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

August 31, 2016

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: An Application by Newfoundland and Labrador Hydro (Hydro) pursuant to Subsection 41(3) of the Act for the approval of the Combustor Inspection and Overhaul of the Combustion Turbine located in Holyrood

Please find enclosed the original and 12 copies of the above-noted Application, plus supporting affidavit, project proposal, and draft order. The proposed project involves the inspection of the combustor and overhaul of the combustion turbine located in Holyrood, which is necessary for the supply of safe and adequate and reliable power to the Island Interconnected System.

Should you have any questions, please contact the undersigned.

Yours truly,

NEWFOUNDLAND AND LABRADOR HYDRO

Tracey L. Pennell
Senior Counsel, Regulatory

TLP/cp

cc: Gerard Hayes – Newfoundland Power
Paul Coxworthy – Stewart McKelvey Stirling Scales
Sheryl Nisenbaum – Praxair Canada Inc.
Thomas Johnson, Q.C. – Consumer Advocate
Thomas J. O'Reilly, Q.C. – Cox & Palmer
Larry Bartlett – Teck Resources Limited

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) pursuant to Subsection 41(3) of the *Act*, for approval of the Combustor Inspection and Overhaul of the Combustion Turbine located In Holyrood.

TO: The Board of Commissioners of Public Utilities (the Board)

THE APPLICATION OF NEWFOUNDLAND AND LABRADOR HYDRO (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's owns and operates a 123.5 MW combustion turbine (CT) at the Holyrood Generating Station (Holyrood). The Holyrood CT was placed into service in February 2015. The Holyrood CT is operated to provide i) spinning reserves to the Island Interconnected System, ii) critical backup in the event if a contingency on the Island Interconnected System, and iii) electricity and power to the Avalon Peninsula. The Holyrood CT is also used to facilitate planned generation and Avalon Peninsula transmission outages.

3. The major components of the Holyrood CT include the gas turbine engine, generator, starting package, air intake structure, exhaust stack and auxiliary systems such as lube oil, fuel, compressed air and controls. The Holyrood CT consists of a Siemens W501D5A engine that is directly coupled to a Siemens SGEN-100-A-2P generator. According to

Siemens, the Original Equipment Manufacturer (OEM), preventative maintenance schedule, a combustor inspection and overhaul is recommended when the total equivalent starts on the unit reaches 400. A combustor inspection consists of the removal of all combustor and turbine end components that are accessible without removing the turbine covers. This preventative maintenance milestone also requires that the fuel nozzles, support housing, baskets, transition and seals be replaced.

4. Based on the anticipated operation of the Holyrood CT, a preventative maintenance strategy was developed that originally forecasted that the Holyrood CT would reach this milestone in the spring of 2018. Due to unanticipated system events in 2015 and 2016, the Holyrood CT has operated more than initially expected. It is now anticipated that the Holyrood CT will reach this maintenance millstone by February 2017, during the 2016/2017 winter period.

5. Continuing to operate the Holyrood CT until it has accumulated 400 equivalent starts will likely result in Hydro performing this work during the winter operating period. This would mean that the Holyrood CT would be unavailable to the system for approximately four weeks during a critical time of the year. Waiting until the end of the 2016/2017 winter period will likely result in operation past the OEM recommended maintenance schedule. Completion of the combustor inspection and overhaul prior to the winter operating season is required to maintain the reliable operation of the Holyrood CT. This will also ensure that Hydro can provide safe, reliable electrical service to its customers.

6. The scope of work includes a combustor inspection and overhaul on the Holyrood CT is set out the engineering report attached to this application.

7. The estimated cost of this project is $4,738,300.

8. The Applicant submits that the proposed combustor inspection and overhaul of the Holyrood CT 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*. An Engineering Report supporting this supplemental capital application is attached.

9. Hydro therefore makes Application for an Order pursuant to section 41(3) of the *Act* approving the combustor inspection and overhaul of the Holyrood CT at an estimated capital cost of $4,738,300, all as set out in this Application and in the attached project description and justification document.

DATED at St. John's in the Province of Newfoundland and Labrador this 31 day of August 2016.

Tracey Pennell

Tracey L. Pennell
Counsel for the Applicant
Newfoundland and Labrador Hydro
500 Columbus Drive P.O. Box 12400
St. John's, NL A1B 4K7
Telephone: (709) 778-6671
Facsimile: (709) 737-1782

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) pursuant to Subsection 41(3) of the *Act*, for approval of the Combustor Inspection and Overhaul of the Combustion Turbine located in Holyrood.

AFFIDAVIT

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

1. I am General Manager, Hydro Production of 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 31 day of August 2016,)
before me:)

Barrister – Newfoundland and Labrador

Jennifer M. Williams

(DRAFT ORDER)
NEWFOUNDLAND AND LABRADOR
BOARD OF COMMISSIONERS OF PUBLIC UTILITIES

AN ORDER OF THE BOARD

NO. P.U. __ (2016)

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) pursuant to Subsection 41(3) of the *Act*, for approval of the Combustor Inspection and Overhaul of the Combustion Turbine located In Holyrood.

WHEREAS the Applicant 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; and

WHEREAS Section 41(3) of the Act requires that a public utility not proceed with the construction, purchase or lease of improvements or additions to its property where:

a) the cost of construction or purchase is in excess of $50,000; or
b) the cost of the lease is in excess of $5,000 in a year of the lease,

without prior approval of the Board; and

WHEREAS in Order No. P.U. 33(2015) the Board approved Hydro's 2016 Capital Budget in the amount of $183,082,800; and

WHEREAS the Board approved supplementary 2016 capital expenditures:

(i) in Order No. P.U. 8(2016) in the amount of $1,000,000 to supplement the Allowance for Unforeseen Items;
(ii) in Order No. P.U. 17(2016) in the amount of $6,300,000 to purchase 12 MW of generating capacity at the Holyrood Thermal Generating Station;
(iii) in Order No. P.U. 19(2016) in the amount of $11,800,000 to replace lower reheater tubes on the Unit 1 and 2 boilers and to complete reliability improvements at the Holyrood Thermal Generation Plant;
(iv) in Order No. P.U. 20(2016) in the amount of $717,000 to reroute transmission line TL227 and distribution line Sally's Cove L1, a multi-year project with capital expenditures of $1,533,000 in 2017 which were also approved in this Order;

(v) in Order No. P.U. 22(2016) in the amount of $3,047,100 for the refurbishment of gas generator End A engine, serial number 202205, at the Hardwoods Gas Turbine Plant and gas generator End A engine, serial number 202204, at the Stephenville Gas Turbine Plant; and

(v) in Order No. P.U. 28(2016) in the amount of $1,977,300 for the rehabilitation of Bay d'Espoir Unit 4 turbine; and

WHEREAS on August 31, 2016, Hydro applied to the Board for approval to complete a combustor inspection and overhaul of the Combustion Turbine located in Holyrood; and

WHEREAS the capital cost of the project is anticipated to be $4,738,300; and

WHEREAS the Board is satisfied that the combustor inspection and overhaul of the Combustion Turbine located in Holyrood is necessary and reasonable to allow Hydro to provide service and facilities which are reasonably safe and adequate and just and reasonable.

IT IS THEREFORE ORDERED THAT:

1. The proposed capital expenditure to complete a combustor inspection and overhaul of the Combustion Turbine located in Holyrood of $4,738,300 is approved.

2. Hydro shall pay all expenses of the Board arising from this Application.

DATED at St. John's, Newfoundland and Labrador, this day of , 2016.

____

____

____

____

____

A REPORT TO

THE BOARD OF COMMISSIONERS OF PUBLIC UTILITIES

REGISTERED PROFESSIONAL ENGINEER PEG Newfoundland and Labrador TODD C. COLLINS SIGNATURE August 29/16 DATE NEWFOUNDLAND & LABRADOR	Electrical
	Mechanical
	Civil
	Protection & Control
	Transmission & Distribution
	Telecontrol
	System Planning

Combustor Inspection Major and Overhaul

Holyrood Combustion Turbine

August 29, 2016

newfoundland labrador hydro
a nalcor energy company

SUMMARY

This project is to complete a combustor inspection major (CI) and overhaul on the 123.5 MW Holyrood Siemens 501D5A combustion turbine (CT). Siemens, the original equipment manufacturer (OEM), recommends that an overhaul be completed when the total equivalent starts (ES) on the turbine reaches 400 for units operating in a cyclic duty or peaking application. The Holyrood CT has operated more than initially expected in 2015 and 2016, and it is anticipated that the Holyrood CT will reach this milestone requiring the inspection and overhaul by February 2017. It was originally anticipated that the unit would not reach this level of operation until the spring of 2018.

The project scope of work includes the following:

1. Removal of the turbine combustion section access covers and inspection of the combustor components for damage;
2. Removal and installation of replacement combustor baskets, combustor transition cylinders, fuel nozzles, and replacement of the row 1 turbine blade vane segments, as required; and
3. Completion of OEM recommended modifications to the turbine exhaust bearing venting system.

This project is necessary to maintain reliable operation of the Holyrood CT plant.

The budget estimate for this project is $4,738,300. The project is expected to be completed over the period October 1, 2016 to December 31, 2016, with the unit being returned to service at the end of November and the project close-out tasks taking place in December.

TABLE OF CONTENTS

1 INTRODUCTION

The Holyrood CT, located at the Holyrood Generating Station, is a 123.5 MW gas turbine generating unit that was constructed in 2014, commissioned in early 2015, and placed in service in February 2015. It provides electricity to the Island Interconnected System. Figure 1 is a diagram of the Provincial generation and transmission grid showing the location of the Holyrood Generating Station site.

Figure 1: Provincial Generation and Transmission Grid

The Holyrood CT provides several critical functions in reliably supplying customer demand requirements. It is operated to support spinning reserves on the Island Interconnected System and provides a critical backup in the event of a contingency, such as the loss of a major generating unit or the loss of a major transmission line. The Holyrood CT, due to its strategic location, also provides power to the Avalon Peninsula which is heavily reliant on the transfer of power over transmission lines from outside of the Avalon Peninsula and the production of power from the Holyrood Thermal Generating Station (HTGS). In addition, it is used to facilitate planned generation and Avalon Peninsula transmission outages.

Figure 2 is an image of the Holyrood CT plant.

Figure 2: Holyrood Combustion Turbine Plant

Figure 3 is an image of the combustion turbine at the Holyrood combustion turbine plant.

Figure 3: Holyrood Siemens Combustion Turbine

2 BACKGROUND

The internal components of a gas turbine wear differently when comparing a continuous duty application to a cyclic duty application where there are more frequent starts and stops. Thermal fatigue is the primary contributor to loss of life for peaking or cyclic loaded machines, whereas creep, oxidation, and corrosion are the contributors to loss of life for continuous duty or base loaded machines. For that reason, Siemens, the original equipment manufacturer (OEM), has developed maintenance schedules for this unit based on the number of ES or equivalent base hours (EBH) of operation, which is further detailed in Appendix A. Total ES takes into account the effects of cyclic thermal stresses caused by starts, unit trips, and load changes during operation and is a function of successful starts, fired aborts, unit trips while under load, and instantaneous load changes for a given type of fuel. Thus, the number of equivalent starts will be more than the number of actual starts.

Refer to Appendix A for further information related to the calculation of equivalent starts. Total EBH considers the effects of run time and temperature during operation and is a function of running hours for a given type of fuel. For this model of combustion turbine, operating on distillate fuel, Siemens recommends that an inspection and overhaul of the combustion section be completed when one of the following criteria is met:

1. Total Equivalent Starts = 400; or
2. Total Equivalent Base Hours = 8000.

Based on the initial anticipated operation of the Holyrood CT, a maintenance strategy was developed based on CT unit achieving the specified number of equivalent starts rather than equivalent hours due to the cyclic nature of its operation, primarily in a peaking role.

2.1 Asset Management Strategy

The asset management strategy for the Holyrood combustion turbine is based on the recommendations of the OEM and includes four distinct points of intervention based on achieving either the number of ES or the number of EBH specified. These four interventions include:

1. When the unit operation has reached 100 ES or 2000 EBH, a combustor minor, a preventative maintenance inspection performed using a borescope, is recommended. This inspection primarily consists of non-intrusive visual inspections and tests, but does not normally include turbine component replacement. This inspection was completed in 2016 with findings within the limits for the operation of the unit. Based on the current forecast operation of the unit, it is expected that this inspection will be performed annually.

2. When the unit operation has reached 400 ES or 8000 EBH, a combustor CI is recommended. This preventative maintenance intervention consists of the removal of all combustor and turbine end components that are accessible

without removing the turbine covers. The fuel nozzles, support housings, baskets, transitions and seals are replaced.

3. When the unit operation has reached 800 ES or 24000 EBH, a hot gas path inspection is recommended. This preventative maintenance intervention consists of the work scope included in the combustor inspection major as well as an inspection of the turbine rows 1-4 blades, vanes and ring segments with replacement as required. This scope of work is focused on the most highly stressed section of the CT's turbine section.

4. When the unit operation has reached 1600 ES or 48,000 EBH, a major inspection is recommended. This preventative maintenance intervention consists of the work scopes included in the CI major and the hot gas path inspection, as well as the inspection of the compressor vanes, blades and seals with replacement as required. This scope of work is focused on the parts replacement required for recovery of optimum unit performance.

Table 1: OEM Recommended Inspection Intervals

Total Equivalent Starts (ES)	**Inspection Type Recommended**
100	Combustor Minor
400	Combustor Major
800	Hot Gas Path
1200	Combustor Major
1600	Major

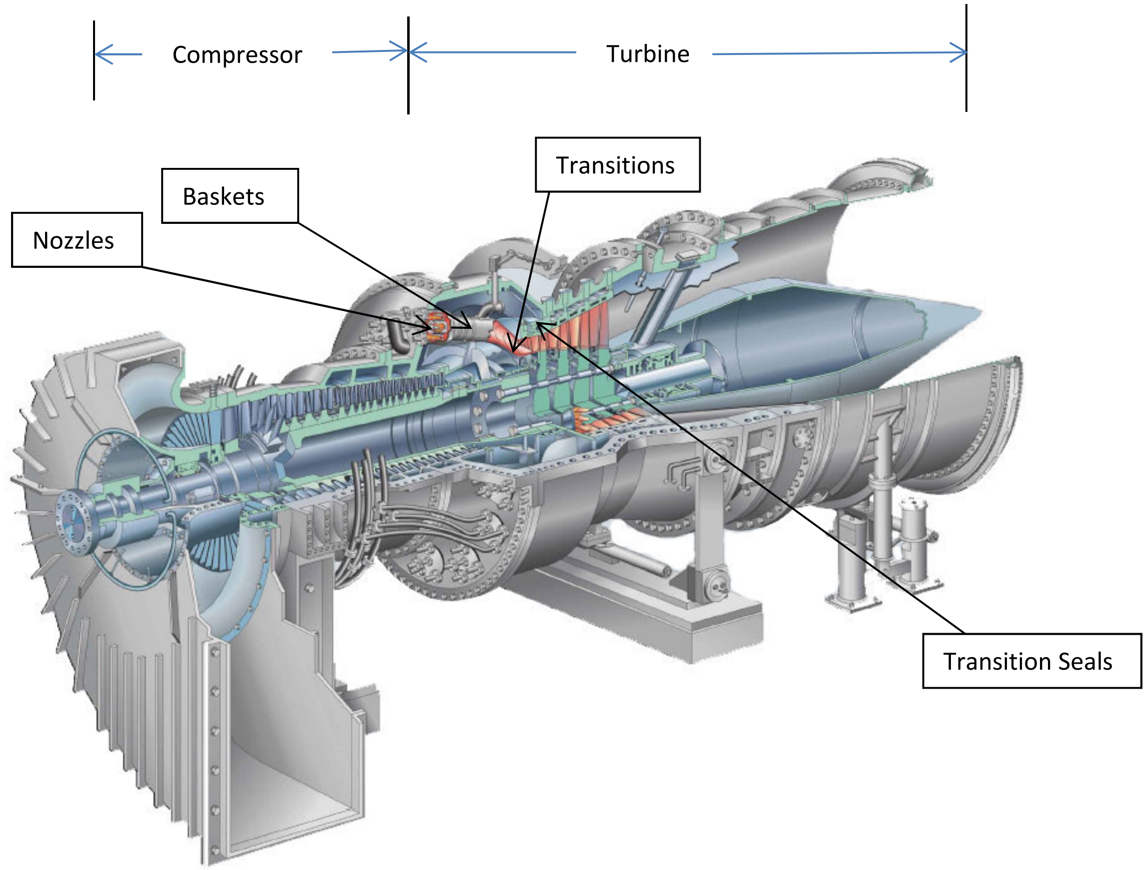

Figure 4: Cutaway view of the Siemens W501D5A combustion turbine

These interventions comprise a complete inspection and maintenance cycle for the combustion turbine and are summarized in Table 1 below. These interventions are required to be repeated at the specified intervals over the life of the unit. Based on the current operating forecast for the Holyrood CT, it is expected that the next intervention, a turbine hot gas path inspection, will be required to be completed in the fall of 2019.

2.2 Asset Maintenance Timing

Prior to the Holyrood CT being placed in service in winter 2015, a forecast was prepared for the operation of the CTs on the Island Interconnected System. The forecast requirements for the CTs were determined based on average forced outage rates of 10% for the Holyrood thermal units and 1% for Hydro's hydraulic units, and in consideration of the peak load forecast and Hydro's typical load duration curve.

In developing forecast operating requirements for the CTs, Hydro determined the expected number of operating hours required and the level of production. The total energy was then allocated to each of the required units on a prorated basis based on the generator maximum continuous rating.

Hydro's forecast for combustion turbine production also assumed that each plant would be exercised at rated output for one hour per month during the non-winter period for testing and for ensuring availability. These units were assumed to be exercised for four hours during each winter month (approximately once per week) for winter readiness and storm preparedness[1].

Although the expected energy production and an estimate of the number of annual operating hours required for peaking (using an assumption for average loading) is able to be provided using this methodology, the expected number of actual starts cannot be readily determined. To estimate the expected number of actual starts, the average operating hours per start for peaking operation was assumed to be four, excluding the hours for testing purposes.

The initial forecasted annual operation requirements of the Holyrood CT, as determined during the fall of 2014, are summarized in Table 2 below. This was based on anticipated annual peaking and testing requirements to the end of 2017.

[1] Reference Hydro's 2013 Amended GRA filing, Regulated Activities, Section 2.6.1, pages 2.77 – 2.78

Table 2: Initial Holyrood CT Forecasted Operating Requirements 2015 - 2017

Year	Hours	Equivalent Hours (EBH)	Actual Starts	Equivalent Starts (ES)
2015	184	239.2	64	83.2
2016	294	382.2	92.5	118.9
2017	444	577.2	129	167.7

Based on this initial forecasted operation of the Holyrood CT from its in service date to the end of 2017, it was originally anticipated that the Holyrood CT would accumulate an average of approximately 100 ES per year and require a CI and overhaul in the spring of 2018. As such, this was the planned first major inspection date. The actual operating requirements and the resultant equivalent starts and hours are presented in Table 3 below.

Table 3: Actual Holyrood CT Operating Requirements 2015 – June 2016

Year	Actual Hours	Equivalent Hours (EBH)	Actual Starts	Equivalent Starts (ES)
2015	823	1069.9	115	250.9
2016 (to June 30)	1494	1942.2	43	65

2.3 Increase in Equivalent Starts Compared to Initial Forecasted Estimate

After the March 4, 2015 power outage event, Hydro implemented practices and strategies which impacted the utilization of standby generation on the Island Interconnected System, especially on the Avalon Peninsula. Specifically, Hydro commenced the practice of operating standby generating units that support the Avalon in advance of Avalon transmission or generation contingencies, rather than starting them after the event has occurred[2]. This practice, in an effort to positively impact system reliability, began in late March 2015.[3]

[2] Consistent with the recommendations of Liberty Consulting in the Review of the March 4, 2015 Voltage Collapse, page 7: "Liberty continues to believe that Hydro should be significantly enhancing its capabilities to plan and manage reliability contingencies."
[3] Hydro previously advised the Board of this in Response A9 of its May 15, 2015 submission to the Board answering the questions of their April 21, 2015 letter related to the March 4 events.

An example of this was the total plant outage at the Holyrood Thermal Generating Station in August 2015, which was required to complete common plant equipment maintenance. Hydro operated the Holyrood CT at minimum output levels for the peak periods of the day to support the Avalon transmission and provide enhanced system reliability. The duration of the total plant outage was 18 days during which the Holyrood CT was operated almost daily, thus accumulating 18 actual starts.

In November 2015, TL201 was taken out of service for planned maintenance. During the outage to TL201, the Holyrood CT was operated daily to reduce the load on TL217, the line which remained in service to guard against another Avalon contingency.

In January and February of 2016, reheater tube failures on Units 1 and 2 at the HTGS resulted in the requirement to further operate the Holyrood CT to replace the generation normally provided by these units, one of its intended purposes, in support of Island generation and Avalon reserves. The Holyrood CT operated 608 hours in January and 632 hours in February to facilitate the outages required to repair HTGS Units 1 and 2 and return them to service. As the Holyrood CT operated almost continuously during the period January 6 to February 27, 2016, this operation did not contribute directly to the requirement to advance the planned maintenance intervention. However, the resulting de-rating of both HTGS Units 1 and 2 to 120 MW from 170 MW resulted in a loss of 100 MW of generating capability on the system. This resulted in continued requirement for operation of the gas turbines through daily peak demand periods in order to support Island and Avalon reserves. The Holyrood CT, being the largest of the gas turbines, was utilized more often due to system requirements resulting from the significant loss of thermal generation.

Up to the end of 2015, the Holyrood CT had actually operated 788 hours and accumulated 94 actual starts over ten months of service, post commissioning. During the period January 1 to June 30, 2016, the Holyrood CT accumulated an additional 43 actual starts and 1494 operating hours.

The monthly ES data from January 2015 to June 2016 is presented in Table 4 below. The equivalent starts accumulated in January and February 2015 were almost exclusively incurred during commissioning.

Table 4: Holyrood CT ES[4] and EBH by Month

Month	ES	EBH
January 2015	24.7	13
February	15.6	46.8
March	44.2	239.2
April	24.7	65
May	26	33.8
June	11.7	7.8
July	3.9	2.6
August	39	254.8
September	6.5	66.3
October	2.6	18.2
November	28.6	250.9
December	23.4	189.8
January 2016	3.9	791.7
February	2.6	825.5
March	28.6	140.4
April	23.4	174.2
May	5.2	22.1
June	1.3	2.6
Total	**315.9**	**3144.7**

Hydro's current operating forecast for the Holyrood CT from July 2016 to April 2017 is presented in Table 5 below. This data is based on required operating hours and does not include any estimate of equivalent starts resulting from unit trips, load changes, etc.

[4] Refer to Appendix A for equivalent starts ES calculations.

Table 5: Holyrood CT Operating Forecast July 2016 - April 2017

Month	ES	EBH
July 2016	2.6	2.6
August	2.6	2.6
September	2.6	2.6
October	2.6	2.6
November	7.8	9.1
December	16.6	27.3
January 2017	31.1	122.2
February	27	79.3
March	21.6	65
April	10.9	41.6
Total	**125.5**	**354.9**

The total EBH from Tables 4 and 5 is 3499.68 as compared to a total EBH of 8000 when an overhaul is recommended by Siemens. However, the total ES from Tables 4 and 5 is 441.4 up to April 2017, which indicates that the Holyrood CT is expected to reach the specified number of equivalent starts recommended to perform a CI and overhaul in February 2017. Performing the work in February would not be acceptable since the Holyrood CT would be out of service during critical production time.

Hydro's forecast of equivalent starts and equivalent base hours of the Holyrood CT for the period 2017 to 2019 is provided in Table 6, below. This estimate is based on forecasted operational requirements only and does not include any allowances for failed starts, trips from load, etc. This also assumes that the HTGS, in combination with the standby units, will supplement hydro and purchases to meet customer load throughout the forecast period.

Table 6: Holyrood CT Forecasted ES and EBH, 2017 to 2019

Year	Equivalent Starts	Equivalent Base Hours
2017	118.3	708.5
2018	130	533
2019	128.7	494
Total	**377**	**1735.5**

Based on the current forecast, the next major maintenance intervention (Hot Gas Path) is expected to occur in the fall of 2019, when the Holyrood CT is expected to have accumulated a further 377 equivalent starts.

3 PROJECT DESCRIPTION

This project includes a CI and overhaul on the Siemens W501D5A engine located at Holyrood. The CI involves the removal of all combustor and turbine end components that are accessible without removing the turbine covers. These parts will then be cleaned, inspected, and replaced, where necessary. Components that are not removable without removing the turbine covers will be inspected in place. The project will include the following scope of work:

1. Removal and replacement of the combustor components including:
    a. combustor transition sections;
    b. combustor baskets;
    c. combustor transition cylinders and V-band clamps; and
    d. fuel nozzles.
2. Removal of the row 1 vane segments, inspect the row 1 turbine blades, and replacement of row 1 vane segments, as required; and
3. OEM recommended modification of the exhaust bearing vacuum line and replacement of the orifice in the bearing lube oil supply line.

The OEM has recommended modifications to the turbine exhaust bearing lube oil system to enhance the operation of this system based on operating experience with the type of bearing which is installed on this unit, which are able to be completed during the required outage. The outage required to complete this work is expected to be of two weeks duration.

4 JUSTIFICATION

The availability and reliability of the Holyrood CT plant is critical for the generation support of the Island Interconnected and Avalon Systems.

4.1 Existing System

The major components of the Holyrood CT plant include the gas turbine engine, generator, starting package, air intake structure, exhaust stack, as well as auxiliary systems such as lube oil, fuel, compressed air, electrical, water treatment, and controls. Structures such as buildings and equipment enclosures comprise the balance of plant that make up the facility.

The Holyrood CT consists of a Siemens W501D5A engine that is directly coupled to a Siemens SGEN-100A-2P generator. It has a starting package that is coupled to the other end of the generator rotor. The starting package includes a 2050 HP motor and a clutch. During the initial start-up, the starting package accelerates the generator and turbine rotors up to approximately 50% of its rotating speed. At that point, the clutch disengages the starting package and ignition occurs in the combustion section of the Holyrood CT. The Holyrood CT uses a combination of No. 2 light fuel oil, compressed air, and ambient combustion air to produce hot gases that are fed into the turbine, causing it to rotate. Demineralized water is also injected into the combustion section of the turbine in order to reduce NO_X emissions during operation.

There has been no major work or upgrades to the Holyrood CT since being placed service in February 2015 and it has been a reliable addition to Hydro's generation fleet.

4.2 Operating Experience

The Holyrood CT has been in service since late February 2015 providing critical generation support to the Island Interconnected System and to the Avalon Peninsula. The table below provides the operating history of the Holyrood CT from March 1, 2015 to June 30, 2016.

Table 7: Holyrood CT Operating Hours and Actual Starts 2015 and 2016

Year	Total Operating Hours	Total Actual Starts
2015 (March 1 to December 31)	788	94
2016 (to June 30)	1494	43

4.2.1 Reliability Performance

This project is necessary to maintain the generating equipment in its optimal operating condition for Hydro to provide safe, least-cost, reliable electrical service to its customers.

4.2.1.1 Outage Statistics

Table 8 below lists the 2015 to 2016 average capability factor, utilization forced outage probability (UFOP) and failure rate for the Holyrood CT compared to all of Hydro's gas turbine units (2011 to 2015) and the latest Canadian Electrical Association (CEA) average (2010 to 2014).

Table 8: Holyrood CT One Year Average (2015-2016) All Causes

Unit	Capability Factor (%)[5]	UFOP (%)[6]	Failure Rate[7]
Holyrood CT (2015/2016)*	96.21	2.49	19.21
CEA (2010-2014)	84.16	9.52	66.60
* From March 1, 2015 to May 31, 2016			

[5] Capability Factor is defined as unit available time. It is the ratio of the unit's available time to the total number of unit hours.

[6] UFOP is defined as the Utilization Forced Outage Probability. It is the probability that a generation unit will not be available when required. It is used to measure performance of standby units with low operating time such as gas turbines.

[7] Failure Rate is defined as the rate at which the generating unit encounters a forced outage. It is calculated by dividing the number of transitions from an operating state to a forced outage by the total operating time.

4.2.2 Legislative or Regulatory Requirements

There are no legislative or regulatory requirements associated with this project.

4.2.3 Safety Performance

An in service failure of the unit due to not completing the combustor inspection and overhaul within the recommended timeline is not expected to create a safety hazard for Hydro employees.

4.2.4 Environmental Performance

This project does not impact environmental performance.

4.2.5 Industry Experience

Siemens has indicated that the majority of utilities that are operating this type of CT have adopted the recommended maintenance strategy based on total ES and EBH criteria outlined above in Section 2 – Background.

4.2.6 Vendor Recommendations

Siemens recommends that a CI and overhaul be completed when the total ES on the combustion turbine reaches 400. The Holyrood CT is expected to reach this critical milestone by February 2017.

4.2.7 Maintenance or Support Arrangements

Normal routine maintenance work is performed by Hydro personnel. In addition, contracted resources are used to perform specialty work and services such as maintenance of the fire protection systems, HVAC systems, etc.

4.2.8 Historical Information

The Holyrood CT plant has been in service for approximately 18 months providing critical generation capability to the Island Interconnected System and in support of transmission and generation on the Avalon Peninsula.

4.2.9 Anticipated Useful Life

A gas turbine system has an anticipated service life of 35 years. This assumes that routine maintenance and overhauls are completed in accordance with OEM recommendations.

4.3 Forecast Customer Growth

Forecasted customer growth is not applicable to this project.

4.4 Development of Alternatives

The following alternatives were considered related to the proposed project.

1. Continue to operate the Holyrood CT until the end of the 2016/2017 winter period and perform the combustor inspection and overhaul in the spring of 2017;
2. Continue to operate the Holyrood CT until it has accumulated 400 equivalent starts, as recommended by the OEM and perform the combustor inspection and overhaul at that time; and
3. Perform the combustor inspection and overhaul prior to the winter of 2016/2017.

4.5 Evaluation of Alternatives

<u>Alternative 1</u>

Continuing to operate the Holyrood CT until the end of the winter 2016/2017 operating period is expected to result in operation past the recommended maintenance interval for this unit by approximately 10%, thus imposing a risk on the CT's reliability including the risk of an in service failure. With little operating history, a complete combustor inspection is required to establish the patterns of wear and gather important information related to future operation of the unit. Operating the Holyrood CT past the OEM-recommended maintenance interval without this information is not recommended. Hydro does not propose this alternative as an appropriate course of action.

Alternative 2

Continuing to operate the Holyrood CT until it has accumulated 400 equivalent starts is expected to result in a requirement to perform this work during the peak winter operating period. Currently, the unit is expected to reach this milestone in February 2017. An outage at this time of year would remove this unit from the system and from its role in supporting the system at a critical time of year. Hydro does not propose this alternative as an appropriate course of action.

Alternative 3

Completing the CI and overhaul of the Holyrood CT prior to the winter operating season ensures a position of winter readiness and reduces the risk of a forced outage during the critical operation period.

Hydro proposes that Alternative 3 be approved, that the appropriate alternative is to complete the CI and overhaul of the Holyrood combustion turbine prior to winter 2016/2017.

4.5.1 Energy Efficiency Benefits

There are no energy efficiency benefits that can be attributed to this project.

4.5.2 Economic Analysis

An economic analysis was not performed in this instance as Hydro proposes the unit must have this work performed prior to the winter operating season.

5 CONCLUSION

This project is justified on the requirement to maintain the generating equipment in its optimal operating condition for Hydro to provide safe, least-cost, reliable electrical service to its customers. Siemens recommends that a CI and overhaul be completed on the Holyrood CT when the total equivalent starts reaches 400. Hydro expects that the Holyrood CT will reach this critical milestone in February 2017. The purpose of the CI and overhaul is to maintain the original design specifications so that the Holyrood CT can safely, efficiently, and reliably meet system demands until the next overhaul. It will also identify any unusual findings that, if not corrected, could lead to premature failure of the equipment. Siemens' recommended maintenance schedule for this unit, based on equivalent starts, involves maintenance interventions every 400 equivalent starts which vary in scope based on the expected service life of specific turbine and compressor components.

The Holyrood CT provides several critical functions in reliably supplying customer demand requirements. It is operated to support spinning reserves on the Island Interconnected System and provides a critical backup in the event of a contingency such as the loss of a major generating unit or the loss of a major transmission line. The Holyrood CT also provides power to the Avalon Peninsula which is heavily reliant on the transfer of power over transmission lines outside of the Avalon Peninsula, as well as the production of power from the Holyrood Thermal Generation Station. In addition, it is used to facilitate planned generation and Avalon Peninsula transmission outages.

5.1 Budget Estimate

The budget estimate for this project is shown in Table 9.

Table 9: Project Budget Estimate

Project Cost: *($ x1,000)*	**2017**	**2018**	**Beyond**	**Total**
Material Supply	0.0	0.0	0.0	0.0
Labour	242.3	0.0	0.0	242.3
Consultant	0.0	0.0	0.0	0.0
Contract Work	3,686.7	0.0	0.0	3,686.7
Other Direct Costs	0.0	0.0	0.0	0.0
Interest and Escalation	23.5	0.0	0.0	23.5
Contingency	785.8	0.0	0.0	785.8
TOTAL	**4,738.3**	**0.0**	**0.0**	**4,738.3**

The above budget is based on a budgetary estimate for Hydro personnel to perform a portion of the work, and there are tasks that must be completed by contractor personnel due to the highly specialized nature of the work.

5.2 Project Schedule

The anticipated project schedule is shown in Table 10. These are tentative dates and reflect an early approval by the Board of Commissioners of Public Utilities (the Board).

Table 10: Project Schedule

Activity		Start Date	End Date
Planning	Job set up	Upon approval	
Design	Contract preparation for CI and overhaul	Upon approval	
Procurement	Award of contract for CI and overhaul	October 2016	October 2016
Construction	CI and overhaul	November 2016	November 2016
Closeout	Project Closeout	December 2016	December 2016

Hydro recognizes that the schedule reflected above is aggressive. However, Hydro plans to complete this work and have the unit returned to service prior to December 1.

This work is being proposed as a supplement to the 2016 Capital Program to ensure that the unit is available and reliable for the 2016/17 winter operating season. Submitting this request as a part of the 2017 Capital Program would potentially result in this unit being unavailable for a part of the 2016/17 winter operating season.

APPENDIX A

Equivalent Starts Calculation

Calculation of Equivalent Starts

The effects of thermal stress caused by starts, trips, and load changes are cumulative and are monitored using equivalent starts. The following equation is used in the calculation of equivalent starts. A sample calculation is provided below to illustrate the use of the equation based on operating data.

$ES = \Sigma(S * Sf*Ff) + \Sigma(A*Ff) + \Sigma(T*Tf*Ff) + \Sigma(I * Lf*Ff)$

Where:

ES = Equivalent Start

S = Successful Start

A = Fired Abort

T = Trip from load

I = Instantaneous Load Change

Sf = Start Factor – normal start = 1; Fast start = 10

Tf = Trip Factor – based on load change % of base load

Lf = Load Change Factor – based on load change % of base load

Ff = Fuel Factor = 1.3 for distillate fuel

Definitions:

1. Fired Abort – A fired abort is a start attempt that aborts or is aborted after combustion ignition has occurred, but shuts down before reaching breaker closure.

2. Trip from load – A trip from load occurs if the unit is shutdown after breaker closure AND the normal shutdown full speed no load (FSNL) cool down sequence is not performed. This is a shutdown that does not follow the normal shut down sequence including but not limited to the specified FSNL cool down sequence.

3. Instantaneous Load Change – Instantaneous load change occurs when a unit abruptly increases or decreases load at a rate greater than the <u>specified ramp rate.</u>

Sample Equivalent Starts Calculation

Following is a example of an equivalent starts calculation for a period of operation in which the events listed below occurred.

10 successful starts – normal start

2 fired aborts

1 trip from load at 40MW

1 instantaneous load change from 80MW to full speed no load (FSNL)

ES = Σ(S * Sf*Ff) + Σ(A*Ff) + Σ(T*Tf*Ff) + Σ(I * Lf*Ff)

ES = (10*1.0*1.3) + (2*1.3) + (1*7.0*1.3) + (1*4.0*1.3)

= 13 + 2.6 + 9.1 + 5.2

= 29.9 ES

So, in a month where there were 10 actual starts, the unit would accumulate 29.9 equivalent starts based on the operating data used. A fuel factor of 1.3 is applied based on the use of diesel fuel.