



Hydro Place, 500 Columbus Drive,
P.O. Box 12400, St. John's, NL
Canada A1B 4K7
t. 709.737.1400 f. 709.737.1800
www.nlh.nl.ca

September 20, 2019

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: Application for Approval of the Refurbishment and Upgrade of an Olympus C Gas Generator
Serial Number 202204**

Please find enclosed one original and eight copies of Newfoundland and Labrador Hydro's ("Hydro") Application for Approval of the Refurbishment and Upgrade of an Olympus C Gas Generator ("Application") plus a supporting affidavit and project proposal.

The estimated cost of the project is \$393,500 and the scope of the project is set out in Schedule 1 to the Application. Hydro submits the proposed capital expenditures are necessary to ensure the continued provision of service which is safe and adequate and just and reasonable as required by section 37 of the *Public Utilities Act*.

Should you have any questions, please contact the undersigned.

Yours truly,

NEWFOUNDLAND AND LABRADOR HYDRO



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

Encl.

cc: Gerard M. Hayes, Newfoundland Power
Paul L. Coxworthy, Stewart McKelvey
Dean A. Porter, Poole Althouse
Gregory A.C. Moores, Stewart McKelvey

Dennis M. Browne, Q.C., Browne Fitzgerald Morgan & Avis
Denis J. Fleming, Cox & Palmer

Senwung Luk, Olthuis Kleer Townshend



Application for Approval of Refurbishment and Upgrade of an Olympus C Gas Generator

Serial Number 202204

September 19, 2019

An Application to the Board of Commissioners of Public Utilities



IN THE MATTER OF the *Electrical Power Control Act*, RSNL 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*”) for approval, pursuant to Subsection 41(3) of the *Act*, of refurbishment and upgrade of an Olympus C Gas Generator serial number 202204 for use as a spare gas generator for the Hardwoods and Stephenville Gas Turbines.

TO: The Board of Commissioners of Public Utilities (“*Board*”)

The Application of Hydro States that:

1. Hydro is a corporation continued and existing under the *Hydro Corporation Act, 2007*, is a public utility within the meaning of the *Act*, and is subject to the provisions of the *Electrical Power Control Act, 1994*.
2. Hydro is the primary generator of electricity in Newfoundland and Labrador. As part of its generating assets, Hydro owns and operates the Stephenville and Hardwoods Gas Turbines. Each gas turbine is rated at 50 MW. The units are used to produce power during system contingencies (i.e., loss of major generating unit or major transmission line, etc.) and are available for power generation over peak load periods should system or load conditions warrant their operation. They also have synchronous condensing capability to provide grid reactive power between sources of generation and points of demand.
3. On November 22, 2018, during a planned borescope inspection, an Olympus C Gas Generator serial number 202204 (“*Gas Generator 202204*”) installed in Hardwoods End B was found to

have a failed high pressure (“HP”) turbine blade. The unit was deemed to be unsuitable for continued operation and was removed from its berth and sent to an overhaul facility for inspection and repair. Hydro installed its spare gas generator in the Hardwoods End B berth and returned the plant to full capacity on December 11, 2018.

4. The detailed strip inspection of the gas generator, described in more detail in the project description and justification document attached to this Application as Schedule 1, confirmed the findings from the borescope inspection. One HP turbine blade lost its tip and outer shroud while in operation. The missing piece of blade caused secondary impact damage of varying extent to some remaining HP turbine blades and several LP guide vanes and turbine blades.
5. As the detailed metallurgical analysis which determined the cause of the damage also indicated that other intact blades of the same age and design exhibit some of the same indicators, it was recommended that all the HP turbine blades of that age and design be replaced to eliminate the risk of that type of failure.
6. The detailed strip report of the gas generator also recommended a more detailed inspection of the installed combustion cans. In recent years, Hydro has experienced failures of the riveted combustion cans similar to those currently installed in Gas Generator 202204. Recent overhauls have included the installation of welded combustion cans to mitigate the risk of a can failure as experienced with the previous riveted combustion can design.
7. The operative experience of Gas Generator 202204, as well as its corrective maintenance history and details of Hydro’s preventive maintenance for Olympus C gas turbines are detailed in the project description and justification document attached to this Application as Schedule 1.

8. The Hardwoods and Stephenville Gas Turbines perform several critical functions on the Island Interconnected System:
 - a. They are part of the island system reserve capacity and thus provides power under system peaking and emergency/contingency conditions;
 - b. They are part of the contingency plan for the reliable supply of power to the island of Newfoundland;
 - c. They are used to facilitate planned generation and transmission outages on the Avalon and Port aux Port Peninsulas; and
 - d. They provide reactive support for load centres on the Avalon and Port aux Port Peninsulas as they are equipped with synchronous condensing capability.

9. The availability of a spare gas generator contributes significantly to an expedited return to service of either of the Hardwoods or Stephenville Gas Turbine facilities in the event of an in-service failure. Hydro continues to assess its critical spares requirements and strives to ensure that the appropriate spares are available to provide an acceptable level of equipment reliability. Both generating facilities will be required at full capacity until after the first winter of operation of Muskrat Falls, currently anticipated for 2021. The availability of a spare will ensure that Hydro can adequately respond to a significant operational issue with a gas generator at either Hardwoods or Stephenville in a timely manner to ensure the reliability and availability of both facilities.

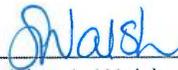
10. As set out in the project description and justification document attached to this Application as Schedule 1, Hydro is recommending the refurbishment and upgrade of Gas Generator 202204, after which it will be stored as a spare for dispatch to either Hardwoods or Stephenville as required.

11. The budget estimate for this project is \$393,500. The gas generator is expected to be returned and available as a spare by December 1, 2019, and the project is expected to be completed by December 31, 2019.

12. Hydro submits that the proposed capital expenditure is necessary to ensure that Hydro can continue to provide service which is safe and adequate and just and reasonable as required by Section 37 of the Act.

13. Therefore, Hydro makes Application that the Board make an Order pursuant to section 41(3) of the Act approving the capital expenditure of approximately \$393,500 for the refurbishment and upgrade of Gas Generator 202204 as more particularly described in this Application and in the project description and justification document attached as Schedule 1.

DATED at St. John's in the Province of Newfoundland and Labrador this 9 day of September, 2019.

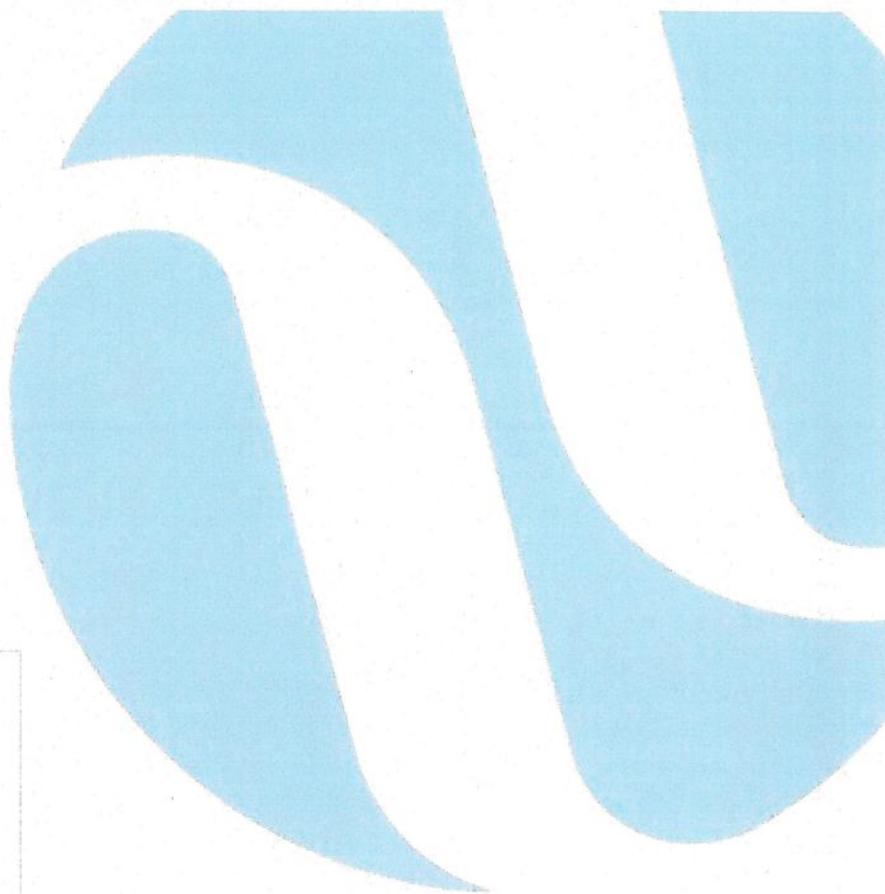


Shirley A. Walsh
Counsel for the Applicant
Newfoundland and Labrador Hydro
500 Columbus Drive P.O. Box 12400
St. John's, NL A1B 4K7
Telephone: 709.737.1365
Facsimile: 709.737.1782



Schedule 1

Gas Generator Refurbishment and Upgrade



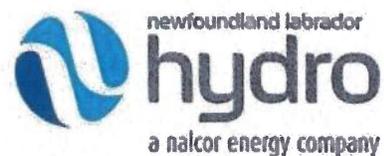
Gas Generator Refurbishment and Upgrade

Refurbishment and Upgrade of Rolls Royce Olympus C Gas Generator

Serial Number: 202204

September 19, 2019

A report to the Board of Commissioners of Public Utilities



*Gas Generator Refurbishment and Upgrade
Refurbishment and Upgrade of Rolls Royce Olympus C Gas Generator
Serial Number: 202204*

1 **Executive Summary**

2 This project is to complete the refurbishment and upgrade of Rolls Royce Olympus C Gas Generator
3 serial number 202204 (“Gas Generator 202204”) previously installed at the Hardwoods Gas Turbine. The
4 scope of work for the project includes the following:

- 5 • Replacement of high pressure turbine blades; and
- 6 • Installation of upgraded combustions cans.

7
8 On November 22, 2018, during a planned semi-annual borescope inspection, Gas Generator 202204,
9 installed in Hardwoods End B, was found to have a failed high pressure (“HP”) turbine blade. The unit
10 was deemed unsuitable for continued operation and was removed from its berth and sent to the
11 overhaul facility for inspection and repair. The detailed inspection of Gas Generator 202204 and the
12 metallurgical analysis of the high pressure turbine blades at the overhaul facility determined that the
13 replacement of the full set of HP turbine blades is required. Newfoundland and Labrador Hydro
14 (“Hydro”) is also proposing the replacement of the Phase 1 combustion cans with Phase 2 combustion
15 cans at this time to mitigate the risk of an in-service failure. Once this project is completed, Gas
16 Generator 202204 will be used as a spare gas generator for either Hardwoods or Stephenville to ensure
17 Hydro’s ability to respond to operational issues, thus improving the reliability of both of the Gas
18 Turbines.

19
20 The budget estimate for this project is \$393,500. The project is expected to be completed by December
21 31, 2019.

*Gas Generator Refurbishment and Upgrade
Refurbishment and Upgrade of Rolls Royce Olympus C Gas Generator
Serial Number: 202204*

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*Gas Generator Refurbishment and Upgrade
Refurbishment and Upgrade of Rolls Royce Olympus C Gas Generator
Serial Number: 202204*

1.0 Introduction

Hydro is proposing the refurbishment and upgrade of Gas Generator 202204 to re-establish a spare gas generator for the Hardwoods and Stephenville Gas Turbines. The scope of the project includes the refurbishment of the HP turbine and upgrade of the combustion section of Gas Generator 202204. This project is required to restore a spare gas generator for the Hardwoods and Stephenville Gas Turbines to ensure their reliable operation through the 2019-2020 operating season.

On November 22, 2018, during a planned borescope inspection, Gas Generator 202204 installed in Hardwoods End B was found to have a failed high Pressure (“HP”) turbine blade. The unit was deemed to be unsuitable for continued operation and was removed from its berth and sent to an overhaul facility for inspection and repair. Hydro installed its spare gas generator in the Hardwoods End B berth and returned the plant to full capacity on December 11, 2018. The detailed inspection of Gas Generator 202204 at the overhaul facility determined that the replacement of the full set of HP turbine blades is required.

Hardwoods and Stephenville Gas Turbines perform several critical functions on the Island Interconnected System:

- They are part of the island system reserve capacity and thus provides power under system peaking and emergency/contingency conditions;
- They are part of the contingency plan for the reliable supply of power to the island of Newfoundland;
- They are used to facilitate planned generation and transmission outages on the Avalon and Port aux Port Peninsulas; and
- They provide reactive support for load centres on the Avalon and Port aux Port Peninsulas, as they are equipped with synchronous condensing capability.

2.0 Background

The Stephenville and Hardwoods Gas Turbines have been in service since 1975 and 1976, respectively. Each rated at 50 MW, the units are used to produce power during system contingencies (i.e., loss of

*Gas Generator Refurbishment and Upgrade
Refurbishment and Upgrade of Rolls Royce Olympus C Gas Generator
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1 major generating unit or major transmission line, etc.) and are available for power generation over peak
2 load periods should system or load conditions warrant their operation. They also have synchronous
3 condensing capability to provide grid reactive power between sources of generation and points of
4 demand.



Figure 1: Hardwoods Gas Turbine

5 The Hardwoods and Stephenville Gas Turbines are Curtiss Wright Mod Pod 50 units, which are double-
6 ended units with two gas generator/power turbine units (End A and End B) connected to a single
7 alternator. The gas generators are Rolls Royce Olympus C engines and the power turbines were supplied
8 by Curtiss Wright. The alternator, supplied by Brush, is located between the two gas generator/power
9 turbine units and connects to the power turbines through mechanical clutches, supplied by SSS Clutch.
10 This configuration allows the alternator to be started by the gas generator/power turbine of either End
11 A or End B without disturbing the other end.

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1 **2.1 Existing System**

2 On November 22, 2018, Hydro completed a detailed borescope inspection of Gas Generator 202204
3 with the assistance of a field service engineer from Alba Power Limited. During the inspection of Gas
4 Generator 202204, installed in Hardwoods End B, it was noticed that one HP turbine blade was missing
5 its tip and outer shroud, see Figure 2. Further inspection of the HP and low pressure (“LP”) turbine
6 sections of the gas generator identified impact damage to some remaining HP turbine blades, as well as
7 on several LP turbine guide vanes and blades. The inspection also determined that the remainder of the
8 gas generator (compressor and combustion sections) were in generally good condition. However, due to
9 the condition of the turbine sections the gas generator was deemed unsuitable for continued operation.
10 The gas generator was removed from its berth and delivered to the overhaul facility on December 18,
11 2018.



Figure 2: Failed High Pressure Turbine Blade

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Figure 3: Low Pressure Turbine Blade Impact Damage

1 The detailed strip inspection of the gas generator confirmed the findings from the borescope inspection.
2 One HP turbine blade lost its tip and outer shroud while in operation. The missing piece of blade caused
3 secondary impact damage of varying extent to some remaining HP turbine blades and several LP guide
4 vanes and turbine blades. Detailed metallurgical analysis of the failed blade determined that it failed
5 due to low stress high cycle fatigue cracking as a result of high temperature differentials during start up
6 and shutdown of the engine. Similar analysis conducted on a comparison blade from the same set that
7 was intact concluded it is of the same microstructure and exhibits the same small fatigue cracks as the
8 failed blade. It was therefore recommended by Alba Power to replace the complete set of HP turbine
9 blades as they are of the same age (44 years) and design as the blade that failed and have been exposed
10 to the same operating conditions. The type of failure that occurred to the HP turbine blade can only be
11 determined through destructive testing and cannot be found during visual or non-destructive
12 examination. Thus, the only way to eliminate the risk of this type of failure would be to install new
13 blades during an overhaul or in shop repair.

14
15 The detailed strip report of the engine also recommended a more detailed inspection of the installed
16 combustion cans. While the installed combustion cans visually appear to be suitable for continued
17 operation the metallurgy of the cans are unknown. In recent years, Hydro has experienced failures of
18 the riveted combustion cans similar to those currently installed in Gas Generator 202204, see Figures 4

*Gas Generator Refurbishment and Upgrade
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- 1 and 5. Recent overhauls have included the installation of welded combustion cans to mitigate the risk of
- 2 a can failure as experienced with the previous riveted combustion can design.



Figure 4: Exterior of Failed Combustion Can From Engine 202205



Figure 5: Interior of Failed Combustion Can From Engine 202205

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1 **2.2 Operating Experience**

2 Gas Generator 202204 was originally placed in service at the Stephenville Gas Turbine in 1975. The gas
3 generator was operated on average less than 30 hours per year until its first overhaul in 2014.¹ At the
4 time, the decision to overhaul this gas generator was based on its age and condition as determined by
5 internal inspections completed by various service providers. As part of this overhaul, the HP turbine
6 blades were inspected and deemed suitable for continued operation. Therefore, they were recoated and
7 reinstalled in the gas generator. The gas generator was then reinstalled in its berth in Stephenville;
8 however, the gas generator experienced an in service bearing failure in March 2016 after approximately
9 246 hours of operation and approximately 48 starts. The gas generator was inspected after this failure
10 and again the HP turbine was found to be in suitable condition for recoating and continued service. The
11 gas generator was once again overhauled and installed in Hardwoods End B and released for service on
12 March 20, 2017. Though this gas generator has been overhauled twice in recent years, the HP and LP
13 turbines are original and have been in operation since 1975.

14
15 Hydro has experienced four combustion can failures in its Olympus C fleet since 2014. Until 2017, all of
16 Hydro's Olympus C Gas Turbines were fitted with Rolls Royce Phase 1 combustion cans, which are of a
17 riveted construction. These Phase 1 combustion cans have been consistently failing at the riveted
18 connection between the metal bands that make up the cans. In order to improve the reliability
19 performance of the combustion cans, all overhauls/repairs since 2017 have included the upgrade to the
20 Phase 2 combustion cans, which are of welded construction. Recent borescope inspections of the
21 upgraded combustion cans have not identified any deterioration of this type of combustion can.

22
23 The operation of the Hardwoods and Stephenville Gas Turbines has increased significantly since 2014.

¹ Hydro did not collect detailed operational data for its gas turbines until 1993. The Stephenville Gas Turbine operated an average of 29 hours annually over the period 1993 to 2013.

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Table 1: Hardwoods Gas Turbine Operation 2014 - 2018

Year	Generation Hours	Synchronous Condense Hours	Total Operating Hours
2014	355	5,766	6,121
2015	410	5,626	6,037
2016	750	5,619	6,369
2017	323	7,127	7,450
2018	497	5,938	6,435
Five Year Total	2,335	30,076	32,412
Annual Average	467	6,015	6,482

Table 2: Stephenville Gas Turbine Operation 2014 - 2018

Year	Generation Hours	Synchronous Condenser Hours	Total Operating Hours
2014	381	6,472	6,853
2015	236	4,748	4,984
2016	227	1,821	2,048
2017	140	7,666	7,806
2018	266	7,056	7,322
Five Year Total	1,250	27,763	29,013
Annual Average	250	5,553	5,803

1 The reliability performance of the Hardwoods Gas Turbine in terms of both UFOP² and DAUFOP³ for the
2 five year period from 2013 to 2017 is presented in Tables 3 and 4, respectively. The performance of the
3 Hardwoods Gas Turbine is compared to the other Hydro Gas Turbines as well as the Canadian Electricity
4 Association (“CEA”) performance of all units. The Holyrood Gas Turbine data presented is not for the full
5 period, but from its March 1, 2015 in-service date to the end of 2017.

Table 3: Hydro Gas Turbine Unit UFOP Performance 2013 - 2017

Unit	UFOP, % (External Conditions Excluded)
Holyrood	2.07
Hardwoods	19.23
Stephenville	11.27
Happy Valley	9.62
Hydro: All units	11.22
CEA: All units	13.42

² UFOP is the Utilization Forced Outage Probability; the probability that a unit will not be available when required.

³ DAUFOP is the De-rated Adjusted Utilization Forced Outage Probability; the probability that a unit will not be available when required (derating included).

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Table 4: Hydro Gas Turbine Unit DAUFOP Performance 2013 - 2017

Unit	DAUFOP, % (External Conditions Excluded)
Holyrood	2.11
Hardwoods	44.30
Stephenville	23.63
Happy Valley	9.98
Hydro: All units	19.0
CEA: All units	14.44

1 **2.3 Maintenance History**

2 **Preventive Maintenance**

3

4 Since 2014, Hydro has continued to review and modify the preventive maintenance program for its
 5 Olympus C Gas Turbines. This includes the increase in borescope inspection frequency, increased lube
 6 oil analysis and instituting annual lube oil changes. Prior to 2014, internal borescope inspections were
 7 completed every two years. However, due to increased operation the frequency was increased to
 8 annually in 2014 and then to semi-annually in 2017 due to the number of combustion can failures
 9 experienced since 2014. This has not eliminated the occurrence of combustion can failures, but it has
 10 improved Hydro’s ability to respond to internal engine damage and minimize the secondary damage to
 11 the engine as a result of such failures. The failure of Gas Generator 202204’s HP turbine blade was
 12 identified during a planned borescope inspection completed in November 2018.

13

14 **Corrective Maintenance**

15

16 Prior to 2014, Gas Generator 202204 required minimal corrective maintenance as it experienced
 17 minimal operational issues due to its limited annual operating hours. However, there was some history
 18 of elevated vibration and exhaust gas temperature (“EGT”) spread deviation issues. There were also
 19 several instances of high EGT spread that required the replacement of the fuel burners and combustion
 20 cans to return the EGT spread to acceptable levels. This gas generator was first overhauled in 2014 due
 21 to its age and internal condition as found during borescope inspections. The gas generator was
 22 reinstalled in its original berth in late 2015 but it experienced a bearing failure early in 2016 after
 23 approximately 246 operating hours and 48 starts. This resulted in the gas generator being overhauled
 24 for the second time in its service life in 2016. Upon its return from the overhaul facility in late 2016, Gas

**Gas Generator Refurbishment and Upgrade
Refurbishment and Upgrade of Rolls Royce Olympus C Gas Generator
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1 Generator 202204 was stored as a spare for both Hardwoods and Stephenville. It was installed in
2 Hardwoods End B on March 20, 2017. On August 11, 2017 higher than expected EGT spread was noticed
3 during the operation of the unit. The fuel burners were replaced with Hydro's spare set of fuel burners
4 and the unit was returned to service on August 18, 2018. It remained in service until the failed HP
5 turbine blade was found during the planned borescope inspection on November 22, 2018.

6 **3.0 Analysis**

7 The project scope includes only the replacement and refurbishment of components of Gas Generator
8 202204 as necessary to upgrade the aged and less reliable internal components and re-establish a spare
9 gas generator for the Hardwoods and Stephenville Gas Turbines. There are no viable alternatives to this
10 project.

11 The availability of a spare gas generator contributes significantly to an expedited return to service of
12 either of the Hardwoods or Stephenville Gas Turbine facilities in the event of an in-service failure. Hydro
13 continues to assess its critical spares requirements and strives to ensure that the appropriate spares are
14 available to provide an acceptable level of equipment reliability. Though the operation of the
15 Hardwoods and Stephenville Gas Turbines as generating facilities is limited, Hydro must ensure the
16 reliable operation of both facilities until they are no longer required to support the Island
17 Interconnected System. Both facilities will be required at full capacity until after the first winter of
18 operation of Muskrat Falls, currently anticipated for 2021. The availability of a spare will ensure that
19 Hydro can adequately respond to a significant operational issue with a gas generator at either
20 Hardwoods or Stephenville in a timely manner to ensure the reliability and availability of both facilities.

21 **4.0 Project Description**

22 This project is proposed to refurbish and upgrade Gas Generator 202204 to ensure the reliable
23 operation of the Hardwoods and Stephenville Gas Turbine facilities. The detailed scope of this project
24 includes:

- 25 • Replacement of Gas Generator 202204's original set of HP turbine blades; and
- 26 • Replacement of existing combustion cans in Gas Generator 202204 with upgraded combustion
27 cans.

Gas Generator Refurbishment and Upgrade
Refurbishment and Upgrade of Rolls Royce Olympus C Gas Generator
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- 1 The gas generator refurbishment will be performed by Alba Power in the overhaul facility where it is
 2 currently located. When the gas generator is returned from the overhaul facility it will be stored as a
 3 spare for both the Hardwoods and Stephenville Gas Turbines.

Table 2: Project Estimate (\$000)

Project Cost	2019	2020	Beyond	Total
Material Supply	0.0	0.0	0.0	0.0
Labour	39.2	0.0	0.0	39.2
Consultant	0.0	0.0	0.0	0.0
Contract Work	324.0	0.0	0.0	324.0
Other Direct Costs	8.5	0.0	0.0	8.5
Interest and Escalation	0.8	0.0	0.0	0.8
Contingency	21.0	0.0	0.0	21.0
Total	393.5	0.0	0.0	393.5

Table 3: Project Schedule

Activity	Start Date	End Date
Planning: Engineering /detail scope development	September 16, 2019	October 11, 2019
Procurement: Award of engine refurbishment	October 15, 2019	October 15, 2019
Construction: Engine refurbishment and test	October 15, 2019	November 22, 2019
Construction: Shipping /storage of unit	November 23, 2019	November 30, 2019
Closeout: Project Closeout	December 1, 2019	December 31, 2019

4 **5.0 Conclusion**

5 On November 22, 2018, it was determined that Gas Generator 202204 was not suitable for continued
 6 operation after a planned borescope inspection. It was determined that one of the original HP turbine
 7 blades (installed in 1975) failed due to low stress high cycle fatigue experienced as a result of start-up
 8 and shut-down of the gas generator over its 44 year service life. The gas generator was removed from
 9 service and was received at the overhaul facility in January 2019. A spare engine was installed
 10 immediately after the removal of Gas Generator 202204.

11
 12 To ensure the reliable operation of Hardwoods and Stephenville Gas Turbines and to minimize the
 13 impact of potential future operational issues the refurbishment and upgrade of Gas Generator 202204 is
 14 required. Once refurbishment of Gas Generator 202204 is complete and it is returned from the overhaul
 15 facility it will be stored as a spare for dispatch to either Hardwoods or Stephenville.



Affidavit

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

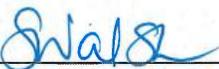
AND IN THE MATTER OF an Application by Newfoundland and Labrador Hydro ("*Hydro*") for approval, pursuant to Subsection 41(3) of the *Act*, of refurbishment and upgrade of an Olympus C Gas Generator serial number 202204 for use as a spare gas generator for the Hardwoods and Stephenville Gas Turbines.

AFFIDAVIT

I, Ron LeBlanc, Professional Engineer, of St. John's in the Province of Newfoundland and Labrador, make oath and say as follows:

1. I am the Vice President, Operations and NLSO for Newfoundland and Labrador Hydro, the Applicant named in the attached Application.
2. I have read and understand the foregoing Application.
3. I have personal knowledge of the facts contained therein, except where otherwise indicated, and they are true to the best of my knowledge, information and belief.

SWORN at St. John's in the)
Province of Newfoundland and)
Labrador this 19 day of September)
2019, before me:)



Barrister, Newfoundland and Labrador



Ron LeBlanc