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February 8, 2022

Board of Commissioners of Public Utilities
Prince Charles Building
120 Torbay Road, P.O. Box 21040
St. John's, NL A1A 5B2

Attention: Ms. Cheryl Blundon
Director of Corporate Services & Board Secretary

Dear Ms. Blundon:

Re: Allowance for Unforeseen Items Account – Holyrood Thermal Generating Station Transformer T2 Failure – Final Report

On November 19, 2021, Newfoundland and Labrador Hydro ("Hydro") notified the Board of Commissioners of Public Utilities of its intent to use the Allowance for Unforeseen Items Account to complete the installation and commissioning of a critical spare transformer. The critical spare transformer was immediately required as a replacement for the damaged Unit 2 T2 transformer to allow safe and reliable operation of Unit 2. Repairs and commissioning were completed and Unit 2 was returned to service on January 13, 2022. Attached is Hydro's final report in relation to this work, as required under the Capital Budget Application Guidelines.[1]

Should you have any questions, please contact the undersigned.

Yours truly,

NEWFOUNDLAND AND LABRADOR HYDRO

Shirley A. Walsh
Senior Legal Counsel, Regulatory
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Encl.

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[1] "Capital Budget Application Guidelines," The Board of Commissioners of Public Utilities, October 2007 (originally issued June 2, 2005).

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Holyrood Thermal Generating Station
Transformer T2 Failure

Final Report

February 8, 2022

A report to the Board of Commissioners of Public Utilities

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1.0 Introduction

The Holyrood Thermal Generating Station ("Holyrood TGS") includes three thermal generating units—Units 1 and 2, each providing a capacity of 170 MW, and Unit 3, providing a capacity of 150 MW. Each thermal generating unit is connected to the electrical grid via a dedicated step up transformer. The step up transformer for Unit 2 ("Holyrood TGS Unit 2") is designated as "T2" (Figure 1). The T2 transformer failed on November 12, 2021.

Newfoundland and Labrador Hydro ("Hydro") conducts asset management activities to proactively identify, replace, repair, or refurbish equipment to minimize the disruption of service and avoid unsafe working conditions due to equipment failure. Transformers are critical and expensive components of an electrical system. Hydro regularly inspects and completes preventive maintenance ("PM") on transformers to identify concerns and issues and undertakes refurbishment or corrective maintenance ("CM") as required. Generally, Hydro identifies the required refurbishment and replacement work in time for inclusion in its capital budget applications; however, there are situations where unforeseen failures occur and require immediate refurbishment and replacement work to maintain safe and reliable operations. In the case of the T2 transformer failure, Hydro had to commence work immediately to restore this significant generation source for operation during the winter period. The timeframes associated with development of the proposal and the regulatory proceeding required to obtain approval of this work as a supplemental capital budget application would have presented delays to the restoration of Holyrood TGS Unit 2, resulting in unacceptable risk to adequate supply on the Island Interconnected System.

Upon the conclusion of an inspection to determine the source of the failure and the extent of the damage, Hydro notified the Board of Commissioners of Public Utilities ("Board") of its intention to utilize the Allowance for Unforeseen Items Account to fund costs associated with completing the work necessary to replace the T2 transformer and allow Holyrood TGS Unit 2 to be returned to service.[1]

[1] "Holyrood Thermal Generating Station Unit 2 Transformer Failure – Allowance for Unforeseen Items Notification," Newfoundland and Labrador Hydro, November 19, 2021.

1.1 Holyrood Transformer T2 Failure

On November 12, 2021, during normal operation of Holyrood TGS Unit 2, the T2 transformer experienced an internal fault. At the time of the event, Holyrood TGS Unit 2 was generating at 130 MW. Transformer protection operated as designed to remove the T2 transformer and Holyrood TGS Unit 2 from service.

Figure 1: Holyrood T2 Transformer

The T2 transformer was isolated from the grid and electrical testing was performed by Hydro personnel to investigate the issue with the transformer. This testing identified a potential issue with the high voltage winding. Online gas monitoring also showed there were combustible gases generated as a result of the event, but none were present leading up to the failure. Follow-up oil samples sent to a certified laboratory also confirmed the results of the online gas monitoring. As a result of the identification of combustible gases in the transformer oil, and the testing which identified a potential problem on the high voltage winding, further investigation was required to determine the exact nature of the fault. The transformer oil was drained and an internal inspection was conducted by a representative of the transformer's original equipment manufacturer ("OEM"), PTI Transformers LP, on November 18, 2021. The internal inspection confirmed that the transformer had experienced a significant failure on its high voltage winding (Figure 2). The OEM representative also advised that the issues with the transformer could not be repaired on site and the winding would need to be rewound. On November 18, 2021, immediately following the internal inspection and upon receipt of additional information from the OEM,

Hydro made the decision to replace the failed transformer with the spare transformer located at the Holyrood site. This was the only option available to return the T2 transformer and Holyrood TGS Unit 2 to service and ensure a reliable supply to customers for winter 2021–2022.

Figure 2: Holyrood Transformer T2 Failed High Voltage Winding

Hydro immediately engaged Hitachi Energy (formerly ABB), the OEM for the spare transformer, to provide support for the removal of the failed unit and installation of the spare. The failed transformer was relocated to a suitable location within the adjacent Holyrood Terminal Station. The spare transformer was tested and an internal inspection was completed by a representative from Hitachi Energy to confirm that there were no issues to prevent it from being placed into service. The spare transformer was then moved to the transformer pad previously occupied by the failed transformer.

The spare transformer was subsequently reassembled, filled with transformer oil, tested, and commissioned. The reassembly included the installation of surge arresters, coolers/radiators, Transfix oil monitoring equipment, grounding, and painting. Transformer testing included the testing of the transformer auxiliaries (winding temperature relay, oil temperature relay, oil level relay, and gas relay), TTR[2] tests, winding resistance tests, insulation resistance tests, Doble power factor and capacitance (overall and bushings) testing, CT[3] testing, SFRA[4] testing, and core ground testing.

[2] Transformer turns ration ("TTR").
[3] Current transformer ("CT").
[4] Sweep frequency response analysis ("SFRA").

All testing proceeded as expected with the exception of one of the five cooler motors, which was determined to be non-functional. Follow up review with Hitachi Energy identified that the unit can be rated at approximately 150 MVA with four cooler motors in service as opposed to its 170 MVA nameplate rating. Exciter settings were adjusted on Holyrood TGS Unit 2 to minimize the reactive (MVAr) contribution from the Holyrood TGS Unit 2 Generator and allow the unit to be rated up to 150 MW without overloading the transformer.

The commissioning of the spare transformer was completed on January 7, 2022 and the energization plan, which included proving Holyrood TGS Unit 2 output to 150 MW, was completed on January 13, 2022, following completion of infrared scanning of Isophase Bus Duct connections during favorable weather conditions.

2.0 System Overview

2.1 Existing System

Holyrood TGS Transformer T2 is a 115/152/190 MVA – 230/16 kV – wye/delta unit manufactured by Federal Pioneer which had been in continuous service since 1989.

The spare transformer, which is now in service, has a nameplate rating of 170 MVA – 230/16 kV – wye/delta. This unit was manufactured by Canadian General Electric in 1970. This unit had been in service as the step up transformer for Holyrood TGS Unit 2 from 1970 until 1989.

2.2 Operating History

2.2.1 Inspection and Test Plan

Transformers are critical and high-value components of an electrical system. Hydro regularly inspects and completes PM on transformers to identify concerns and issues and undertakes refurbishment or CM as required.

2.2.2 Holyrood TGS T2 5-Year Maintenance History and Corrective Maintenance

Hydro implements a PM program that includes the following for Holyrood TGS Unit T2 transformer:

- Daily dissolved gas analysis (“DGA”) and moisture samples to ensure acceptable levels of dissolved gases through online monitoring;
- Annual oil quality analysis of the transformer oil to confirm acceptable oil quality parameters;

- A 120-day PM routine, which includes cooling fan function testing, operational data collection, visual inspection;
- Furan oil testing every four years to determine the strength of insulation; and
- A 6-year PM, which includes electrical testing (Doble testing, winding resistance, winding insulation resistance, protective device insulation resistance, and surge arrester grounding continuity), protective device function testing, tap changer function testing, cooling fan function testing, and visual inspection.

The following lists the corrective maintenance performed over the past five years on Holyrood TGS T2:

- In August 2020, the gas relay was deemed faulty. It was immediately replaced;
- In January 2020, the transformer tripped during a storm. Ice had built up on the surge arrestors and caused a flashover. The arrester was immediately cleaned and power was restored;
- In December 2019, a fan motor was deemed faulty. It was immediately replaced;
- In January 2019, the online DGA monitor became defective. It was fixed in March 2019;
- In August 2017, a leak was identified on the X2 bushing. The leak was fixed in October 2017;
- In August 2017, passivator was added to the transformer oil to remediate corrosive sulphur;
- In May 2017, the pressure relief device was determined to be faulty. It was immediately replaced;
- In May 2017, a leak was identified on the H0 bushing. The leak was immediately fixed;
- In December 2016, a fan motor was identified to be faulty. It was immediately replaced; and
- In August 2016, the internal low voltage connections were inspected for copper sulphate from corrosive sulphur being present in the oil. No issues found on connectors.

As of February 7, 2022, no direct cause has been identified for the Holyrood TGS T2 failure and the investigation is ongoing.

3.0 Alternatives Considered

3.1 Deferral

Holyrood TGS Unit 2 could not be returned to service until corrective actions were completed. This unit is critical to the provision of reliable service for the upcoming winter season. It was determined that the T2 transformer could not be repaired on site in a timely manner. Given Hydro's commitment to have the Holyrood TGS fully available for generation, deferral of this project was not viable.

3.2 Replacement with a New Transformer

This alternative involves the replacement of the failed transformer with a new transformer, which would be procured as a direct replacement. Budgetary quotes indicated that the cost of a new transformer would be approximately $3.4 million with a lead time of 14 months. Due to cost and the requirement to have Holyrood TGS Unit 2 operational for the winter 2021–2022 season, this alternative was not viable.

3.3 Replacement with the On-Site Spare Transformer

This alternative involves the replacement of the failed transformer with the on-site spare transformer at an estimated cost of $1.4 million and an estimated return to service date of December 17, 2021, subject to favorable weather conditions.

3.4 Chosen Alternative

As it was the least-cost alternative and given the commitment to have Holyrood TGS Unit 2 available for the winter season, Hydro chose to replace the failed transformer with the on-site spare transformer. As Holyrood TGS Unit 2 is required to provide sufficient generating reserves for the 2021–2022 winter season, Hydro determined that it could not delay this work and proceeded with the installation of the available spare under the Allowance for Unforeseen Items Account.

4.0 Project Description

4.1 Project Scope

The failed transformer, which had already been drained of transformer oil, was disassembled, which is a necessary step for the relocation of a large transformer. The radiators, conservator tank, and high voltage bushings were removed, prepared, and placed in storage. The existing Transfix oil monitoring equipment and surge arresters were removed and temporarily stored on site, as it was required to be reinstalled on the spare transformer. The deluge system piping surrounding the transformer was

removed to allow the transformer to be moved. A division of Hitachi Energy, which specializes in the moving of power transformers, mobilized a heavy hauler from out of province to the Holyrood TGS site and relocated the failed transformer to a suitable location within the adjacent Holyrood Terminal Station.

The transformer oil within the spare transformer was drained and an internal inspection was completed to confirm that there were no issues to prevent it from being placed into service. The spare transformer was then moved to the transformer pad previously occupied by the failed transformer by the heavy hauler (Figure 3).

Figure 3: Spare Transformer Being Relocated

The spare transformer was assembled and filled with new transformer oil as the old oil contained polychlorinated biphenyls. The assembly included the installation of coolers/radiators and cooling pumps, which had been stored in the Bishop Falls warehouse. It also included the installation of the Transfix oil monitoring equipment and surge arresters (which had been installed on the old transformer), the installation of grounding, and painting. Modifications to the isolated phase bus ("IPB") were made to permit the connection of the low voltage bushings to the IPB via the braided connectors that had been used on the old transformer. The deluge system piping surrounding the transformer was reinstalled and the system was recommissioned.

The spare transformer was tested and commissioned. Transformer testing included the testing of the transformer auxiliaries (winding temperature relay, oil temperature relay, oil level relay, and gas relay),

TTR tests, winding resistance tests, insulation resistance tests, Doble power factor and capacitance (overall and bushings) testing, CT testing, SFRA testing and core ground testing.

All of the previously noted scope of work was required to remove the failed T2 transformer and install the spare transformer. This work was all required to return Holyrood TGS Unit 2 to service and was therefore all completed as part of the Allowance for Unforeseen Items project.

Hydro's plans to refurbish the failed T2 transformer or to procure a new spare transformer will depend on long-terms plans for the Holyrood TGS. Hydro is currently assessing long-term supply considerations for the Island Interconnected System as part of the ongoing *Reliability and Resource Adequacy Study Review* proceeding. This analysis will include a review of generation requirements as well as a review of the viability of the Holyrood TGS as a long-term solution. The outcomes of these analyses will include determinations as to the requirement for the extension of thermal generation at the Holyrood TGS beyond March 31, 2024, and any associated capital investment.

4.2 Project Timeline

The project milestones and actual completion dates are listed in Table 1.

The original estimated timeline would have had the transformer in service by December 17, 2021. However, the timeline was extended due to several factors during the execution of the project. On November 24, 2021, heavy rain washed out portions of the Trans-Canada Highway in western Newfoundland (Port aux Basques, North Branch, and Tompkins). Marine Atlantic cancelled several of its crossings between the North Sydney and Port aux Basques Terminals, which delayed the arrival of the heavy hauling equipment. Hydro worked with Marine Atlantic to minimize these delays, and the heavy hauling equipment was rerouted such that it arrived on the island via the Argentia Terminal. Extended drying time was also required to reduce the dew point of the transformer to a suitable level. Poor weather also delayed the transformer assembly work as well as the energization plan due to the requirement for thermal scanning of the low voltage bus connections when there was no precipitation. The T2 transformer was returned to service on January 13, 2022.

Table 1: Project Timeline

Milestone	Completion Date
Failed Transformer Relocated	3-Dec-2021
Spare Transformer Moved To Pad	7-Dec-2021
Spare Transformer Assembled	28-Dec-2021
Commissioning Complete	7-Jan-2022
Energization Plan Complete and Released For Service	13-Jan-2022

5.0 Project Costs

The current expenditures for this project are shown in Table 2. The original preliminary estimate was $1,383,600. Current actual expenses are approximately $1,929,000, due to additional costs associated with the heavy hauler delays, assembly of the spare transformer, the removal and reinstallation of the deluge fire protection system, and other weather-related delays. The cost may change marginally as Hydro receives final invoicing from all contractors. Actual final costs will be reported in Hydro's Allowance for Unforeseen monthly reporting.[5]

Table 2: Project Expenditures ($)

Project Expenditure	Cost
Internal Labour and Equipment	539,184
Heavy Hauler Equipment	310,683
OEM Construction Contract	874,674
Fire Protection	43,529
Miscellaneous Contracts/Materials	160,932
Total	**1,929,002**

6.0 Conclusion

On November 12, 2021, the Holyrood TGS Unit 2 T2 transformer experienced an internal fault. The unavailability of this transformer meant that Holyrood TGS Unit 2 was unable to supply power to the provincial grid. Once it was determined that the failed transformer could not be repaired on site in a timely manner, and due to the importance of Holyrood TGS Unit 2 to the provision of relatable service, Hydro determined that the replacement of the failed transformer with a spare transformer, which had been locally stored and was available for this purpose, was the most prudent alternative. The work was completed and the transformer was released for service on January 13, 2022.

[5] Filed with the Board on the tenth business day of each month.