newfoundland labrador hydro
a nalcor energy company

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

July 24, 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 Refurbishment of the Hardwoods Gas Turbine Alternator Exciter End Bearing and the Purchase of an Exciter Bearing Liner and Thrust Pads**

Please find enclosed one original and eight copies of Newfoundland and Labrador Hydro's ("Hydro") Application, plus a supporting affidavit and project proposal.

The estimated capital cost of the project is $225,500 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 & LABRADOR HYDRO

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

Encl.

cc: Gerard Hayes, Newfoundland Power
Paul Coxworthy, Stewart McKelvey
Dean Porter, Poole Althouse
Dennis Browne, Q.C., Browne Fitzgerald Morgan & Avis
Denis Fleming, Cox & Palmer

ecc: Gregory Moores, Stewart McKelvey
Senwung Luk, Olthuis Kleer Townshend LLP

Application for Approval of Refurbishment of the Hardwoods Gas Turbine Alternator Exciter End Bearing and the Purchase of an Exciter Bearing Liner and Thrust Pads

July 24, 2019

A report to the Board of Commissioners of Public Utilities

newfoundland labrador hydro
a nalcor energy company

Application

newfoundland labrador hydro
a nalcor energy company

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

AND IN THE MATTER OF an Application by Newfoundland and Labrador Hydro ("Hydro") for approval of refurbishment of the Hardwoods gas turbine alternator exciter end bearing and the purchase of an exciter bearing liner and thrust pads pursuant to Subsection 41(3) of the *Act*.

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 Hardwoods Gas Turbine. The Hardwoods Gas Turbine is rated at 50 MW and is used to produce power during system contingencies. It is also available for power generation over peak load periods should system or load conditions warrant its operation.

3. On February 21, 2019, the Hardwoods Gas Turbine tripped during startup of one of its gas generator/power turbine units (End B) while operating in generate mode with the other gas generator/power turbine unit (End A). Several attempts to place End B online were unsuccessful

with the unit tripping each time as a result of high exciter bearing vibration.

4. The Hardwoods Gas Turbine was derated from its full capacity of 50 MW to 25 MW from February 21, 2019, to May 28, 2019, due to the vibration issue.

5. During the inspection to determine the cause of the vibration issue it was discovered that the exciter thrust bearing assembly had moved out of position, resulting in insufficient clearance to allow its proper function when placing End B online. In addition, the lower and upper half of the exciter bearing liner showed signs of shaft contact.

6. The alternator exciter end bearing was replaced with the available capital spare. The exciter bearing liner was replaced with the available capital spare and Hardwoods Gas Turbine was returned to service at full capacity on May 28, 2019.

7. During the inspection, Hydro realized the criticality of the exciter bearing thrust pads as a critical spare component of the exciter bearing. If the thrust pads had been damaged beyond operational suitability, the unit could not have been returned to service and would have had to remain unavailable for approximately 16 to 20 weeks. These components are original to the unit. Although they have been polished and returned to service on a number of occasions, they have not been replaced in the unit's 42 year service life to date. Their current condition, while deemed suitable for further service, is not ideal. They are showing signs of significant wear and may not be able to be returned to service if further issues arise.

8. Hardwoods Gas Turbine performs several critical functions on the Island Interconnected System:

    a. It is part of the island system reserve capacity and thus provides power under system

peaking and emergency/contingency conditions;

b. It is part of the contingency plan for the reliable supply of power to the island of Newfoundland;

c. It is used to facilitate planned generation and transmission outages on the Avalon Peninsula; and

d. It provides reactive support for load centres on the Avalon Peninsula and is equipped with synchronous condensing capability.

9. The available spare bearing components were utilized to replace the existing alternator exciter end bearing and the exciter bearing liner to return the Hardwoods Gas Turbine to its full capacity. The components utilized must now be replaced to maintain the recommended level of critical spares to ensure reliable future operation of the Hardwoods Gas Turbine. In addition, spare thrust pads are an Original Equipment Manufacturer recommended spare for this alternator/exciter and need to be procured.

10. As set out in the project description and justification document attached to this Application as Schedule 1, Hydro is recommending restoration of the capital spares required for the Hardwoods Gas Turbine alternator and exciter bearings including the refurbishment of the alternator exciter end bearing removed from service in May 2019, as well as the purchase of an exciter bearing liner and thrust pads. This project is scheduled to be completed by the end of October, 2019.

11. The estimated capital cost of the project is $225,500.

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 $225,500 for the restoration of the capital spares required for the Hardwoods Gas Turbine alternator and exciter bearings including the refurbishment of the alternator exciter end bearing removed from service in May 2019, as well as the purchase of an exciter bearing liner and thrust pads 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 24 day of July, 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

Restoration of Hardwoods Gas Turbine Capital Spares

newfoundland labrador hydro
a nalcor energy company

Restoration of Hardwoods Gas Turbine Capital Spares

July 2019

A report to the Board of Commissioners of Public Utilities

newfoundland labrador hydro
a nalcor energy company

Executive Summary

The Hardwoods Gas Turbine was derated from its full capacity of 50 MW to 25 MW from February 21, 2019 to May 28, 2019, due to a vibration issue. While there was no issue with the operation of the End B gas generator/power turbine, the unit could not be placed in service due to high exciter vibration, which reached unit trip level when the unit approached synchronous speed (3600 rpm) on start up.

During the week of May 20, 2019, the exciter bearing was disassembled and inspected to determine the cause of the high exciter bearing vibration when starting End B. During this inspection it was discovered that the exciter thrust bearing assembly had moved out of position, resulting in insufficient clearance to allow its proper function when placing End B online. In addition, the lower and upper half of the exciter bearing liner showed signs of shaft contact. Inspection of the alternator exciter end bearing showed signs of wear and it was replaced with the available capital spare. The exciter thrust bearing assemblies were removed, and the thrust pads were polished and then reinstalled to Original Equipment Manufacturer ("OEM") specifications. The exciter bearing liner was replaced with the available capital spare and Hardwoods Gas Turbine was returned to service at full capacity on May 28.

Restoration of the capital spares required for the Hardwoods Gas Turbine alternator and exciter bearings, including the refurbishment of the alternator exciter end bearing removed from service in May 2019 and the purchase of an exciter bearing liner and thrust pads, is important to ensure reliable operation of the Hardwoods Gas Turbine. The estimated cost of the project is $225,500 and is expected to be complete by the end of October 2019.

Contents

1.0 Introduction

Newfoundland and Labrador Hydro ("Hydro") is proposing to re-establish capital spare bearing components associated with the alternator and exciter for the Hardwoods Gas Turbine. The alternator exciter end bearing will be refurbished and a new exciter bearing liner and thrust pads will be purchased. This project is required to restore capital spares required for the Hardwoods Gas Turbine to ensure its reliable operation.

On February 21, 2019, the Hardwoods Gas Turbine tripped during start-up of End B while operating in generate mode with End A. Several attempts to place End B online were unsuccessful with the unit tripping each time as a result of high exciter bearing vibration. While operating in synchronous condense mode or in generate mode with End A online, all bearing vibrations remained within operating limits and comparable with historical vibration levels.

Hardwoods Gas Turbine performs several critical functions on the Island Interconnected System:

- It is part of the island system reserve capacity and thus provides power under system peaking and emergency/contingency conditions;
- It is part of the contingency plan for the reliable supply of power to the island of Newfoundland;
- It is used to facilitate planned generation and transmission outages on the Avalon Peninsula; and
- It provides reactive support for load centres on the Avalon Peninsula and is equipped with synchronous condensing capability.

With End B not available to be placed on line, the Hardwoods Gas Turbine was de-rated to 25 MW. With this unit de-rated, the capacity became unavailable to the Island system as well as for regional generation requirements on the Avalon.

2.0 Background

The Hardwoods Gas Turbine has been in service since 1976. Rated at 50 MW, the unit is used to produce power during system contingencies (i.e., loss of major generating unit or major transmission line, etc.) and is available for power generation over peak load periods should system or load conditions warrant

its operation. It also has synchronous condensing capability to provide grid reactive power between sources of generation and points of demand.

The Hardwoods Gas Turbine is a Curtiss Wright Mod Pod 50 unit, which is a double-ended unit with two gas generator/power turbine units[1] (End A and End B) connected to a single alternator. The Gas Generators ("GG") are Rolls Royce Olympus C engines and the Power Turbines ("PT") were supplied by Curtiss Wright. The alternator, supplied by Brush, is located between the two gas generator/power turbine units and connects to the power turbines through mechanical clutches, supplied by SSS Clutch. This configuration allows the alternator to be started by the gas generator/power turbine of either End A or End B without disturbing the other end. It also allows the alternator to be brought to synchronous speed (3600 rpm) utilizing either end for synchronous condenser operation, disengaging the gas generator/power turbine and allowing them to come to rest. Then, if desired, it allows restarting either or both ends to engage the clutch at 3600 rpm and generate power for the system.

Figure 1, is a sketch of the Hardwoods Gas Turbine showing the arrangement of the unit's major components including the alternator and exciter shafts and associated bearings.

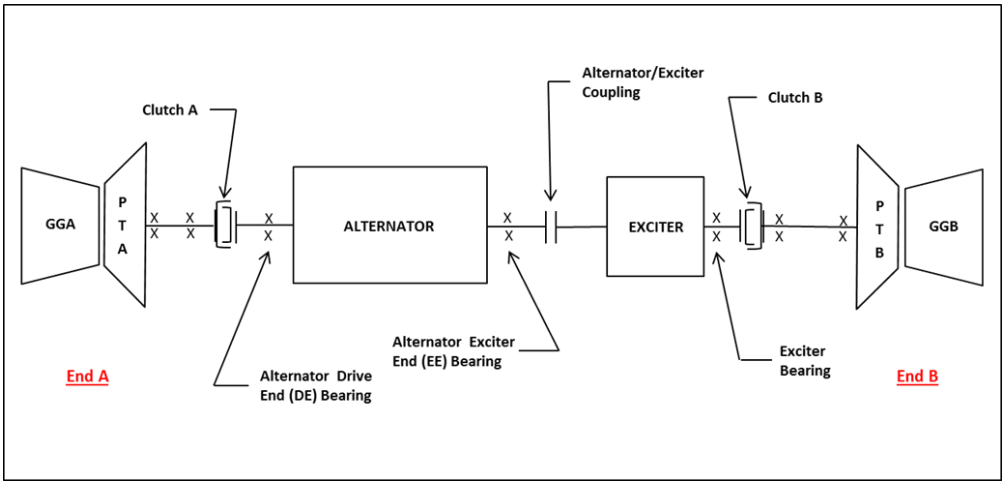

Figure 1: Hardwoods Gas Turbine Machine Sketch

The main mechanical components of the alternator are the alternator rotor, the exciter rotor, and the alternator stator. The exciter rotor is solidly connected to the alternator rotor by means of a coupling. The alternator/exciter rotor combined is approximately 9.3 metres in length and is supported by three

[1] From Figure 1, the two gas generators are GGA and GGB; the two power turbines are PTA and PTB.

hydrodynamic bearings, one at each end of the alternator and the third at the outboard, or B side, of the exciter (Figure 1). Hydrodynamic bearings are commonly used in large turbines, generators, compressors, gearboxes, and pumps in the power generation and the oil, gas, and chemical processing industries. Bearings are used to position and support the rotor in industrial machinery, transferring loads from the rotating components to the stationary casing. Thrust type bearings are used to accommodate axial loads, and journal type bearings are used to accommodate radial loads. Bearing components are typically constructed of steel with a layer of a soft tin alloy called babbitt bonded to the bearing surface, which helps protect the shaft from damage in the event of contact between it and the bearing surface.

2.1 Existing System

On February 21, 2019, the Hardwoods Gas Turbine tripped during start up of End B while operating in generate mode using End A. The unit tripped as a result of high exciter bearing vibration when End B reached synchronous speed. Several attempts to place End B on line resulted in unit trips. It was decided that End B would not be placed on line until the exciter bearing could be inspected to try and determine the cause of the trips. End A remained in service as the unit did not exhibit the same behaviour when End A was placed on line. Hydro decided at this time to keep the unit in service at a lower capacity rather than remove the entire unit from service during the winter operating season.

Prior to the trip, exciter vibration was trending up on start up of End B, but did not reach the alarm setting. This condition has existed since the original installation of the generator. Exciter vibration did not reach alarm or trip limits prior to this event.

During the week of May 20, 2019, the exciter bearing and alternator exciter end bearing were inspected to determine their condition and to determine the cause of the issues with placing End B online. Prior to bearing disassembly, shaft lift checks were completed utilizing the unit's jacking oil system. Lift was achieved at both alternator bearings 1 and 2, but no recordable lift was achieved at the exciter bearing (location shown in Figure 1). The exciter bearing (Figure 2) and the alternator exciter end bearing (Figure 3) were then disassembled and inspected to determine their condition and to determine the cause of the issues with placing End B in service. Upon exciter bearing disassembly, it was found that there was no measureable clearance on either side of the thrust bearing. The thrust pads showed signs of wear (Figures 4 and 5), but were determined suitable for further service.

Upon inspection of the exciter bearing, the lower half of the liner exhibited evidence of shaft touch and the liner top half had a small area of damage as well.

Figure 2: Exciter Bearing Liner Lower half, as Found

Upon inspection of the alternator exciter end bearing, it also showed evidence of shaft contact. The bearing, while still in serviceable condition, was replaced with the on-site spare to ensure the reliable operation of the alternator going forward. This replacement requires the oversight of a Brush representative and was therefore completed while the field service engineer was on site, avoiding the requirement for a future site visit to complete this work.

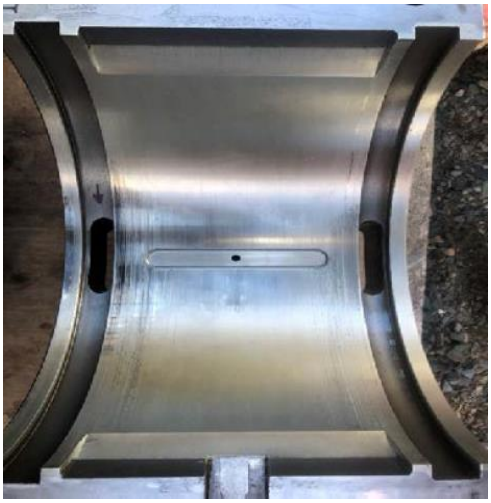

Figure 3: Alternator Exciter End Bearing Lower Half, as Found

Figure 4: Exciter Bearing Thrust Ring B Side, as Found

Figure 5: Exciter Bearing Thrust Ring A Side, as Found

Based on as found condition, the alternator exciter end bearing and the exciter bearing liner were replaced with the available capital spares. Having been deemed suitable for service, the exciter bearing thrust pads were polished and reinstalled. The exciter bearing journal[2] was also polished prior to completing the reinstallation of the exciter bearing components. Dimensional checks were completed on all bearing components to ensure conformance to OEM specifications prior to return to service. Figures 6 through 8 are photos of the as installed condition of the new and polished bearing components.

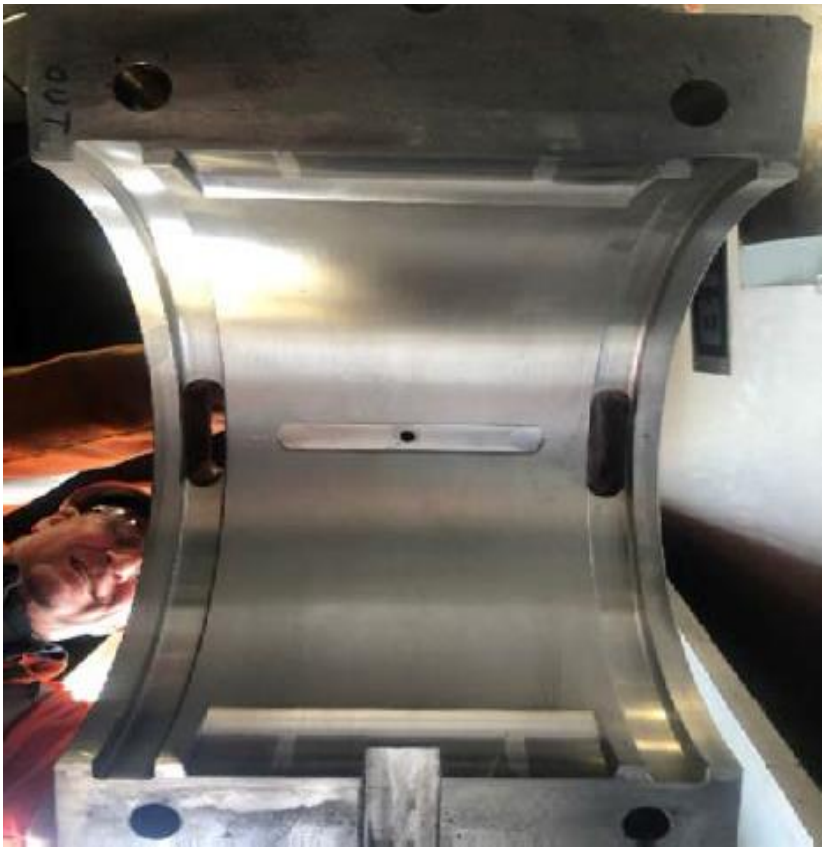

Figure 6: New Alternator Exciter End Bearing Lower Half Prior to Installation

[2] The journal is the shaft in the area of the bearing.

Figure 7: New Exciter Bearing Liner Lower Half Prior to Installation

Figure 8: Polished Thrust Ring Prior to Reinstallation

2.2 Operating Experience

The original alternator and exciter at Hardwoods were replaced in 2013 and the unit has operated approximately 2400 hours in generate mode and 33,300 hours in synchronous condense mode for a total of about 35,700 operating hours since the new components were placed in service in January 2014. The 2013 project replaced the originally installed alternator and exciter, but the exciter and alternator support bearings were not replaced and remain original to the unit. The exciter bearing liner was replaced at the time of exciter replacement, as it was found to be undersized for the new shaft when inspected. The purchase of a spare liner for the exciter bearing was also included in the project scope.

Since being placed in service in January 2014, the alternator and exciter have operated reliably. The unit operating hours by year in both modes of operation are presented in Table 1.

Table 1: Hardwoods Gas Turbine Operation 2014 to 2018

Year	Generation Hours	Synchronous Condense Hours	Total Operating Hours
2014	355	5766	**6121**
2015	410	5626	**6037**
2016	750	5619	**6369**
2017	323	7127	**7450**
2018	497	5938	**6435**
Five Year Total	**2335**	**30076**	**32412**
Annual Average	**467**	**6015**	**6482**

The reliability performance of the Hardwoods Gas Turbine in terms of both UFOP[3] and DAUFOP[4] for the five year period from 2013 to 2017 is presented in Tables 2 and 3, respectively. The performance of the Hardwoods Gas Turbine is compared to the other Hydro gas turbines as well as the CEA performance of all units. The Holyrood Gas Turbine data presented is not for the full period, but from its March 1, 2015 in-service date to the end of 2017.

[3] UFOP is the Utilization Forced Outage Probability; the probability that a unit will not be available when required.
[4] DAUFOP is the Derated Adjusted Utilization Forced Outage Probability; the probability that a unit will not be available when required (derating included).

Table 2: Hydro Gas Turbine Unit UFOP Performance 2013 to 2017

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

Table 3: Hydro Gas Turbine Unit DAUFOP Performance 2013 to 2017

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

2.3 Maintenance History

2.3.1 Preventive Maintenance

Since being placed in service in January 2014, annual inspection of the alternator and exciter has been performed by the OEM, Brush in accordance with the recommended maintenance strategy for the generator. In May 2018 a 25,000 hour inspection was completed by Brush with all parameters tested and found to be within specifications.

2.3.2 Corrective Maintenance

In June 2018, a problem with the alternator jacking oil system caused damage to the alternator bearings due to reduced lubricating oil flow on shut down of the unit. The alternator Drive End ("DE") bearing was replaced with the on site spare. The alternator Exciter End ("EE") bearing, while damaged, was determined to be suitable for further operation and was polished and reinstalled. The exciter bearing

was inspected with no visible signs of damage found and all parameters within specifications. The unit was returned to service with acceptable vibration levels on the alternator and exciter bearings.

In May 2018, the Hardwoods Gas Turbine tripped as a result of a system fault. Following the trip, the unit could not be placed on line due to high alternator/exciter vibration. A complete inspection of the alternator, including visual, electrical, and mechanical testing was performed with no issues found. Following a mechanical run, the unit was returned to service with no issues observed and all alternator and exciter bearing vibration levels within operating limits and comparable to historical levels.

In 2017, a lightning strike at the Hardwoods Terminal Station caused damage to the exciter. Several diodes were replaced and the unit was returned to service with no further issues.

3.0 Analysis

The project scope includes only the replacement and refurbishment of components of the alternator and exciter bearings as necessary to re-establish an appropriate level of capital spares for the Hardwoods Gas Turbine alternator and exciter. There are no viable alternatives to this project.

The availability of critical spare parts contributes significantly to an expedited return to service of a generator and its support systems. 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. Hydro has maintained critical spares for its alternator and exciter bearings including spare alternator bearings, as well as a spare exciter bearing liner. At the time of this exciter bearing vibration issue, the spares were available on site and the unit was able to be returned to service relatively quickly. However, during the course of the inspection of the alternator and exciter bearings, Hydro realized that exciter bearing thrust pads are a critical spare component of the exciter bearing. If the thrust pads had been damaged beyond operational suitability, the unit could not have been returned to service and would have had to remain unavailable for approximately 16 to 20 weeks. These components are original to the unit and have been polished and returned to service on a number of occasions but have not been replaced in the unit's 42 year service life to date. Their current condition, while deemed suitable for further service, is not ideal. As can be seen in Figures 9 and 10, they are showing signs of significant wear and may not be able to be returned to service if further issues arise. Generally, the thrust pads

have developed deep scratches and grooving over the years which cannot be removed as the babbitt surface has been thinned over time through cleaning and polishing.

Figure 9: Thrust Pad Wear

Figure 10: Thrust Pad Wear

4.0 Project Description

This project is proposed to restore the availability of required capital spares for the Hardwoods Gas Turbine alternator and exciter bearings. The existing spare bearing components were utilized in May 2019 to return the unit to service following a trip of the gas turbine as a result of high exciter bearing vibration.

The detailed project scope includes the following:

1) Purchase of a replacement exciter bearing liner;
2) Purchase of replacement thrust pads and miscellaneous materials required for thrust pad installation; and
3) Refurbishment (re-babbiting) of the spare alternator exciter end bearing.

The project will be completed by Hydro personnel with technical support from the alternator OEM, Brush. Bearing liner and thrust pad supply will be by Brush and will be the specified components for this alternator. Re-babbitting of the alternator exciter end bearing will also be performed by Brush to original equipment specifications. Table 4 provides the project estimate; Table 5 provides the expected project schedule.

Table 4: Project Estimate ($000s)

Project Cost	2019	Total
Material Supply	196.1	**196.1**
Labour	8.9	**8.9**
Consultant	0.0	**0**
Contract Work	0.0	**0**
Other Direct Costs	0.0	**0**
Interest and Escalation	3.6	**3.6**
Contingency	16.9	**16.9**
Total	**225.5**	**225.5**

Table 5: Project Schedule

Activity	Start Date	End Date
Planning: Obtain quotes	June 2019	June 2019
Procurement: Develop procurement package, place order, and receive parts	July 2019	September 2019
Bearing Refurbishment: Shipping and bearing refurbishment	August 2019	October 2019
Closeout: Project Closeout	October 2019	October 2019

5.0 Conclusion

The Hardwoods Gas Turbine was de-rated to 25 MW from February 21, 2019 to May 28, 2019 as a result of End B not being available due to high exciter bearing vibration on start up.

Inspection of the alternator exciter end and exciter bearings during the week of May 20, 2019 found the bearings to be out of specification for continued operation. At that time, the available spare bearing components were utilized to replace the existing alternator exciter end bearing and the exciter bearing liner to return the Hardwoods Gas Turbine to its full capacity (50 MW). The spare bearing components utilized must now be replaced to maintain the recommended level of critical spares to ensure reliable future operation of the Hardwoods Gas Turbine. In addition, spare thrust pads, while not identified during the critical spares review of the gas turbines, are an OEM recommended spare for this alternator/exciter and will be purchased as part of this project.

Affidavit

newfoundland labrador hydro
a nalcor energy company

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

AND IN THE MATTER OF an Application by Newfoundland and Labrador Hydro ("Hydro") for approval of refurbishment of the Hardwoods gas turbine alternator exciter end bearing and the purchase of an exciter bearing liner and thrust pads pursuant to Subsection 41(3) of the *Act*.

AFFIDAVIT

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

1. I am the Director of Operations 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 24 day of July 2019, before me:

Barrister, Newfoundland and Labrador

Scott Crosbie