived by it. That application will include the entire project scope and capital expenditure plan. The NSUARB should not have any objection to the application, especially due to the context and the work already performed to determine the need of it.
- Nova Scotia Department of Environment and Climate Change: we don’t need approvals or permits from them, due to the fact that there are no changes to the current infrastructure of the powerplant or the dam, other than new equipment inside. The use of water will remain the same or be reduced due to a more efficient turbine. During construction, there is no disruption to water flow either.is
- Berwick Electric Commission: yes, the same asset owner as the grid operator, already guaranteed the interconnection of the new turbine to their own grid without additional permitting required.

# APPENDIX