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March 29, 2023

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

Attention: Cheryl Blundon
Director of Corporate Services and Board Secretary

Re: Purchase and Replace Last Stage Blades for Units 1 and 2 at the Holyrood Thermal Generating Station

Please find enclosed Newfoundland and Labrador Hydro's ("Hydro") application for approval for replacement of the last stage blades ("LSBs") on Units 1 and 2 at the Holyrood Thermal Generating Station ("Holyrood TGS"), including the purchase of a second set of LSBs. This project is required to support the reliable and safe operation of the Holyrood TGS at full generation capacity until alternative long-term sources of supply options become available. The project is expected to be completed in 2023 and 2024 at an estimated cost of $6,408,700.

Should you have any questions, please contact the undersigned.

Yours truly,

NEWFOUNDLAND AND LABRADOR HYDRO

Shirley A. Walsh
Senior Legal Counsel, Regulatory
SAW/sk

Encl.

ecc:

Board of Commissioners of Public Utilities
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Bernice Bailey, Browne Fitzgerald Morgan Avis & Wadden
Bernard M. Coffey, KC

Purchase and Replace Last Stage Blades for Units 1 and 2

Holyrood Thermal Generating Station

March 29, 2023

An application to the Board of Commissioners of Public Utilities

IN THE MATTER OF the *Electrical Power Control Act, 1994*, SNL 1994, Chapter E-5.1 ("*EPCA*") and the *Public Utilities Act*, RSNL 1990, Chapter P-47 ("*Act*"), and regulations thereunder; and

IN THE MATTER OF an application by Newfoundland and Labrador Hydro ("Hydro") pursuant to s 41(3) of the *Act* for approval of the replacement of the Holyrood Thermal Generating Station ("Holyrood TGS") Unit 1 last stage blades ("LSBs"), purchase of a set of LSB, inspection of Unit 2 LSBs, and replacement of Unit 2 LSBs.

To: The Board of Commissioners of Public Utilities ("Board")

THE APPLICATION OF HYDRO STATES THAT:

A. Background

1. Hydro, a corporation continued and existing under the *Hydro Corporation Act, 2007*,[1] is a public utility within the meaning of the *Act*, and is subject to the provisions of the *EPCA*.

2. Hydro is the primary generator of electricity in Newfoundland and Labrador. As part of its generating assets, Hydro owns and operates the Holyrood TGS, which has three oil-fired generating units that provide an installed capacity of 490 MW. The Holyrood TGS represents approximately one third of Hydro's Island Interconnected System generating capacity and approximately one quarter of the total Island Interconnected System capacity when included with all other customer-owned generation.

B. Application

3. The Holyrood TGS consists of 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 supplied with steam generated by a dedicated boiler for each unit. The steam is transferred from each boiler through high-energy piping to a steam turbine. Passage of steam through the various stages of the turbine rotor blades converts the energy of the steam into rotational energy in the turbine, which drives a generator to convert the rotating energy into electrical power.

[1] *Hydro Corporation Act, 2007*, SNL 2007 c H-17.

4. Hydro retained Hatch Ltd. ("Hatch"), with support from the original equipment manufacturer, General Electric ("GE"), to complete the "HTGS Condition Assessment and Life Extension Study" in March of 2022.[2] As part of this assessment, in July 2021, Hatch considered the results of major inspections and non-destructive examinations ("NDE") performed on the various stages of the Unit 1 turbine rotor blades as part of the 2021 Unit 1 major turbine overhaul project. The NDE showed a 3/8 inch linear crack on one of the LSB. GE provided an interim solution to mitigate supply risk and, in 2022, Hydro filed a supplemental application for the purchase of one set of LSBs to be used in the event of LSB failure on either Unit 1 or 2.[3,4] Based on the operational extension of the Holyrood TGS at that time to March 31, 2024, only one set of spare LSBs was purchased.

5. As detailed in Schedule 1 to this application, cracking of turbine blades could lead to unacceptable operational vibration in the turbine, forcing the unit offline until the replacement of the blades occurs. This could also lead to extensive damage to the unit and possible steam release into the powerhouse. An LSB failure during operation can lead to an extended forced outage of the generating unit for approximately 22 weeks to replace the equipment, with an additional 9 to 12 months if a set of LSB has to be procured.

6. Hydro has since determined that the Holyrood TGS is required as a bridging solution until alternative long-term sources of supply options become available, as detailed in the "Reliability and Resource Adequacy Study – 2022 Update."[5] GE has recommended that Hydro replace the LSBs on both Unit 1 and Unit 2, as detailed in Attachments 1 and 2 to Schedule 1 of this application.

7. Unit 2 at the Holyrood TGS is identical to Unit 1 and has been subjected to near identical operating conditions and hours; however, there has been no indication of cracks to Unit 2's LSBs. Hydro intends to perform an *in-situ* turbine inspection on Unit 2 in April 2023 to determine if repairs or replacement of the LSB is required imminently.

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[2] "*Reliability and Resource Adequacy Study Review* – Assessment to Determine the Potential Long-Term Viability of the Holyrood Thermal Generating Station," Newfoundland and Labrador Hydro, March 31, 2022, att. 1, att. 2, and att. 3.
[3] "Application for Approval to Purchase Last Stage Blades for Holyrood Thermal Generating Station Units 1 and 2," Newfoundland and Labrador Hydro, April 26, 2022.
[4] *Public Utilities Act*, RSNL 1990, Board Order No. P.U. 17(2022), Newfoundland and Labrador Hydro, May 20, 2022.
[5] "Reliability and Resource Adequacy Study – 2022 Update," Newfoundland and Labrador Hydro, October 3, 2022.

8. Considering Hydro's current commitment to maintaining the availability of the Holyrood TGS beyond 2024 and the increased risk of LSB failure associated with extending the operation of Units 1 and 2, Hydro is proposing to purchase a second set of LSBs and replace the turbine LSB on Units 1 and 2 in 2023 and 2024, respectively. Schedule 1 to this application provides Hydro's analysis supporting this proposal.

9. The procurement of an additional set of LSBs, along with the installation of replacement LSBs on both units, the *in-situ* inspection, and non-destructive testing ("NDT") on Unit 2 turbine LSBs, is expected to cost $6,408,700. The inspection of Unit 2, installation of the LSBs on Unit 1, and the purchase of the LSBs for Unit 2 will occur in 2023, with the installation of the LSBs on Unit 2 occurring in 2024. Further details regarding the scope, timing, and cost of Hydro's proposals are provided in Schedule 1 to this application.

C. Hydro's Request

10. Hydro submits that the proposed capital expenditures detailed herein and further described in Schedule 1 to this application are necessary to ensure that Hydro can continue to provide service that is safe and adequate and just and reasonable as required by Section 37 of the *Act.*

11. Hydro requests that the Board make an order pursuant to Section 41(3) of the *Act* approving:

    (i) *In-situ* inspections and NDT on the Unit 2 turbine LSBs;

    (ii) Purchase of a second set of turbine LSBs for replacement of the Unit 2 LSBs;

    (iii) Replacement of Unit 1 turbine LSBs in 2023; and

    (iv) Replacement of Unit 2 turbine LSBs in 2024.

D. Communications

12. Communications with respect to this application should be forwarded to Shirley A. Walsh, Senior Legal Counsel, Regulatory for Hydro.

DATED at St. John's in the province of Newfoundland and Labrador on this 29th day of March 2023.

NEWFOUNDLAND AND LABRADOR HYDRO

Shirley A. Walsh
Counsel for the Applicant
Newfoundland and Labrador Hydro,
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St. John's, NL A1B 4K7
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Schedule 1

Replace Turbine Last Stage Blades for Units 1 and 2

Holyrood Thermal Generating Station

Replace Turbine Last Stage Blades for Units 1 and 2

Holyrood Thermal Generating Station

March 2023

A report to the Board of Commissioners of Public Utilities

Replace Turbine Last Stage Blades for Units 1 and 2

Location: Holyrood Thermal Generating Station

Investment Classification: Renewal

Asset Category: Thermal Generation

Executive Summary

The generating units at the Holyrood Thermal Generating Station ("Holyrood TGS") consist mainly of a steam turbine coupled with a generator, supplied by a heavy fuel-oil boiler. The unit steam turbines are exposed to several degradation mechanisms such as fatigue cracking, erosion, wear, and creep. The turbine's last stage blades ("LSBs"), being larger than the other blades in the turbine low-pressure section, are subject to instances of higher stress.

In July 2021, as part of the "Holyrood TGS Condition Assessment and Life Extension Study,"[1] Hatch Ltd ("Hatch"), with support from the original equipment manufacturer, General Electric ("GE"), completed an assessment of the turbine blades that showed cracking on a last stage blade ("LSB") on Unit 1. GE provided an interim solution by weld repairing the crack to mitigate the risk of failure until the LSBs could be replaced. This repair was completed in the summer of 2021. The results of this assessment also included a recommendation from Hatch to replace both sets of LSBs to maintain the reliable operation of the Holyrood TGS to 2030.

In May 2022, the Board of Commissioners of Public Utilities ("Board") approved Newfoundland and Labrador Hydro's ("Hydro") supplemental capital application for the purchase of one set of LSBs to be used in the event of failure ("2022 LSBs Application").[2,3] This was deemed necessary to support the reliable and safe operation of the Holyrood TGS at full generation capacity until March 31, 2024.[4] As

[1] Filed as part of the "Reliability and Resource Adequacy Study Review – Assessment to Determine the Potential Long-Term Viability of the Holyrood Thermal Generating Station," Newfoundland and Labrador Hydro, March 31, 2022.
[2] "Application for Approval to Purchase Last Stage Blades for Holyrood Thermal Generating Station Units 1 and 2," Newfoundland and Labrador Hydro, April 26, 2022.
[3] *Public Utilities Act*, RSNL 1990, Board Order No. P.U. 17(2022), Newfoundland and Labrador Hydro, May 20, 2022.
[4] At the time of the "Application for Approval to Purchase Last Stage Blades for Holyrood Thermal Generating Station Units 1 and 2," Hydro had made a commitment to have the Holyrood TGS fully available for generation until March 31, 2024, as stated in the "Reliability and Resource Adequacy Study Review – Additional Considerations of the Labrador-Island Link Reliability Assessment and Outcomes of the Failure Investigation Findings – Additional Information," Newfoundland and Labrador Hydro, February 4, 2022, p. 7, item 3.

both Units 1 and 2 are identical in design and have been subjected to near identical operating conditions and hours, the blades were procured to serve as a replacement for either unit. At the time of filing the 2022 LSBs Application, Unit 2 had last been inspected in 2014 and had no indications of blade failure. The next scheduled inspection and overhaul for Unit 2 was approved in Board Order No. P.U. 2(2023)[5] in relation to Hydro's "2023 Capital Budget Application" ("2023 CBA").[6]

As the Holyrood TGS is now required as a bridging solution until long-term sources of supply are developed, [7] GE has recommended that Hydro replace the LSBs on both Unit 1 and Unit 2, as they are well beyond their intended design life.

Cracking of turbine blades could lead to unacceptable operational vibration in the turbine, forcing the unit offline until the blades are replaced. The increased vibrations of the rotor could cause extensive damage to other turbine components and possible steam release into the powerhouse, creating a safety hazard.

This project was not considered for inclusion in Hydro's 2023 CBA, as Hydro endeavoured to balance the requirement for plant availability with the cost of mitigating the risk to supply on both units. At the time of the filing of its 2023 CBA, Hydro's commitment to have the Holyrood TGS available at its full generation capacity was until March 31, 2024. Hydro believed that a single set of spare blades would appropriately address the supply risk, as there were no indications of failure on Unit 2. Considering Hydro's current commitment to maintaining the availability of the Holyrood TGS beyond 2024, and the increased risk of LSB failure associated with extending the operation of Units 1 and 2, Hydro is proposing to purchase a second set of LSBs and replace the turbine LSBs on Units 1 and 2 in 2023 and 2024, respectively. The inclusion of this proposal in Hydro's 2024 Capital Budget Application would not provide sufficient time to procure the second set of LSBs before the beginning of the 2024 maintenance season when replacement would be scheduled to occur.[8]

Hydro's application requests approval of a supplemental capital expenditure to enable the replacement of the LSBs on Unit 1 and Unit 2, including the procurement of a second set of LSBs.

[5] *Public Utilities Act*, RSNL 1990, Board Order No. P.U. 2(2023), Newfoundland and Labrador Hydro, January 26, 2023.
[6] "2023 Capital Budget Application," Newfoundland and Labrador Hydro, July 13, 2022.
[7] "Reliability and Resource Adequacy Study – 2022 Update," Newfoundland and Labrador Hydro, October 3, 2022.
[8] Current lead time is 9 to 12 months.

This project is required to support the safe and reliable operation of the Holyrood TGS. Completion of Unit 1 is planned for 2023 and Unit 2 in 2024 with a total project estimate of $6,408,700.

Contents

List of Attachments

1.0 Introduction

The Holyrood TGS consists of 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 supplied with steam generated by a dedicated boiler for each unit. The steam is transferred from each boiler through high-energy piping to a steam turbine. Passage of steam through the various stages of the turbine rotor blades converts the energy of the steam into rotational energy in the turbine, which drives a generator to convert the rotating energy into electrical power.

Hatch, with support from GE, completed a detailed assessment of the turbine LSBs in 2021 as part of the "Holyrood TGS Condition Assessment and Life Extension Study." This assessment considered the results of major inspections and non-destructive examination ("NDE") performed on the various stages of the Unit 1 turbine rotor blades as part of the 2021 Overhaul Unit 1 Turbine and Valves - Holyrood project.[9] The NDE showed a 3/8 inch linear crack on one of the LSBs. GE provided an interim solution to mitigate supply risk.

In 2022, Hydro filed the 2022 LSBs Application. To balance cost and reliability and in light of the relatively short operating period before the expected decommissioning of Units 1 and 2, Hydro decided to purchase only one set of spare LSBs to reduce the risk of an extended forced outage due to LSB failure. In the 2022 LSBs Application, Hydro noted, "As Unit 2 is an identical unit with a similar operating history, similar issues may be found on the Unit 2 LSBs during the scheduled overhaul in 2023."[10] Hydro's application was approved and Hydro subsequently purchased a set of LSBs as capital spares for the turbine of Unit 1 or Unit 2. Considering the current extension of Hydro's commitment to maintaining the Holyrood TGS past March 31, 2024 and the increased risk of LSB failure associated with this extension, Hydro accepts GE's recommendation to purchase a second set of LSBs and complete replacement on both Units 1 and 2.

The previously purchased spare set will be used to replace the LSBs on Unit 1 in 2023. Due to the long-lead time of approximately 9 to 12 months to manufacture and supply the LSBs, another set must be ordered in 2023 for Hydro to replace the LSBs on Unit 2 in 2024. While there are no current indications that Unit 2 has experienced cracking to the level Unit 1 had before the repair, Hydro intends to perform

[9] "2021 Capital Budget Application," Newfoundland and Labrador Hydro, rev. November 2, 2020 (originally filed August 4, 2020), vol. II, tab 1.

[10] At that time, in consultation with GE, Hydro determined that it was not necessary to conduct the major overhaul earlier than scheduled and to incur the associated costs, as there were no indications of issues with the LSBs on Unit 2.

an *in-situ* turbine inspection on Unit 2 in April 2023 to determine if repairs or replacement of the LSBs is required imminently. Should this be the case, Hydro will assess the risk to supply for both units and replace the blades on the unit that presents the greater risk and mitigate the risk on the other unit, as appropriate.

2.0 Project Description and Justification

This project involves the replacement of LSBs on Units 1 and 2 in 2023 and 2024, respectively.

The LSBs of Units 1 and 2 turbines are approximately 54 years old and have exceeded their design life. Cracking initiation indicates that the LSBs have deteriorated to a critical condition, which could lead to failure. As per a letter from GE dated November 21, 2022, provided as Attachment 1, the findings on Unit 1 are an early indication that the LSBs have reached a point of "rapidly increasing unreliability."[11] GE's experience is that these LSBs are well beyond the normal experience base and more cracking initiation and propagation to critical size to failure is anticipated.

With the operational extension of the Holyrood TGS past March 31, 2024, Hydro sought further clarification on the applicability of GE's recommendation on Unit 2. In February 2023, GE recommended that Hydro proceed with the LSB replacement on Unit 2, as detailed in Attachment 2.[12] While Unit 2 is also considered at risk of failure, as it is of identical design to Unit 1 and has been subjected to near-identical operating conditions and hours, there have been no significant operational issues observed on Unit 2 to date.

An LSB failure during operation can lead to an extended forced outage of the generating unit for approximately 22 weeks to replace the equipment, with an additional 9 to 12 months if a set of LSBs has to be procured.[13]

Hydro plans to replace the Unit 1 turbine LSBs in 2023 to resolve the cracking issue that has already been initiated. Due to outage constraints, this will require deferring the previously-approved Overhaul Unit 2 Turbine and Valves (2023) – Holyrood project[14] to 2024, as it is not feasible to complete both

[11] "Steam Turbines 940310 and 940311; Justification for replacement of last stage blades," GE Power Portfolio Product Service, November 21, 2022, p. 1.
[12] "Holyrood GS Unit # 1 & 2 Last Stage Blade L-0," GE Steam Power Canada Inc., February 20, 2023.
[13] Equipment lead time based on vendor quotations, including tendering and procurement activities.
[14] Approved as per *Public Utilities Act*, RSNL 1990, Board Order No. P.U. 2(2023), Board of Commissioners of Public Utilities, January 26, 2023 in relation to "2023 Capital Budget Application," Newfoundland and Labrador Hydro, July 13, 2022.

scopes of work in the same year. The delay to 2024 allows for the replacement of the LSBs on Unit 2 coincident with the overhaul. This plan was developed during a comprehensive risk review with GE and Hatch. Given there are no significant operating concerns observed on Unit 2, completing the replacements in this order addresses the greatest supply risk by resolving a known issue, which was supported by GE, as noted in Attachment 2.

Approval of the installation of the LSBs on Unit 2 at this time will result in a cost savings of $2.2 million, as Hydro will be able to take advantage of the previously-approved turbine overhaul work for Unit 2 and combine the overlapping outage and disassembly requirements.

3.0 Asset Overview

3.1 Asset Background

The Unit 1 and 2 turbines were manufactured by GE in 1969. The turbine consists of a high-pressure ("HP") section, an intermediate-pressure ("IP") section, and a low-pressure ("LP") section. Each section contains blades mounted to the turbine rotor in rows, as per Figure 1. The passage of steam through the blades in each row (stage) converts the energy of the steam into rotational energy in the turbine. The LP section is a "parallel flow" design. The LSBs are mounted on both end rows of the LP section. Steam enters the middle of the LP section through the crossover pipes, as can be seen in Figure 2, and passes through the blades in both directions of the LP section simultaneously until reaching the LSBs. The turbine rotor is directly coupled to the generator rotor as shown in Figure 2 and Figure 3.

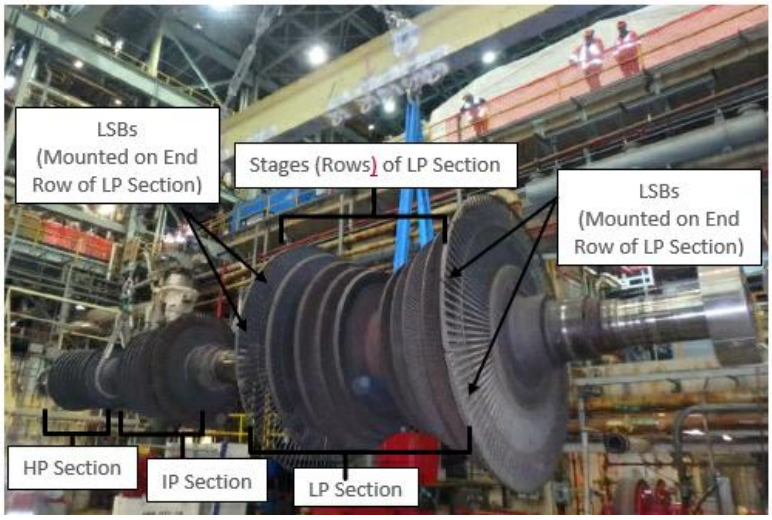

Figure 1: Turbine Rotor (Removed from Unit 1)

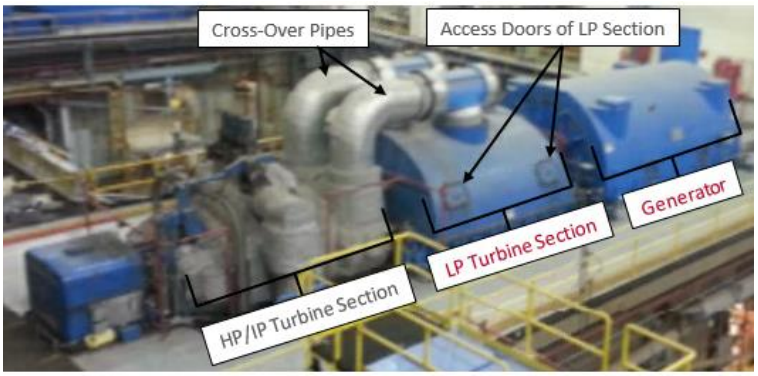

Figure 2: Turbine Generator

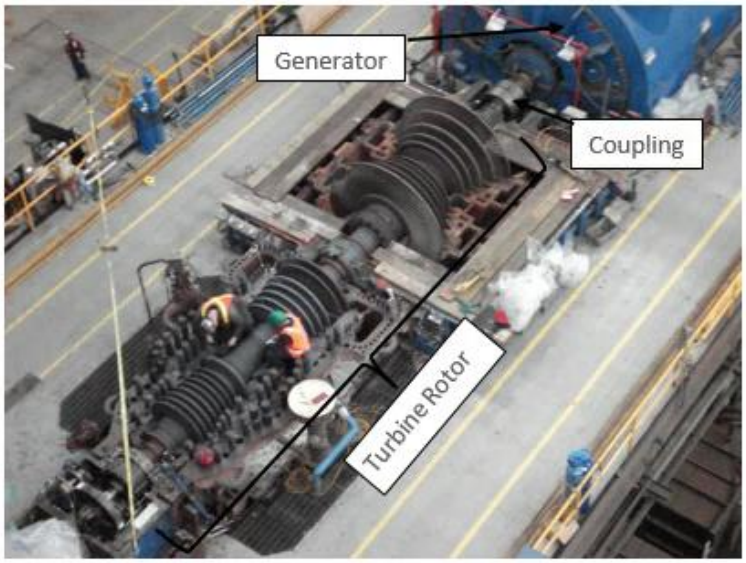

Figure 3: Turbine Generator (with Turbine Upper Half Casing Removed)

The LSBs can be accessed for inspection by removing the access doors on the LP hood referenced in Figure 2. The LSBs are longer than other blades of the turbine LP section; therefore, they are exposed to higher bending stresses due to the impact of steam flow. In general, statistics show that LP turbine blades are more susceptible to failure compared to those of the HP and IP sections. Fatigue cracking is the main degradation mechanism affecting the turbine LP blades. It takes place because of vibration arising from the fluctuation of bending stress due to the asymmetric flow of steam through the blades. Once a crack has been initiated, the component is assumed to have reached a critical condition of failure, since crack growth takes place rapidly.

3.2 Historical Reliability

Hydro performs a major turbine overhaul on a nine-year cycle. Completion of the last Unit 1 and Unit 2 turbine overhauls occurred in 2021 and 2014, respectively. A turbine major overhaul scope includes the removal of the turbine casings, rotor, diaphragms, and bearings. Completion of visual inspections, NDT, and any replacement or refurbishment required to ensure safe and reliable operation occurs during the major turbine overhaul. There were no cracks found on the turbine blades in overhauls before 2021, including the Unit 2 inspection in 2014; however, initiation of cracking on the Unit 1 LSBs was found in the 2021 turbine major overhaul. With no evidence of impact or other physical damage due to contact with the blade that could cause the cracking, it is apparent that the mode of failure is related to fatigue associated with the operating hours of the unit. GE provided an interim solution by weld repairing the crack on the Unit 1 LSBs until a spare set of LSBs could be procured. This repair was completed in the summer of 2021.

3.3 Asset Condition

As previously noted, the LSBs of the Units 1 and 2 turbines are original to the units. As part of the 2021 Unit 1 Major Turbine Overhaul project, the NDE showed a 3/8 inch linear crack on one of the Unit 1 turbine LSBs. GE provided an interim solution in the summer of 2021 to mitigate the risk of failure until the LSBs could be replaced by weld repairing the crack on the Unit 1 LSB. The last Unit 2 turbine inspection was completed in 2014 with no signs of LSB cracking noted. As Units 1 and 2 turbine LSBs are of identical design and have been subjected to near-identical operating conditions, they are both considered at risk of failure. GE has noted that the Unit 1 and 2 LSBs are well beyond their intended service life and the cracking observed on Unit 1 is likely a leading indicator; therefore, unit reliability will become increasingly uncertain unless the LSBs are replaced.

4.0 Analysis

4.1 Evaluation of Alternatives

The following alternatives were considered:

- Deferral of the proposed replacements to a future year;
- Upgrade life extension;

- Like-for-Like Replacement: Replacement of LSBs on Units 1 and 2 turbines; and
- Alternative Strategies.

4.1.1 Deferral

Deferring this project increases the risk of unit turbine failure while in operation. Each unit has a capacity of 170 MW, which would be unavailable in the event of a failure on either unit. Should LSB cracking propagate to a critical size leading to failure during the in-service operation of Units 1 and/or 2, extensive downtime would be required during a forced outage of approximately 22 weeks to replace the LSBs. This forced outage would be longer should the current set of blades already be utilized or a second set not be available. In addition, an in-service failure of LSBs leads to increased vibrations of the rotor, which could cause extensive damage to other turbine components and possible steam release into the powerhouse, creating a safety hazard.

As Hydro has committed to extend the availability of the Holyrood TGS until long-term sources of supply are developed, this project must be undertaken to continue safe and reliable operation at the Holyrood TGS.

4.1.2 Upgrade Life Extension

As the LSBs on both Units 1 and 2 are well beyond their normal operating base and short-term refurbishment activities have already taken place on Unit 1, upgrade life extension is not a viable option.

4.1.3 Like-for-Like Replacement: Replacement of LSBs on Units 1 and 2 Turbines

Both Units 1 and 2 turbine LSBs are at risk of failure as they are at the end of their design life. Replacement of the LSBs on Unit 1 in 2023 will mitigate the supply risk associated with the previously observed cracking issue. Procuring a second set of LSBs in 2023 will reduce the unit downtime in the event of an in-service failure of the Unit 2 LSBs, and replacing the LSBs on Unit 2 as soon as possible in 2024 will significantly reduce the risk of asset failure.

4.1.4 Alternative Strategies

Given the age of the assets, their criticality to the system, and the requirement for Holyrood TGS to be available at full generation capacity as a bridging solution until long-term sources of supply are developed, Hydro has not identified any viable alternative strategies for this proposal.

4.2 Least-Cost Evaluation

Hydro has not identified any viable alternative strategies to facilitate a least-cost evaluation.

4.3 Recommended Alternative

Hydro accepts GE's recommendation and believes that the prudent approach is the replacement of the LSBs on Units 1 and 2 turbines in 2023 and 2024, respectively. This would include the *in-situ* inspection of Unit 2 and the procurement of a second set of LSBs.

This alternative allows Hydro to continue the safe and reliable operation of the Holyrood TGS and maintain the generation availability until alternative supply becomes available.

4.3.1 Risk of Asset Stranding

Due to the current assumptions for the Holyrood TGS, capital expenditures for this facility to operate as a generator continue to be required. Depreciation is required to be calculated on an accelerated basis (i.e., monthly depreciation = capital investment divided by remaining months of service life). In the event the investment does not meet the criteria for capitalization, the expenditures would be recorded as an expense in the year incurred. As per Board Order P.U. 33(2021),[15] the Board approved the deferral of the expenditure variances over $2.5 million above the test year to mitigate material increases in Holyrood assets due to the projected end-of-generation date.

4.3.2 Risk Mitigation

Hydro assessed the pre- and post-implementation risk of this project in accordance with Hydro's Capital Risk Assessment process, as detailed in Section 7.0 of the Capital Budget Overview of Hydro's 2023 CBA.[16] The outcome of this assessment is provided in Table 1.

Table 1: Risk Scoring Pre- and Post-Implementation

	Impact	Likelihood	Score
Pre-Execution	5	5	**25**
Post-Execution	5	2	**10**
Risk Mitigated			**15**
Risk Mitigated per $1 Million			**2.3**

[15] "*Public Utilities Act,* RSNL 1990, c P-47, Board Order No. P.U. 33(2021)," Board of Commissioners of Public Utilities, December 8, 2021.
[16] "2023 Capital Budget Application," Newfoundland and Labrador Hydro, July 13, 2022, vol. I, sch. 1, s. 7.0.

5.0 Scope of Work

The project scope of work includes the following:

1) Perform *in-situ* inspections and NDT on Unit 2 turbine LSBs while the turbine rotor is in place;

2) Purchase a second set of turbine LSBs;

3) Replace Unit 1 turbine LSBs in 2023 using the previously-purchased set of spare LSBs; and

4) Replace Unit 2 turbine LSBs in 2024 using the second set of LSBs purchased on this project.

5.1 Project Budget

The estimate for this project is shown in Table 2.

Table 2: Project Estimate ($000)

Project Cost	2023	2024	Beyond	Total
Material Supply	130.0	1,170.0	0.0	1,300.0
Labour	251.4	37.6	0.0	289.0
Consultant	0.0	0.0	0.0	0.0
Contract Work	2,650.5	1,000.0	0.0	3,650.5
Other Direct Costs	5.8	0.0	0.0	5.8
Interest and Escalation	100.0	283.8	0.0	383.8
Contingency	458.8	320.8	0.0	779.6
Total	**3,596.5**	**2,812.2**	**0.0**	**6,408.7**

5.2 Project Schedule

The anticipated project schedule is shown in Table 3.

Table 3: Project Schedule

Activity	Start Date	End Date
Planning		
Prepare project planning documentation	April 2023	April 2023
Procurement		
Procure a set of LSBs	April 2023	April 2024
Construction		
Inspect Unit 2 turbine LSBs	April 2023	May 2023
Replace Unit 1 turbine LSBs	May 2023	September 2023
Replace Unit 2 turbine LSBs	May 2024	September 2024
Close Out		
Prepare project close-out documentation	October 2024	December 2024

6.0 Conclusion

The NDE of the Unit 1 turbine during its major overhaul in 2021 showed cracking of one of the LSBs. As the LSBs of Units 1 and 2 turbines are of the same design and have been exposed to near identical operating conditions since 1969, it is anticipated that additional cracking will be initiated in the LSBs and potentially propagated to a critical size to failure.

This project will replace the LSBs on Holyrood TGS Unit 1 turbine in 2023 using the previously-purchased set of LSBs and replace the LSBs on the Unit 2 turbine in 2024. A second set of LSBs will be procured under this project to be used for the replacement of the Unit 2 LSBs. These blades must be purchased in 2023 to allow for the long lead time for procurement.[17]

This project was not considered for inclusion in Hydro's 2023 CBA, as at the time of filing that application Hydro's commitment regarding the Holyrood TGS was that it would be fully available for generation until March 31, 2024. Given Hydro's current commitment to extend the full generation availability of the Holyrood TGS as a bridging solution until new long-term sources of supply are available, Hydro agrees with Hatch and GE's recommendation to replace the LSBs on Units 1 and 2 turbines. Hydro's application requests approval of this supplemental capital expenditure to enable the replacement of the Unit 1 LSBs at the earliest opportunity and to commence procurement of a second set of blades in 2023 to replace the Unit 2 LSBs in 2024.

[17] Inclusion in Hydro's 2024 Capital Budget Application would not provide sufficient time to procure the second set of LSBs in advance of the 2024 maintenance season.

Schedule 1, Attachment 1

Steam Turbines 940310 and 940311; Justification for replacement of last stage blades

November 21, 2022 Letter from GE Power Portfolio Product Service

GE Power Portfolio
Product Service

Eric Ekland
Principal Engineer
Steam Turbine Product Service

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Mr. Ghanshyam Patel
Senior Customer Service Manager
32 Arrowpoint Drive
Brampton L6Y 0 Y9
Ontario Canada

21 November 2022

Subject: Steam Turbines 940310 and 940311; Justification for replacement of last stage blades

Mr. Patel,

This letter supersedes my letter to you of 18 November. It is updated to add discussion of risk, and to clarify some statements based on customer comments.

Newfoundland & Labrador Hydro has requested discussion on the topic of replacement of the last stage blades for the subject units. The site has an uncertain timeline to retirement, complicating the determination of return on investment for performing this replacement. The following points were discussed verbally with site management as a plan is developed.

- The installed hardware on both units is original, having shipped from the factory in 1969, 53 years ago. The GE experience for a unit of this type is that at least 20-25 years of "normal" service is typical at the time of replacement. It is uncommon for owners to retain last stage blades beyond 30 years due to reliability concerns. Even considering that these units are currently only running in winter months, **the hardware has exceeded its design life**. At this point issues that are the result of accumulated low-level events like operating off normal frequency for short periods, or chemistry upsets that have left deposits in creviced areas will begin to **affect reliability of the blades**, and therefore availability of the unit.
- Unit 1 (940310) recently had a crack in a single blade weld repaired. This repair is not considered permanent, and there is a GE recommendation outstanding to replace this row. The site is mitigating this issue with periodic inspection, but if the repaired blade, or any other blade in the row is found cracked during this inspection, the only remedy will be a forced outage to either replace the row or remove it and run in a derated condition until a second outage is taken to restore the row. Given the age of this equipment, **GE engineering considers the single blade finding on U1 to be an early warning indication that the last stage blades have reached the point of rapidly increasing unreliability.**
- Replacement of last stage blades is a time-consuming operation. Scheduled replacement of this hardware is far less costly than emergent repair, not even considering the loss of generation associated with a forced outage. Scheduling this scope as part of other planned work would minimize the financial impact.

With respect to the risk of not replacing L-0 buckets, the consequence of a partial bucket liberation will be very dependent on the nature of a failure in service. However, regardless of how significant a failure occurs, there will be a forced outage of some duration associated with the event. The length of the outage could run from several weeks to several months, depending on the ability to either move the LP rotor to a shop, or bring a portable lathe/balance machine to site.

In a "best case" scenario of a single bucket failure just at the tip, damage to surrounding components (essentially everything from the L-0 diaphragm to the condenser tubes) will be minor and can be dressed by hand tools. In this case, outage time will primarily involve cutting off the offending row and rebalancing the rotor. In a more significant scenario, such as a bucket failure closer to the base of the blade, damage would be significant enough that components might need to be shipped off site for major repair, like nozzle replacement in the L-0 diaphragm. In either of these two cases, consequential damage to the L-0 buckets is not important. This is because regardless of the damage done, these blades would be removed prior to return to service.

Please note that the forced outage scenarios above do nothing to mitigate the remaining rows of L-0 buckets on the two units.

Please let me know if you have any questions or concerns regarding these thoughts.

Eric J. Ekland
Steam Turbine Product Service

cc: C. Kuehne, Manager (acting), SPS Steam Turbine Product Service

Schedule 1, Attachment 2

Holyrood GS Unit # 1 & 2 Last Stage Blade L-0

February 20, 2023 Letter from GE Steam Power Canada Inc.

GE Steam Power Canada Inc
1420 Blair Towers Place,
Suite 500
Ottawa, K1J 9L8
Ontario, Canada

To,
Jessica McGrath, P.Eng
Project Manager, Newfoundland and Labrador Hydro
Holyrood Generating Station
1 Thermal Road
Holyrood – Newfoundland
A0A 2R0
JessicaMcGrath@nlh.nl.ca

February 20, 2023

RE: Holyrood GS Unit # 1 & 2 Last Stage Blade L-0

Dear Jessica,

The meeting was held between GE, Newfoundland & Labrador Hydro (site and headquarters personnel), and their independent consultant (Hatch) on 8 February 2023. One point of discussion was the applicability of the finding of a crack in a single last stage blade on U1 (commonly referred to as the L-0 stage, or LSB). The site needs clarification on the applicability of this finding to U2. They also solicited GE's thoughts about the risk of deferring a major outage on U2 by one year to enable replacement of at-risk hardware earlier on U1.

With respect to the applicability of the finding on U1, given that the root cause of the cracking on the LSB is not known, both rows of L-0 blades on U1, and both rows of blades on U2 are considered at risk as they have experienced similar grid conditions and operating service as the blade that cracked on U1. These buckets are original to the installation, and are now slightly more than 50 years old. The GE experience is that in most applications, last stage blades are replaced as part of routine maintenance somewhere between 20 and 30 calendar years from commissioning. So in that regard, these buckets are well beyond the normal experience base, and finding cracking developing is not particularly surprising.

The concern of GE is that the single blade crack on U1 is a leading indicator, and as time passes the reliability of both rows in both units will become uncertain. Loss of a single LSB at the location of the crack found in U1 would result in a forced outage, but it would be very unlikely to result in a catastrophic failure that would endanger the asset or plant personnel. Allowing additional blades to begin cracking without action would eventually result in a condition where a single blade failing could result in a cascading failure of other compromised blades, and this would lead to a much more serious event. This is the rationale behind recommending replacement of the L-0 blades on U1, and also for U2.

With respect to the sequencing of maintenance activities, if there are no indications of issues developing in U2, GE Engineer (Eric Ekland) personal engineering opinion would be that it is preferable to take an outage to resolve a known issue, deferring maintenance on a unit that has no known issues. That being said, it is prudent to perform some limited maintenance on U2 while U1 is down for installing new L-0 blades. Specifically, an in-hood inspection of the L-0 blades, and inspection of main turbine valves and bearings to ensure reliable operation until a major outage occurs. This would result in an incremental increase in risk of forced outage in U2, from deferring a major inspection from 2023 to 2024. The upside to this path is that the deferred outage would presumably install L-0 blades not currently available.

Sincerely,

Ghanshyam Patel
Customer Service Leader
GE Steam Power Canada Inc

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ghanshyam.patel@ge.com

c.c Jeff Vincent, Plant Manager (NLH),
John Adams, Asset Manager (NLH)
Eric Ekland, Principal Engineer - Fleet Management (GE)

Affidavit

IN THE MATTER OF the *Electrical Power Control Act, 1994,* SNL 1994, Chapter E-5.1 ("*EPCA*") and the *Public Utilities Act*, *RSNL 1990*, Chapter P-47 ("*Act*"), and regulations thereunder

IN THE MATTER OF an application by Newfoundland and Labrador Hydro ("Hydro") pursuant to s 41(3) of the *Act* for approval of the replacement of the Holyrood Thermal Generating Station ("Holyrood TGS") Unit 1 last stage blades ("LSBs"), purchase of a set of LSB, inspection of Unit 2 LSBs, and replacement of Unit 2 LSBs.

AFFIDAVIT

I, Robert Collett, of St. John's in the province of Newfoundland and Labrador, make oath and say as follows:

1. I am Vice President, Engineering and NL System Operator for Newfoundland and Labrador Hydro, the applicant named in the attached application.
2. I have read and understand the foregoing application.
3. To the best of my knowledge, information, and belief, all of the matters, facts, and things set out in this application are true.

SWORN at St. John's in the province of Newfoundland and Labrador this 29th day of March 2023, before me:)

Commissioner for Oaths, Newfoundland and Labrador

Robert Collett

SAMANTHA KEATS
A Commissioner for Oaths in and for
the Province of Newfoundland and Labrador.
My commission expires on December 31, 2027