# Attachment 12

## Bay d'Espoir Unit 8 – Basis of Design

Newfoundland and Labrador Hydro

newfoundland labrador hydro

# Bay d'Espoir Unit 8

## Basis of Design

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| **Comments:** The purpose of this document is to define the key governing design requirements and criteria for the Bay d'Espoir Unit 8 Project. | **Total # of Pages (including Cover): 10** |

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# Contents

# 1.0 Scope of Document

The purpose of this document is to define the key governing design requirements and criteria for the Bay d'Espoir Unit 8 Project.

# 2.0 Abbreviations and Acronyms

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|---|---|
| ASHRAE | American Society of Heating Refrigeration and Air Conditioning Engineers |
| BDE | Bay d'Espoir Hydroelectric Plant |
| BOD | Basis of Design |
| BOP | Balance of Plant |
| CER | Clean Energy Regulations |
| EqFOR | Equivalent Forced Outage Rate |
| HTGS | Holyrood Thermal Generating Station |
| IIS | Island Interconnected System |
| LIL | Labrador Island Link |
| MIRC | Minimum Investment Required Expansion Plan |
| NERC | North American Electrical Reliability Corporation |
| NLH | Newfoundland and Labrador Hydro |
| NLOHSR | Newfoundland and Labrador Occupational Health & Safety Regulations |
| NPCC | Northeast Power Coordinating Council |
| PCC | Protection, Control & Communications |
| RRA | Reliability and Resource Adequacy Study |

# 3.0 Background

Through the Reliability and Resource Adequacy Study Review proceeding, NLH identified the need for additional generation to meet system reliability requirements. To meet this need, an additional unit at the BDE was identified as a preferred, least-cost, environmentally responsible resource option. All supply expansion analysis completed throughout the 2024 Resource Plan was conducted based on Hydro's resource planning criteria in consideration of cost, reliability, and environmental responsibility. The MIRC was the plan recommended by the RRA to meet the demands of the Slow Decarbonization Case load forecast. The MIRC included Bay d'Espoir Unit 8 as one of the capacity options to meet Hydro's resource planning criteria. The Slow Decarbonization Case is a conservative estimate of load growth and represents less adverse future load conditions than the Reference Case which is a forecast for more adverse future load conditions.

The existing development at the BDE Facility has a 600 MW nominal capacity and includes a reservoir, a spillway, and two powerhouses. The BDE Unit 8 Project will supplement the existing BDE Hydroelectric Development, via the use of the existing reservoir, Terminal Station #2 and Powerhouse #2. BDE Unit 8 is expected to add an additional 150 MW nominal capacity[1] to the provincial grid.

During the original planning of the third phase of development in BDE, NLH planned the addition of Powerhouse #2 which contained 2 – 150 MW turbine generators, referred to as Units 7 and 8. Although both units were planned, only Unit 7 was completed. However, some concrete and embedded parts for the future unit's draft tube were built at that time. The key scope items identified below are required to support the completion of BDE Unit 8 Project:

- New headrace, intake & penstock;
- Tailrace widening;
- Powerhouse #2 expansion;
- Balance of Plant (BOP) systems;
- Turbine - Generator package including Governor and Excitation systems;
- Generator Step-Up Transformer;
- Protection, Control and Communication (PCC) systems;
- Transmission line; and
- Bay d'Espoir Terminal Station #2 yard-expansion.

The items listed above are not considered an exhaustive list, but rather are considered to represent the majority of items required to support a complete working plant.

# 4.0 Technical Requirements

## 4.1 Safety by Design

The BDE Unit 8 Project will align with Safety by Design principles. NLH systematically identifies hazards and failure modes that pose safety risks to workers and the public during the construction, operation, and maintenance of the equipment. NLH then assesses these hazards and failure modes through the design process to eliminate or reduce the associated safety risks. The objective is to produce safer designs to enable safer operability and maintainability. The BDE Unit 8 Project's design will consider the following Safety by Design principles at minimum:

- **Limits of Approach**: The equipment layouts will comply with limits of approach requirements, as required by CAN/ULC 801 and NLH;
- **Isolation**: Means of isolating and locking out systems to protect workers from hazardous materials, conditions or energy will be provided wherever required to protect workers in accordance with NLOHSR;

[1] Nominal capacity is noted at 150 MW; however, this may be improved upon through design optimizations during the engineering/procurement phases.

- **Arc Flash**: High Voltage equipment enclosures will be constructed to contain or safely redirect the hazardous energy caused by electric faults and will be Arc Resistant Type 2B as a minimum., in accordance with ANSI/IEEE C37.20.7;
- **Hazardous Materials**: Use of hazardous materials will be eliminated wherever practical. Where elimination is not practical, use shall be minimized and protocols and infrastructure for handling, transport and disposal will be incorporated;
- **Noise Reduction**: The ambient and localized noise output of the generator in operation will be target reduced to be at or below 85 decibels; and
- **Confined Space & Work at Height**: The requirement of confined space entry procudures or fall arrest equipment to access equipment that requires annual inspection or maintenance will be minimized as much as is practical. Where these conditions cannot practically be eliminated, means of following OHS requirements for this type of work (fall arrest anchors, isolation points etc.) will be incorporated into the design.

Safety by Design principles will continue to be applied during detailed design so that the systems and equipment minimize the risk of injury during construction, operation, and maintenance.

## 4.2 Performance Requirements

### 4.2.1 Reliability

The system will be designed to have a mean forced outage rate of 3% over the first 60 years of its lifespan.

### 4.2.2 Headrace

- The location of the headrace will be selected to minimize impacts on existing unit operation by minimizing flow effects on the existing intakes;
- The shape of the headrace canal will be designed to minimize velocities in the new canal and reduce the risk of frazil ice; and
- Design will take into consideration means and methods of construction to minimize in-water work at the entrance.

### 4.2.3 Intake

- Design will minimize the likelihood of vortex formation and meet minimum submergence requirements at minimum operating levels and rated unit capacity;
- Venting will be provided to ensure safe filling and emptying of the penstock without damage to any components due to vacuum pressure or blowback;
- The intake will have a single intake operating gate and an upstream maintenance gate with a hoist house that will allow for full removal of the gates from their guides for maintenance without the use of a mobile crane; and
- The design life of the embedded parts will be 110 years and the design life of non-embedded structural components (gates, trashracks, etc.) and lifting devices will be 50 years.

#### 4.2.4 Penstock

- Design will be buried steel type with varying diameters from 5.2 m at the intake to 3.76m at the connection to the spiral case;
- The penstock will be designed for the pressure increase of a load rejection without the use of a surge tank or pressure relief valve without damage or fatigue affecting its service life; and
- The design life will be 70 years.

#### 4.2.5 Tailrace

- The tailrace will be enlarged to maintain the existing operating level range, minimize head-losses and decrease any transient effects on the existing units; and
- Design will anticipate and facilitate methods of construction that minimize in-water work to mitigate impacts on the environment.

#### 4.2.6 Powerhouse #2 Extension

- The new unit will require an extension to the existing Powerhouse #2 and will utilize the existing draft tube gate infrastructure that was built for Unit #8 during original construction;
- The powerhouse extension will have its own maintenance bay similar in size to the existing Powerhouse #2 bay;
- The rails of the existing overhead crane and the draft tube deck monorail will be extended for use with the new unit;
- A gender-neutral washroom suitable for one occupant will be provided;
- A new service elevator will be provided to facilitate construction, operation, and maintenance activities for both units in Powerhouse #2;
- The powerhouse building will be of similar construction to the existing building including concrete foundation and steel superstructure with concrete panel cladding; and
- The design life of the powerhouse extension will be 100 years.

#### 4.2.7 Balance of Plant Systems

- BOP systems will generally be similar to those existing in Powerhouse #2;
- Fire Protection Systems will be independent of existing Powerhouse #2 systems, and will meet all relevant current industry standards;
- Fire Protection System shall be of the same type as the existing systems in Powerhouse 2 to minimize the requirement for additional spares inventory imposed by new or novel suppression system types;
- Fire detection and alarm systems will be designed in accordance with all current relevant industry and NLH standards;

- The Fire alarm control panel will be single stage, zoned, addressable, fully supervised, software controlled and microprocessor-based system;
- Heating Systems will utilize electric-resistance heating elements and be designed to ensure freeze protection of piping and other temperature sensitive components during outages only;
- Ventilation systems will consist of roof top exhaust fans with passive intake louvers and shall be sized in accordance with ASHRAE standards;
- An outdoor emergency diesel generator will be provided to supply emergency and black start power to Units 7 and 8;
- Piping Systems will utilize plastic and stainless-steel materials wherever possible to reduce fouling and corrosion commonly incurred with the system's source water; and
- Piping Systems will be selected for toughness and ease of repair and modification without the requirement for welding, proprietary systems or specialties.

### 4.2.8 Turbine

- The turbine will consist of a Francis type water turbine coupled to a generator by a vertical shaft, with mechanical and electrical support systems for unit operation and control;
- The runner will be designed to run continuously within the hydraulic constraints defined in Table 1 without damage;
- Efficiency, cavitation, and vibration performance will be optimized to the planned operating regime;
- The turbine and its associated draft tube shall be designed to integrate with the existing Unit 8 draft tube infrastructure; and
- The turbine will have a minimum design life of 55 years.

### 4.2.9 Generator

- The generator will be a synchronous machine capable of being operated as a synchronous condenser;
- It will be designed to be incorporated into the existing IIS and comply with NERC and NLH standards for grid-connected generating equipment; and
- The generator will have a minimum design life of 65 years.

### 4.2.10 Excitation System

- The system will be of the static type with manual and automatic modes of operation and designed to satisfy the generator's excitation requirements;
- The system will utilize common spare parts and design similarities with the existing powerhouse 2 exciter wherever feasible and practical;
- The system will comply with the current relevant industry and NLH standards.; and

- The exciter will have a minimum design life of 32 years.

### 4.2.11 Generator Step-Up Transformer

- The transformer will be an oil filled, three-phase, 129/172 MVA, 13.8kV-230kV bushing type power transformer;
- The transformer will be designed to meet current relevant industry and NLH standards for Outdoor Power Transformers;
- The exterior dimensions will be essentially the same as the existing Unit 7 transformer to facilitate interchangeability of spares; and
- The transformer will have a minimum design life of 55 years.

### 4.2.12 Protection, Control, and Communication (PCC) Systems

- New fiber optic line and tele-protection systems will follow NLH design standards;
- SCADA communications between PH2 and TS2 will be via fiber-optic cable;
- Redundant protection or primary and backup protection systems will be used as appropriate to the voltage level and specific equipment to be protected.;
- The design and all work for protection and control systems will be designed to all current relevant industry and NLH standards;
- To ensure full functionality; the designs, components and materials used will be compatible with existing plant PCC systems which include some proprietary systems;
- Communication systems will be powered by 48VDC with a single backup battery bank and charger;
- Protection, control, alarm and telemetering will be powered by 125 V DC with redundant backup battery banks and chargers with AC power from both the normal and emergency station service panels;
- Intake SCADA communication and Teleprotection will follow NLH Standards and utilize fiber-optic cable between Powerhouse #2 and Intake #5;
- The Security Video Monitoring System will be similar in design to the existing Powerhouse # 2 system; and
- PCC systems will have a minimum design life of 20 years.

### 4.2.13 Transmission Line:

- The new transmission line will be a 230kV line that will be routed from Powerhouse #2 to Bay d'Espoir Terminal Station #2;
- The line route selected will minimize environmental impacts and interference with other lines;
- Transmission line will include an OPGW fiber line providing communications between PH2 to TS2;

- The transmission line will be a hybrid design of wood and steel pole construction and will be designed to all current relevant industry and NLH standards; and
- The transmission line will have a minimum design life of 60 years.

#### 4.2.14 Terminal Station Expansion:

- The expansion will be designed to all known environmental, climatic, and geotechnical design conditions;
- The design will be a breaker-and-a-half scheme that will comply with all current relevant industry and NLH standards for terminal stations; and
- All electrical equipment for the terminal station expansion will be designed with a minimum design life of 40 years.

## 4.3 Operating Requirements

This section details the operating requirements of the design that are outside the control of the BDE Unit 8 Project. These include system water levels and operating regime.

### 4.3.1 Water Levels

The new hydroelectric system will be designed to operate under the existing operating conditions of the existing reservoir and tailrace. Table 1 outlines the existing maximum and minimum bounds of the system.

**Table 1 Hydraulic Constraints**

| Constraint | | Abbr. | Elevation (m CGVD28) | Notes |
|---|---|---|---|---|
| Turbine Runner Center Line Level | | TCL | 0.93 | Assumed to be impractical to change given existing powerhouse geometry. |
| Headrace (Reservoir Intake) | Maximum Flood Level | MaxFL | 184.20 | Extreme high design level. System must be safely operable at this level for extended but infrequent periods. |
| | Spring/Summer Maximum Operating Level | MOL | 182.70 | Normally expected high design level. System should be efficient at this level and capable of operating for extended periods. |
| | Normal Operating Level | NOL | 180.94 | Expected average level to which system should be optimized. |
| | Low Supply Level | LSL | 178.01 | Normally expected low design level. System should be efficient at this level and capable of operating for extended periods. |
| Tailra ce | Maximum Tailwater Level | MaxTL | 3.21 | Normally expected high design level. System should be efficient at this level and capable of operating for extended periods. |

| Constraint | | Abbr. | Elevation (m CGVD28) | Notes |
|---|---|---|---|---|
| | Normal Tailwater Level | NTL | 1.21 | Expected average level to which system should be optimized. |
| | Low Tailwater Level | LTL | 0.93 | Normally expected low design level. System should be efficient at this level and capable of operating for extended periods. |
| | Minimum Tailwater Level | MinTL | 0.47 | Extreme low design level. System must be safely operable at this level for short periods where low tide coincides with very low plant load. |
| Maximum Head Loss | | MaxHL | 6.0 | Friction loss in the hydraulic passage upstream and downstream of the turbine head measuring sections at design flow rate of 102 m3/s shall not exceed this value. |

Notes:

1) The tailrace water levels in the above table are original design elevations and will need to be validated once accurate TWL measurements are obtained by NLH.
2) There are tidal impacts in the tailrace. Tidal information has been obtained for the St. Alban's station from Fisheries and Oceans Canada, 2024, Water Level and Flow Information, https://wla.iwls.azure.cloud.dfo-mpo.gc.ca/ High tide has been taken as the highest tide and low tide has been taken as the lowest low tide in a typical year.

### 4.3.2 Operating Regime

Unit 8 will be designed to be operated in a regime analogous to the historical operating patterns of Unit 7 between April 2023 and April 2025. This period was chosen as one when the LIL was in reliable operation and COVID effects were negligible.