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

January 31, 2019

The 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 Corporate Services & Board Secretary

Dear Ms. Blundon:

Re: **Newfoundland and Labrador Hydro - The Board's Investigation and Hearing into Supply Issues and Power Outages on the Island Interconnected System – Rolling 12 Month Performance of Hydro's Generating Units**

In accordance with item 2.8 of the Liberty Report Recommendations dated December 17, 2014, please find attached one (1) original plus twelve (12) copies of the quarterly *Rolling 12 Month Performance of Hydro's Generating Units report* (the "Report").

On November 16, 2018 Hydro filed the Reliability and Resource Adequacy Study with the Board of Commissioners of Public Utilities ("Board"). The Reliability and Resource Adequacy Study included Hydro's proposed planning assumptions for consultation and discussion with the Board and other stakeholders. For the enclosed report, which covers the performance of Hydro's generating units for the quarter ending December 31, 2018, the assumptions that were reported in the previous 2018 quarterly reports have been maintained for clarity prior to the transition to the new assumptions. Future quarterly reports will utilize the planning assumptions included within the Reliability and Resource Adequacy Study.

We trust the foregoing is satisfactory. If you have any questions or comments, please contact the undersigned.

Yours truly,

NEWFOUNDLAND AND LABRADOR HYDRO

Shirley A. Walsh
Senior Legal Counsel – Regulatory
SAW/kd

cc: Gerard Hayes – Newfoundland Power
Paul Coxworthy – Stewart McKelvey
Danny Dumaresque
Dennis Browne, Q.C. – Browne, Fitzgerald, Morgan & Avis
Dean Porter – Poole Althouse

ecc: Dennis Fleming – Cox & Palmer
Roberta Frampton Benefiel – Grand Riverkeeper Labrador
Larry Bartlett – Teck Resources Limited

Quarterly Report on Performance of Generating Units

For the Quarter ended December 31, 2018

January 31, 2019

A Report to the Board of Commissioners of Public Utilities

newfoundland labrador hydro
a nalcor energy company

Table of Contents

1.0 Introduction

In this report, Newfoundland and Labrador Hydro ("Hydro") provides data on forced outage rates of its generating facilities. The data provided pertains to historical forced outage rates, and assumptions used by Hydro in its assessments of resource adequacy. On November 16, 2018 Hydro filed its Reliability and Resource Adequacy Study with the Board of Commissioners of Public Utilities ("Board"). The Study included Hydro's proposed planning assumptions for further discussion with the Board and intervenors. This quarterly report covers the performance of Hydro's generating units for the quarter ending December 31, 2018. The assumptions used throughout are the same as reported in the previous 2018 quarterly reports except where new assumptions are included and identified in Table 12. The continued use of the assumptions and style used in previous reports is to ensure clarity prior to the transition to the new assumptions. Future quarterly reports will utilize the planning assumptions included within the Reliability and Resource Adequacy Study.

The report contains forced outage rates for the current 12-month reporting period of January 1, 2018 to December 31, 2018 for individual generating units at hydraulic facilities, the Holyrood Thermal Generating Station, and Hydro's gas turbines. The report also provides, for comparison purposes, the individual generating unit data on forced outage rates for the previous period January 1, 2017 to December 31, 2017. Further, total asset class data is presented based on a calendar year for the years 2006-2016.

The forced outage rates of Hydro's generating units are calculated using three measures: Derated Adjusted Forced Outage Rate ("DAFOR") for the hydraulic and thermal units; and Utilization Forced Outage Probability ("UFOP") and Derated Adjusted Utilization Forced Outage Probability ("DAUFOP") for the gas turbines.

DAFOR is a metric that measures the percentage of the time that a unit or group of units is unable to generate at its maximum continuous rating due to forced outages. The DAFOR for each unit is weighted to reflect differences in generating unit sizes in order to provide a company total and reflect the relative impact a unit's performance has on overall generating

performance. This measure is applied to hydraulic and thermal units; however, it is not applicable to gas turbines because of their operation as standby units, and their relatively low operating hours.

UFOP and DAUFOP are measures used for gas turbines. UFOP measures the percentage of time that a unit or group of units will encounter a forced outage and not be available when required. DAUFOP is a metric that measures the percentage of time that a unit or group of units will encounter a forced outage and not be available when required, but this metric includes the impact of unit deratings.

The forced outage rates include outages that remove a unit from service completely, as well as instances when units are derated. If a unit's output is reduced by more than 2%, the unit is considered derated under Canadian Electricity Association ("CEA") guidelines. CEA guidelines state to calculate derated levels of a generating unit a by converting the operating time at the derated level into an equivalent outage time.

In addition to forced outage rates, this report provides details for those outages that contributed materially to forced outage rates exceeding those used in Hydro's generation planning analysis for both the near and long term.

Note that the data for 2006 to 2016 in Figures 1 through 7 are annual numbers (January 1 to December 31), while the data for 2017 and 2018 are 12-month rolling numbers (January 1 to December 31 for each year).

As part of its Reliability and Resource Adequacy Study, filed with the Board on November 16, 2018, Hydro detailed the process undertaken to determine the forced outage rates most appropriate for use in its near-term reliability assessments and long-term resource adequacy analysis. The revised forced outage rates, which were the outcome of this process, are included in Sections 8 and 9 of this report. The potential impacts of these revised forced outage rates on future performance reporting is also discussed.

2.0 Overview for Period Ending December 31, 2018

Table 1: DAFOR, UFOP, and DAUFOP Overview (%)

Class of Units	Jan 1, 2017 to Dec 31, 2017	Jan 1, 2018 to Dec 31, 2018	Base Planning Assumption	Near-term Planning Assumption[1]
Hydraulic (DAFOR)	2.29	0.21	0.90	2.60
Thermal (DAFOR)	14.91	28.97[2]	9.64	14.00
Gas Turbine (Combined) (UFOP)	6.93	3.62	10.62	20.00
Gas Turbine (Holyrood) (UFOP)	2.02	0.00	5.00	5.00
Gas Turbine (Hardwoods/ Stephenville) (DAUFOP)	19.72	21.67	-	30.00
Gas Turbine (Happy Valley) (DAUFOP)	22.18	2.11	-	15.00
Gas Turbine (Holyrood) (DAUFOP)	2.02	0.00	-	5.00

There was an improvement in hydraulic DAFOR and a decline in thermal DAFOR performance for the current 12-month period ending December 2018, compared to the previous 12-month period ending December 2017 (see Table 1). The combined[3] gas turbine UFOP performance shows an improvement in performance for the current period compared to the previous period, while DAUFOP shows a slight decline in performance.

[1] Near-term Generation Adequacy Report, November 15, 2017, see section 5.0 for further details.
[2] The thermal DAFOR is 12.74% with the air flow derating removed.
[3] Combined Gas Turbines include the Hardwoods, Happy Valley, and Stephenville units. The performance of the Holyrood unit was not included in the combined base planning or sensitivity numbers as these numbers were set prior to its in service date.

In the 10-year period prior to 2015, the hydraulic units showed a somewhat consistent DAFOR. The DAFOR of the current 12-month period compared to the previous 10 years is higher, primarily due to penstock issues experienced on Bay d'Espoir Units 1 and 2 in 2016 and 2017.

For the Holyrood thermal units, the forced outage rate of the current period ending December 2018 is 28.97%[4], which is above the base planning assumption of 9.64%, the sensitivity of 11.64% (refer to Section 3), and above the near-term planning assumption of 14.00%.[5] This is primarily caused by an air flow derating on Unit 1 and Unit 2 that continued in 2017 and 2018 and an extended forced outage on Unit 1 in February 2018.

The current Holyrood period DAFOR is not an indicator of what to expect for the 2018-2019 winter season due to the work that was completed to improve the unit's performance for air flow limitations. Unit 2 has been successfully tested to 175 MW,[6] and Unit 3 has been successfully tested to 150 MW. Unit 1 has been load tested to 162 MW. Following the load test in the fall of 2018, further investigation was completed on efforts required to reinstate the 8 MW. At this time, Hydro has not approved the project to proceed with reinstating the additional 8 MW. The time, cost, and potential risk to other parts of the generating system associated with suggested work are drivers for the decision not to proceed at this time.

Hydro's combined gas turbines' UFOP in the 10-year period prior to 2015 was generally consistent at approximately 10%, until the year 2012 when the rate exceeded 50%. Since 2012, the UFOP has been improving each year.

Hydro began reporting DAUFOP performance in January 2018, for which the first full 12-month period ending December 31, 2018 is included. For the current 12-month period, the combined

[4] The thermal DAFOR is 12.74% with the air flow derating removed.

[5] While the near-term planning assumption for thermal was materially exceeded in the preceding 12 month period, there were no supply issues experienced. Improved performance of the other assets contributed to this outcome. Further, the near-term planning assumption is a probabilistic view of system performance under various criteria.

[6] The unit has normally been considered capable of sustained running at 170 MW. Under the right conditions and with the boiler in very clean condition, it is able to go to 175 MW. However, at this maximum limit, the unit is unable to respond to load increases and as normal fouling from operation progresses, it might not be available. Therefore, this 5 MW is not part of the continuous rating and is not used for planning purposes, but would be used if available and required by the system.

gas turbines DAUFOP (Hardwoods and Stephenville units only) performance is primarily impacted by a lengthy forced outage to the Stephenville unit.

3.0 Generation Planning Assumptions

The Reliability and Resource Adequacy Study submitted to the Board in November 2018 introduced new generation planning assumptions; however, the assumptions used throughout this report are the same as reported in the previous 2018 quarterly reports. The potential impacts of these revised assumptions on reporting of generation unit performance are discussed in Section 9 of this report. The continued use of the assumptions and style used in previous reports is to ensure clarity prior to the transition to the new assumptions.

Hydro produced reports based on comprehensive reviews of energy supply for the Island Interconnected System ("IIS"). This is part of Hydro's analysis of energy supply up to the Muskrat Falls interconnection. The most recent Near-Term Generation Adequacy report, filed on May 22, 2018 contains analysis based on the near-term DAFOR and DAUFOP, and the resulting implication for meeting reliability criteria until the interconnection with the North American grid. The near-term analysis has been updated since that time to reflect changes in assumptions around the in-service of the Labrador-Island Link ("LIL"). The results of this analysis were presented to the Board as part of the LIL In-Service Update submitted October 1, 2018. This analysis will be updated accordingly if asset assumptions change materially.

Hydro's DAFOR and UFOP planning assumptions are provided in Table 2. The Holyrood gas turbine has a lower expected rate of unavailability than the older gas turbines, (5% compared to 10.62%), due to the fact that the unit is new and can be expected to have better availability than the older units.[7]

[7] Hydro selected a 5% UFOP for the new Holyrood GT following commentary on forced outage rates contained in the *Independent Supply Decision Review – Navigant (September 14, 2011).*

Table 2: 2017[8] DAFOR and UFOP Long Term Planning Assumptions

	DAFOR (%)		UFOP (%)	
	Base Planning Assumption	**Sensitivity**	**Base Planning Assumption**	**Sensitivity**
Hydraulic Units	0.90	0.90		
Thermal Units	9.64	11.64		
Gas Turbines - Existing			10.62	20.00
Gas Turbines - New			5.0	10.0

The DAFOR and DAUFOP assumptions used in developing Hydro's May 2018 Near-Term Generation Adequacy report are noted in Table 3.

Table 3: DAFOR and DAUFOP Near-Term Generation Adequacy Analysis Assumptions

	DAFOR (%) Near-Term Generation Adequacy Assumption	**DAUFOP (%) Near-Term Generation Adequacy Assumption**
All Hydraulic Units	2.6	
Bay d'Espoir Hydraulic Units	3.9	
Other Hydraulic Units	0.7	
Holyrood Plant	14.0	
Hardwoods & Stephenville Gas Turbines		30.0
Happy Valley Gas Turbine		15.0
Holyrood Gas Turbine		5.0

4.0 Hydraulic Unit DAFOR Performance

Detailed results for the 12-month period ending December 31, 2018, are presented in Table 4, as well as the data for the 12-month period ending December 31, 2017. These are compared to Hydro's short term generation adequacy assumptions, as used in the May 2018 Near-Term Generation Adequacy report, and Hydro's long-term generation planning assumptions for the forced outage rate.

[8] Near-term Generation Adequacy Report, November 15, 2017, see section 5.0 for further details.

Table 4: Hydraulic Weighted DAFOR

Generating Unit	Maximum Continuous Unit Rating (MW)	12 months ending December 2017 (%)	12 months ending December 2018 (%)	Hydro Generation Base Planning Assumption (%)	Near-Term Planning Assumption (%)
All Hydraulic Units - weighted	954.4	2.29	0.21	0.90	2.60
Hydraulic Units					
Bay D'Espoir 1	76.5	9.33	0.07	0.90	3.90
Bay D'Espoir 2	76.5	14.11	0.64	0.90	3.90
Bay D'Espoir 3	76.5	0.03	0.00	0.90	3.90
Bay D'Espoir 4	76.5	0.27	0.15	0.90	3.90
Bay D'Espoir 5	76.5	0.00	0.00	0.90	3.90
Bay D'Espoir 6	76.5	1.48	0.54	0.90	3.90
Bay D'Espoir 7	154.4	1.80	0.00	0.90	3.90
Cat Arm 1	67	0.22	0.94	0.90	0.70
Cat Arm 2	67	0.09	0.00	0.90	0.70
Hinds Lake	75	0.89	0.07	0.90	0.70
Upper Salmon	84	0.81	0.15	0.90	0.70
Granite Canal	40	0.11	0.45	0.90	0.70
Paradise River	8	1.70	0.00	0.90	0.70

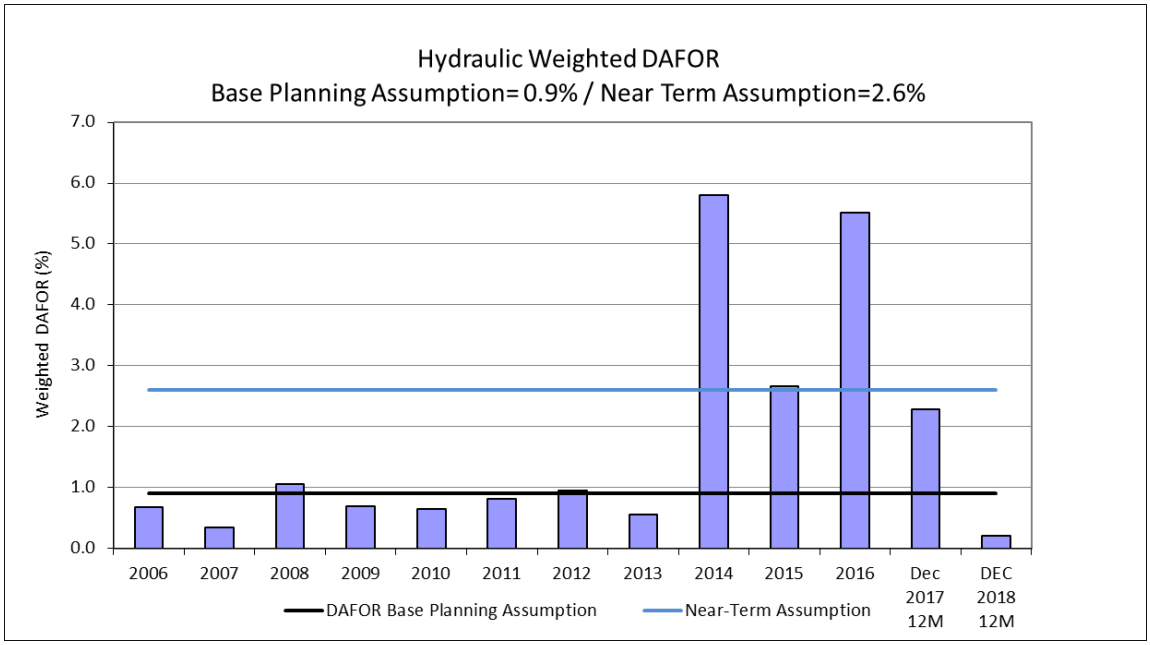

Figure 1: Hydraulic Weighted DAFOR

1 Considering the individual unit performance, the Hydro generation base planning DAFOR was
2 exceeded for Cat Arm Unit 1 for the current period.

The Cat Arm Unit 1 DAFOR of 0.94% exceeded the base planning assumption of 0.9% and the near-term assumption of 0.7% for an individual Cat Arm unit. This was due to a forced derating of Cat Arm Unit 1 from 67 MW to 57 MW for the period of July 5, 2018 to August 6, 2018 as a result of an issue with Needle #1 transducer feedback. This issue has since been resolved by replacement of the needle feedback transducer during the annual maintenance outage for the unit.

5.0 Thermal Unit DAFOR Performance

Detailed results for the 12-month period ending December 31, 2018, are presented in Table 5, as well as the data for the 12-month period ending December 31, 2017. These are compared to Hydro's short term generation adequacy assumptions, as used in the May 2018 Near-Term Generation Adequacy report, and Hydro's long-term generation planning assumptions for the forced outage rate.

Table 5: Thermal DAFOR

Generating Unit	Maximum Continuous Unit Rating (MW)	12 months ending December 2017 (%)	12 months ending December 2018 (%)	Hydro Generation Base Planning Assumption (%)	Near-Term Planning Assumption (%)
All Thermal Units - weighted	490	14.91	28.97	9.64	14.00
Thermal Units					
Holyrood 1	170	19.35	36.66	9.64	15.00
Holyrood 2	170	19.14	24.03	9.64	10.00
Holyrood 3	150	5.84	22.80	9.64	18.00

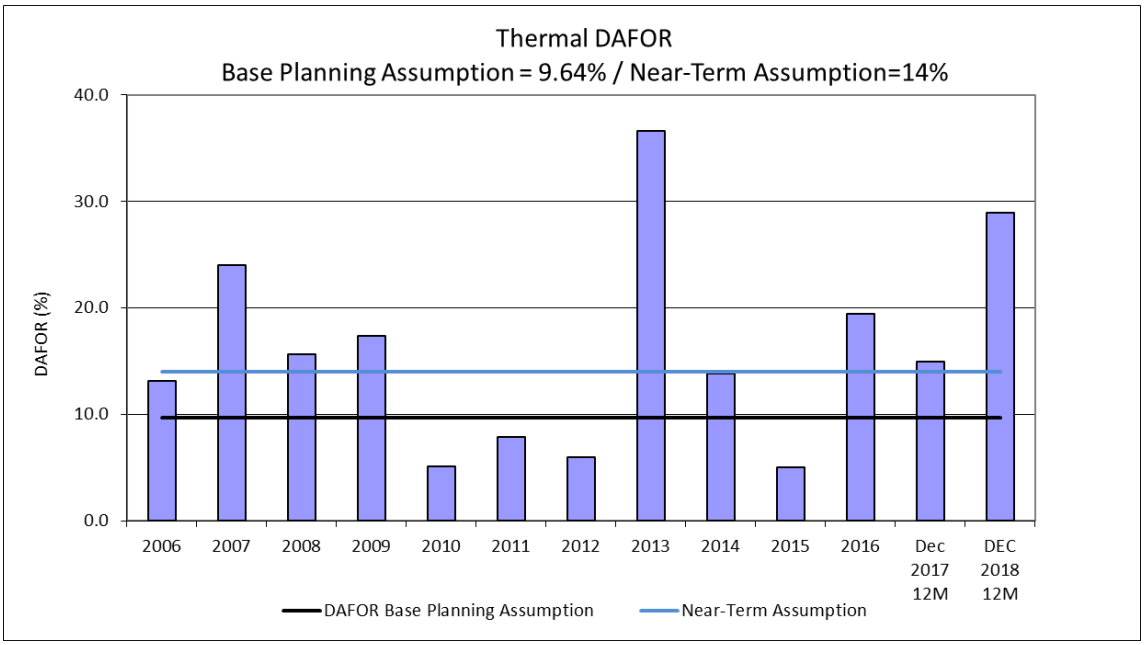

Figure 2: Thermal DAFOR

For the 12-month period ending December 31, 2018, the weighted DAFOR for all thermal units of 28.97%[9] is above the assumed Hydro generation base planning DAFOR value of 9.64%, and the near-term assumption of 14.00%. Unit 1 DAFOR was 36.66% and Unit 2 DAFOR was 24.03%. The performance for both Units 1 and 2 was above the base planning assumption of 9.64% and the near-term assumption of 15% (Unit 1) and 10% (Unit 2). Unit 3 DAFOR was 22.80%, which is above the base planning assumption of 9.64% and the near-term assumption of 18.0%.

The DAFOR performance for Holyrood Unit 1 (170 MW) was affected by the following events in the current 12 month to date period:

- The capability of the unit declined during the winter operating season due to ongoing fouling during operation. The capability was 150 MW at the beginning of the year. On January 3, 2018 the unit capability was reduced from 150 to 135 MW as a result of oscillations in the turbine control valve hydraulic ram. An outage was taken from January 5, 2018 to address the issue. After this work, the load was restored to 145 MW, limited by high furnace pressure, and it was noted that the control valve oscillations had not been eliminated. On January 18, 2018 the oscillations had increased and the load

[9] The thermal DAFOR is 12.74% with the air flow derating removed.

was reduced to 140 MW as a result. On January 20, 2018 the unit was taken off line to replace another control cable as recommended by General Electric to resolve the oscillation issue. While the unit was off line for this work, the boiler stop valve failed, which resulted in an extension to the outage. The unit remained off line until February 2, 2018 while stop valve refurbishment was ongoing. During this time, the hydraulic ram was removed from the turbine and sent off site for refurbishment to ensure that the oscillation problem had been resolved. Also a high pressure wash (12,500 psi) was completed on the air heater baskets.

- The outage due to the boiler stop valve failure extended from January 20, 2018 until February 21, 2018, following several solutions which attempted to address the leak. On February 21, 2018 the stop valve work was complete and the unit was returned to service.
- On February 22 the unit had to be taken off line due to a turbine bearing issue. Lube oil had leaked, undetected, from the bearing during the stop valve outage. This led to a smoldering underneath the bearing when the components heated up. The contaminated insulation was replaced and close inspection of the bearing confirmed no active leak. The unit was returned to service on February 25, 2018.
- On February 28 a load test was completed to 148 MW, with load limited by high furnace pressure due to boiler and air heater fouling. By the end of March 2018 the unit's capability had reduced to 137 MW as a result of continued fouling in the boiler and air heaters.
- There were two unit trips related to Forced Draft fan variable frequency drive ("VFD") trips. These occurred on March 19, 2018 and March 26, 2018. In both instances the unit was returned to service using replacement parts from inventory. During the outage related to the March 19, 2018 trip, a problem with the Mark V turbine governor system was also resolved. Hydro is continuing to work towards resolving the problems with VFD reliability.
- On April 12, 2018 the load was reduced to 126 MW, limited by high furnace pressure as a result of continued boiler and air heater fouling. The capability of the unit continued

to decline for the same reason. On May 6, 2018 the capability was 122 MW and on May 15, 2018 it was 116 MW.

- On May 21, 2018 the unit tripped at 70 MW on high boiler drum level. The cause was determined to be a failure of a turbine control valve stem. The valve stem was replaced during the planned 2018 turbine valve outage.
- On June 4, 2018 the unit was further de-rated to 100 MW, limited by high furnace pressure as a result of on-going boiler and air heater fouling. By the end of June 2018 this had further reduced to 88 MW.
- On June 16, 2018, while on a brief planned outage to change worn generator brushes, a pressure gauge failed on the fuel oil system resulting in a spill. This had to be cleaned up before the unit could be safely returned to service. On June 17, 2018 while starting up the unit, a bearing failed on the east forced draft fan and had to be replaced. The unit returned to service on June 18, 2018 but the same bearing failed after only a few hours of operation. The bearing was again replaced and the unit was successfully returned to service on June 19, 2018. A field representative from the fan's original equipment manufacturer travelled to site to assist with the failure analysis of these bearings. It was concluded that the bearing liner babbitted surface failed. Additional checks have been added to the Preventive Maintenance work for these bearings to prevent such a failure.
- The planned maintenance outage for Unit 1 started on July 27, 2018. Outage work included a chemical wash of the economizer, and replacement of the hot end air heater baskets to address air flow and furnace pressure load restrictions.
- The unit was returned to service following the annual outage on October 20, 2018, with a load restriction of 140 MW pending completion of on-line safety valve testing. After completion of the valve testing, the available load was confirmed to be 162 MW on December 6, 2018 and continued to year end. Boiler tuning was completed by a boiler tuning expert from December 17, 2018 to December 20, 2018. This improved the operation of the boiler, but did not increase the available load.
- On November 3, 2018, the unit tripped due to contamination in the turbine hydraulic system. A full overhaul was completed and the unit was returned to service on

November 24, 2018. The observations on Unit 1 triggered the same refurbishment of the Unit 2 turbine hydraulic system, which was completed in December 2018.

- On December 9, 2018, the unit tripped due to a failure of a potential transformer ("PT"), which led to the immediate failure of a second PT. The PTs were replaced with available spares. Electrical testing was completed on the remaining four PTs and the generator windings before returning the unit to service on December 14, 2018. No further issues were identified.

The DAFOR performance for Holyrood Unit 2 (170 MW) was primarily affected by the following events:

- The capability of the unit declined during the winter operating season due to ongoing fouling during operation. On January 4, 2018 the capability had reduced to 154 MW. On January 25, 2018 the capability had reduced to 135 MW due to high furnace pressure as a result of boiler and air heater fouling. On February 14, 2018 the capability had reduced to 117 MW. At the end of February 2018 the capability had reduced to 100 MW. System requirements, given the issues with Unit 1, had precluded an air heater wash on this unit during the month of February 2018. An air heater wash was completed from March 5, 2018 to March 6, 2018; however this was not successful in restoring any capacity. By the end of March 2018, the unit capability had reduced to 90 MW as a result of continued boiler and air heater fouling during operation.
- On February 7, 2018 the unit was taken off for a short, planned outage to replace generator brushes. There was a forced extension to this outage when a unit board breaker tripped during re-start of the unit. Electricians were called in to reset the breaker.
- The unit was further de-rated to 70 MW from March 1, 2018 to March 2, 2018 due to an issue with the west boiler feed pump. A water leak from a reference line nearby caused contamination of the pump lube oil and the pump was taken off line until the repairs were completed.
- On March 22, 2018, one of the turbine reheat intercept valves became stuck during regular on-line testing and the unit had to be taken off line for approximately eight

hours to replace the servos on these valves. To address this problem, the hydraulic fluid was replaced and the system flushed during the 2018 annual outage. Additional flushing and maintenance of the hydraulic system was completed in a maintenance outage in December 2018 based on observations and issues observed in Unit 1 in November 2018.

- At the beginning of April 2018 the unit was rated at 80 MW due to high furnace pressure as a result of boiler and air heater fouling. This capability further reduced to 70 MW on April 24, 2018 and remained at this level until the unit was taken off line for the annual outage.
- On April 3, 2018 the unit was taken off line on a forced outage to repair a leak in the turbine control valve hydraulic ram. The ram was rebuilt and the unit returned to service on April 4, 2018; however, once installed the seals required additional adjustment. The unit was returned to service April 5, 2018. Return to service after this outage was delayed by approximately eight hours on April 5, 2018 due to an issue in the switchyard. TRO replaced the B2T2 breaker during the 2018 annual outage, which resolved this issue.
- Unit 2 was available but not operating from April 26, 2018 to May 18, 2018, with the available load de-rated to 70 MW due to high furnace pressure as a result of boiler and air heater fouling. During this time the unit was kept in hot standby, maintaining an eight hour return to service time if recalled. On May 18, 2018 the unit was taken offline to address a suspected stress failure, not a thinning failure, of a tube in the lower water wall (not in the area of previous boiler tube issues). At the time of the failure, Hydro determined that the unit was no longer required for system reliability reasons prior to the scheduled planned outage and could be placed on planned outage in preparation for the annual overhaul.
- The tube leak was corrected during the overhaul. Two adjacent leaking tubes were found in the lower front wall. Through investigation and laboratory failure analysis it was determined that the original failure occurred at a butt welded joint in the tube, and that this weld was part of the original construction, and of relatively poor quality. Other welds in the area were inspected with no damage found. The leak had been present for an unknown period of time underneath the boiler casing and impinged upon the

adjacent tube, which also failed as a result. Several other tubes in the immediate area were corroded due to the presence of the leak, but had not failed. A total of seven tube sections were replaced.

- Also during the planned overhaul, work was completed to correct the air flow and furnace pressure issues in the boiler. A chemical wash of the economizer was completed and the hot end air heater baskets were replaced. The unit was returned to service on September 15, 2018 with the fuel additive system in service and it was immediately noted that the furnace pressure and air flow conditions had been greatly improved. Equipment issues related to start up caused a number of short forced outages and de-rates during the first few days of operation. On September 21, 2018, the unit was load tested to 140 MW, limited because the on-line safety valve testing had not been completed. However, it was clear from the boiler performance that full load should be achievable. This was later confirmed on October 11, 2018 when the unit was tested to 171 MW and was capable of more.
- On September 26, 2018 there was a boiler trip related to starting a boiler feed pump. The fan was in vane control and it was demonstrated that this trip would not occur in VFD air flow control. The fans were switched to VFD control mode, which ensures that the drives are more reliable, and that the savings on auxiliary power use can be realized.
- On October 16, 2018, there was a bypass of a power cell in one VFD drive, which caused a fan to trip resulting in a short derating to 70 MW until the fan could be restarted.

The DAFOR performance for Holyrood Unit 3 (150 MW) was primarily affected by the following events:

- The capability of the unit declined during the winter operating season due to ongoing fouling during operation. On December 31, 2017, the available load was 131 MW. On January 18, 2108 the available load was determined to be 120 MW, and on February 10, 2018, this had further reduced to 100 MW. An air heater wash outage was completed from February 10, 2018 to February 11, 2018. System requirements, with Unit 1 already off line, had precluded an air heater wash on this unit until that time. When the unit was returned to service there was a de-rating to 70 MW for approximately 10 hours when

the west boiler feed pump failed to start. This was resolved and the available load was determined to be 110 MW, still limited by air heater fouling. The unit was capable of 100 MW at the beginning of March 2018. This capability further reduced to 75 MW on March 20, 2018. An air heater wash outage was completed on March 28, 2018 and the predicted load after this wash was 110 MW. This unit was not required for the system, and was left on standby until the planned unit outage started on April 2, 2018.

- On January 11, 2018, a ¾" diameter domestic water pipe located above the Unit 3 exciter ruptured at a cap and the resulting water leak contacted the exciter causing a unit trip. There was no significant equipment damage resulting from this incident and once the exciter was safely dried, the unit was returned to service on January 12, 2018. This event was investigated and the leak repaired. A shut off valve was relocated for improved access in the event of a further trip, regular inspections of the area were implemented, and a plan was formulated to replace this piping during the annual outages. On February 14, 2018 the unit load was reduced to 50 MW for approximately eight hours as a precautionary measure because of another leak in a domestic water line in close proximity to the exciter. After this event, the piping was relocated so that further leaks would not impact the exciter.
- The annual outage was from April 2, 2018 until June 1, 2018. Air flow issues could not be corrected during the annual outage because of the long lead times for replacement air heater materials. The remainder of the planned work was completed, and a two week outage was planned for October 2018 to complete the air heater work required to restore load capability.
- The Unit 3 generator was put in service in synchronous condenser mode on June 1, 2018 and ran until September 24, 2018, when it was taken off line for a maintenance outage to replace some generator brushes. There was a problem with the drive controller that prevented re-start of the synchronous condenser. On September 28, 2018 the unit was placed on a maintenance outage to prepare for conversion to generation mode.
- The hot end air heater baskets were replaced during the outage in October 2018 to address the air flow restrictions on the unit. The unit returned to service on October 30, 2018, limited to 140 MW pending on-line testing of the safety valves, which was

completed on November 6, 2018. Full load capability to 150 MW was confirmed by load test on December 2, 2018, and available at 150 MW for the remainder of 2018.

- On November 13, 2018, the unit tripped due to an issue with the west boiler feed pump discharge valve. The unit was returned to service later that same day after troubleshooting.
- On November 15, 2018 the unit was taken off line on a forced outage to repair a water wall tube leak. The unit was returned to service on November 20, 2018.
- On December 3, 2018 the unit tripped when an operator changed control to a drum level transmitter that had a fault. Unit protection operated properly and the unit was returned to service within an hour.

6.0 Gas Turbine UFOP Performance

The combined UFOP for the Hardwoods, Happy Valley and Stephenville gas turbines was 3.62% for the 12-month period ending December 31, 2018 (see Table 6 and Figure 3). This is below the base planning assumption of 10.62%, and the near-term assumption of 20.00%. The current period UFOP is significantly better than the previous period UFOP of 6.93%. The Hardwoods UFOP for the current period is 4.80%, which is better than the base planning assumption of 10.62%. The Stephenville UFOP for the current period is 1.45%, which is better than the base planning assumption of 10.62%. The Happy Valley UFOP is 2.11% for the current period, which is below the base planning assumption of 10.62%.

Table 6: Gas Turbine UFOP

Gas Turbine Units	Maximum Continuous Unit Rating (MW)	12 months ending December 2017 (%)	12 months ending December 2018 (%)	Hydro Generation Base Planning Assumption (%)	Near-Term Planning Assumption (%)
Combined Gas Turbines	125	6.93	3.62	10.62	20.00
Stephenville	50	5.59	1.45	10.62	20.00
Hardwoods	50	2.91	4.80	10.62	20.00
Happy Valley	25	19.32	2.11	10.62	20.00

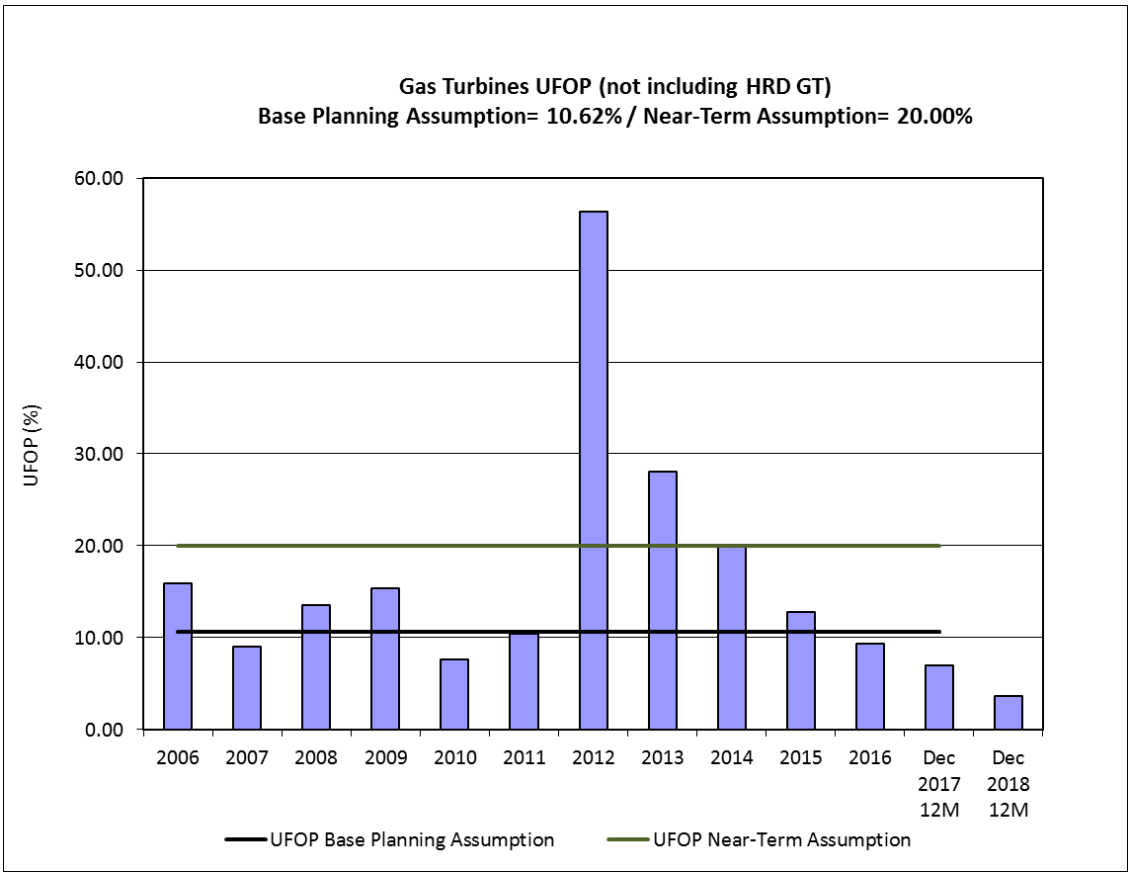

Figure 3: Gas Turbine UFOP – Hardwoods/Happy Valley/Stephenville Units

1 The Holyrood UFOP of 0.00% for the current period is better than the base and near-term
2 planning assumptions of 5.00% (see Table 7 and Figure 4).

Table 7: Holyrood GT UFOP

Gas Turbine Units	Maximum Continuous Unit Rating (MW)	12 months ending December 2017 (%)	12 months ending December 2018 (%)	Hydro Generation Base Planning Assumption (%)	Hydro Generation Near-Term Planning Assumption (%)
Holyrood GT	123.5	2.02	0.00	5.00	5.00

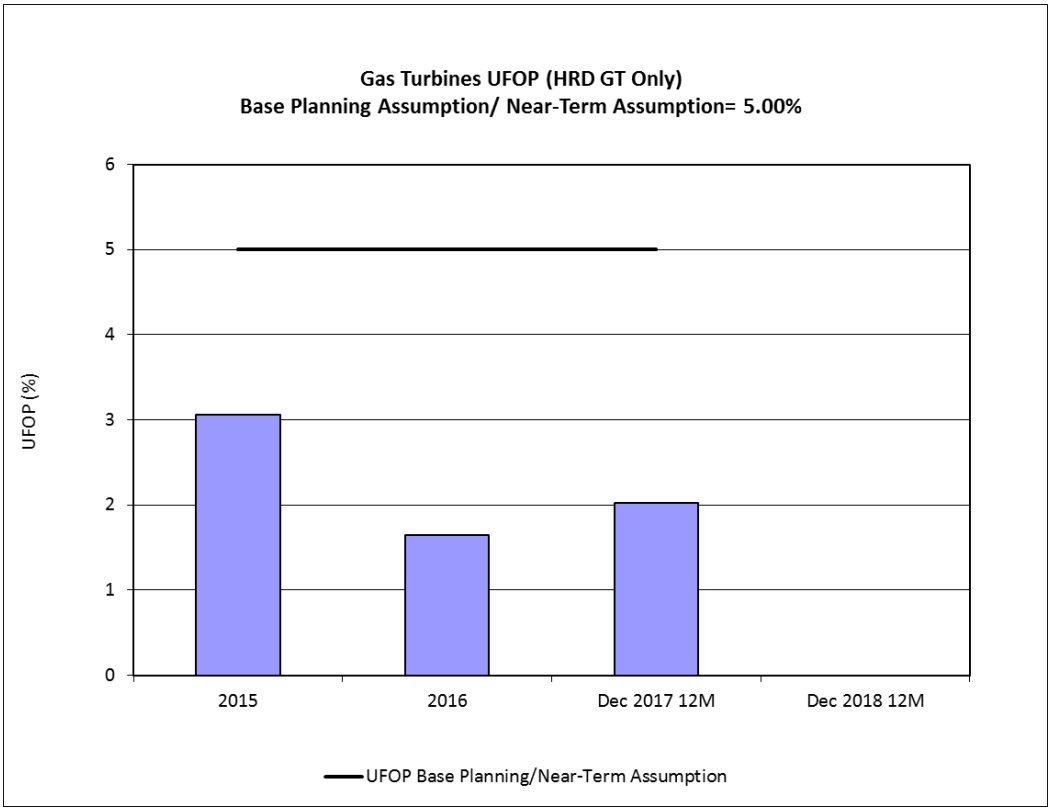

Figure 4: Gas Turbine UFOP – Holyrood Unit

7.0 Gas Turbine DAUFOP Performance

The combined DAUFOP for the Hardwoods and Stephenville gas turbines was 21.67% for the 12-month period ending December 31, 2018 (refer to Table 8 and Figure 5). This is below the near-term planning assumption of 30.00%. The Hardwoods DAUFOP for the current period is 8.28%, which is better than the near-term planning assumption of 30.00%. The Stephenville DAUFOP for the current period is 47.48%, which is above the near-term planning assumption of 30.00%.

Table 8: Hardwoods/Stephenville Gas Turbine DAUFOP

Gas Turbine Units	Maximum Continuous Unit Rating (MW)	12 months ending December 2017 (%)	12 months ending December 2018 (%)	Near-Term Planning Assumption (%)
Gas Turbines (HWD/SVL)	100	19.72	21.67	30.00
Stephenville	50	40.06	47.48	30.00
Hardwoods	50	10.86	8.28	30.00

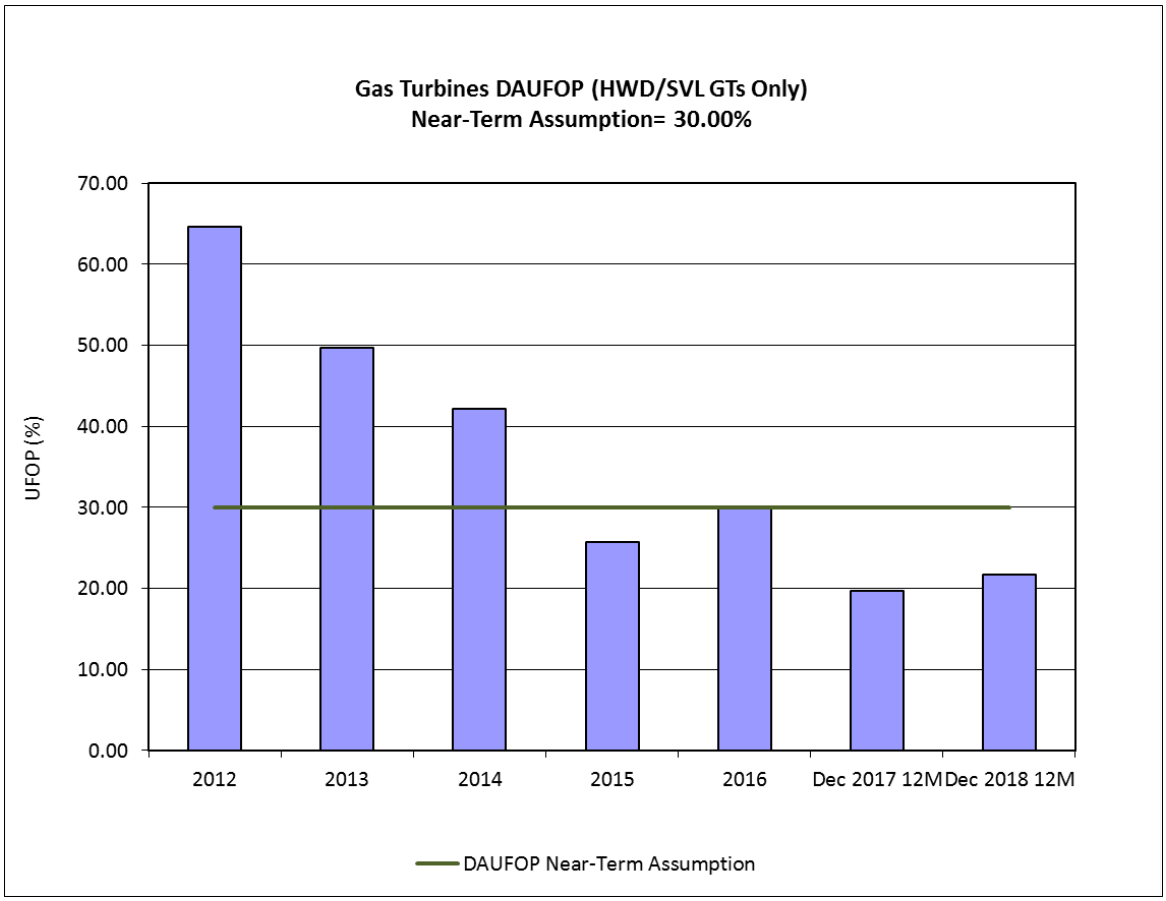

Figure 5: Gas Turbine DAUFOP – Hardwoods/Stephenville Units

The DAUFOP for the Happy Valley gas turbine was 2.11% for the 12-month period ending December 31, 2018 (refer to Table 9 and Figure 6). This is below the near-term planning assumption of 15.00%.

Table 9: Happy Valley Gas Turbine DAUFOP

Gas Turbine Units	Maximum Continuous Unit Rating (MW)	12 months ending December 2017 (%)	12 months ending December 2018 (%)	Near-Term Planning Assumption (%)
Happy Valley	25	22.18	2.11	15.00

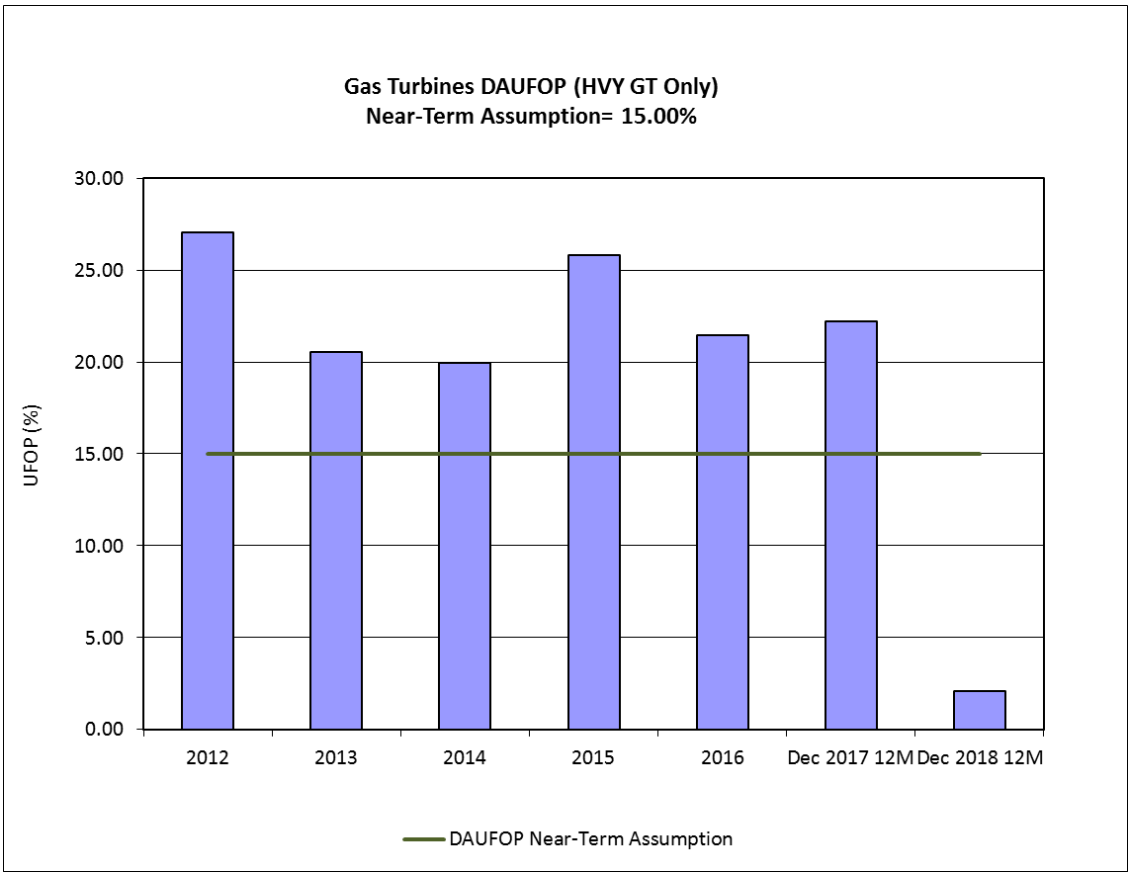

Figure 6: Gas Turbine DAUFOP – Happy Valley Unit

The Holyrood gas turbine DAUFOP of 0.00% for the current period is better than the near-term planning assumption of 5.00% (see Table 10 and Figure 7).

Table 10: Holyrood Gas Turbine DAUFOP

Gas Turbine Units	Maximum Continuous Unit Rating (MW)	12 months ending December 2017 (%)	12 months ending December 2018 (%)	Near-Term Planning Assumption (%)
Holyrood GT	123.5	2.02	0.00	5.00

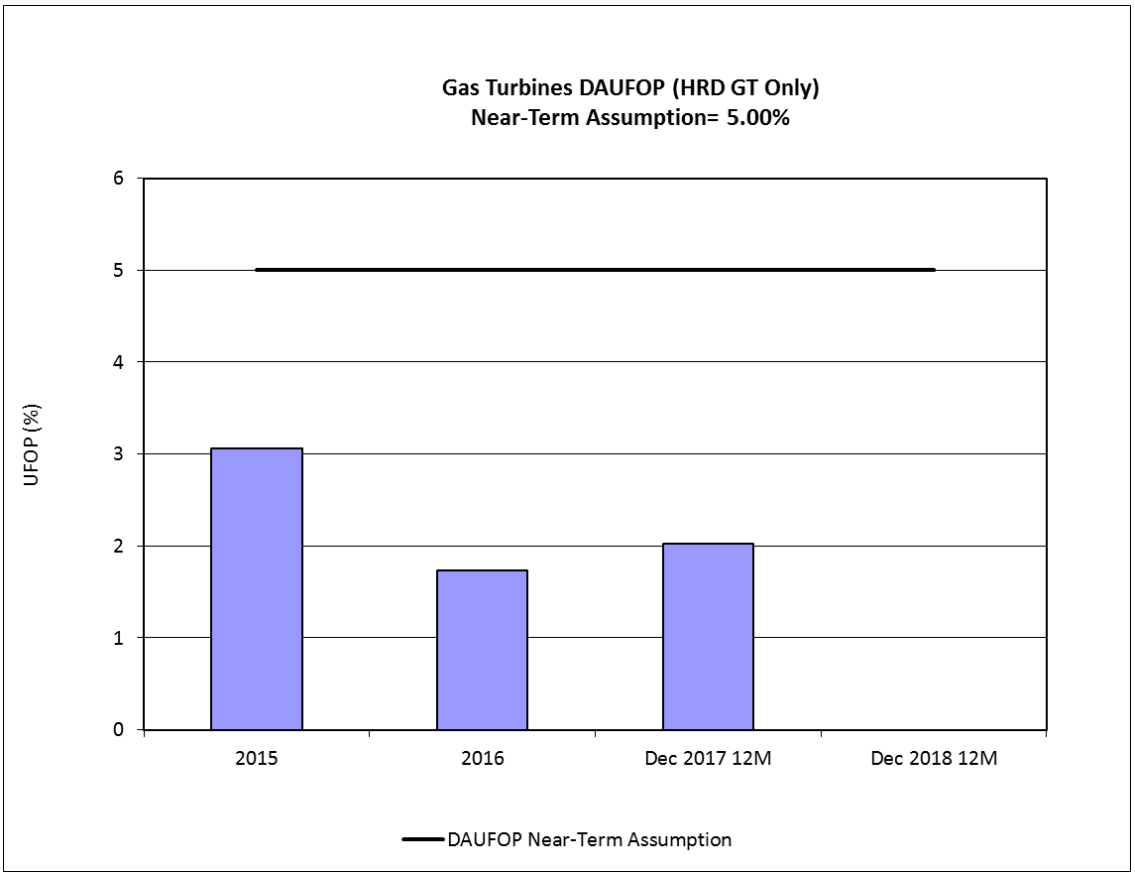

Figure 7: Gas Turbine DAUFOP – Holyrood Unit

The Stephenville gas turbine DAUFOP for the period is impacted by the unavailability of End A as a result of an exhaust bellows failure at Hardwoods gas turbine End A on December 28, 2017. Stephenville End A was unavailable at this time due to issues with the power turbine rear bearing, which required the bearing to be replaced. Hydro decided to remove the bellows from End A at Stephenville and install it at Hardwoods End A to return that unit to full capacity.

8.0 Updated Planning Assumptions/Analysis Values

As part of its Reliability and Resource Adequacy Study filed with the Board in November 2018, Hydro detailed the process undertaken for determining the forced outage rates most appropriate for use in its near-term reliability assessments and long-term resource adequacy analysis. The Table 11 summarizes the analysis values that were utilized in the study.

Table 11: Hydro's Reliability and Resource Adequacy Study Analysis Values

Unit Type	Measure	Near-term Analysis Value (%)	Resource Planning Analysis Value (%)
Hydraulic	DAFOR	3.50	1.93
Thermal	DAFOR	15	N/A
Gas Turbines:			
Happy-Valley	DAUFOP	13.92	12.59
Hardwoods, Stephenville	DAUFOP	30	N/A
Holyrood	DAUFOP	3.06	2.24

For the hydroelectric units (Bay d'Espoir, Cat Arm, Hinds Lake, Granite Canal, Upper Salmon, and Paradise River) a three-year capacity-weighted average was applied to these units for the near-term analysis, resulting in a DAFOR of 3.50%, while a ten-year capacity-weighted average was applied for use in the resource planning model, resulting in a DAFOR of 1.93%. The DAFOR value was based on historical data which is reflective of Hydro's maintenance program over the long term.

DAFORs of 15, 18, and 20% were applied to the Holyrood Thermal Generating Station in order to determine the sensitivity of the system to Holyrood availability in the near term. This is consistent with the May 2018 Near-Term Generation Adequacy Report. As the Holyrood units are being retired from generation mode in 2021, they were not included in the long term analysis and thus there is no resource planning analysis value listed for these units. For the total plant, an all units weighted value of 15.00% is used.

As the gas turbines in the existing fleet are in varied condition, each was considered on an individual basis, rather than applying a weighted average across all units. For the Happy Valley gas turbine, a three-year capacity-weighted average was applied to the unit for the near-term analysis, resulting in a DAUFOP of 13.92%, while a ten-year capacity-weighted average was applied for use in the resource planning model resulting in a DAUFOP of 12.59%. The DAUFOP

values were based on historical data founded upon the unit's past reliable performance. As the Holyrood gas turbine has only been in operation for the past three years, the near-term analysis considered performance in the worst case year of its operational history[10]. For the long term analysis, the average of the three years of operational data was applied for the unit, resulting in a long-term DAUFOP of 2.24%. For the Hardwoods and Stephenville gas turbines, a DAUFOP of 30% was used for the near-term analysis, consistent with what was considered in Hydro's May 2018 Near-Term Generation Adequacy Report. As the Hardwoods and Stephenville gas turbines are being considered for retirement in 2021, they were not included in the longer term analysis and thus there is no resource planning analysis value listed for these units.

9.0 Comparison of Planning Assumptions/Analysis Values

As Hydro's reliability and adequacy planning assumptions have been historically used in reporting on the performance of Hydro's generating units, a comparison of the values used most recently (May 2018 Near Term Generation Adequacy Report) to these new values (November 2018 Reliability and Resource Adequacy Study) is provided in Table 12 for clarity.

Hydro notes that the Reliability and Resource Adequacy Study did not utilize UFOP in its analysis. The analysis utilized instead the DAUFOP measure with changes as shown in the table.

[10] The Holyrood gas turbine had a DAUFOP of 3.06% for 2015.

Table 12: Comparison of Hydro's Planning Assumptions

Generating Unit Type	Measure	Historical Planning Assumptions		Reliability and Resource Planning Assumptions	
		Base Planning Assumption (%)	Near-term Planning Assumption (%)	Near-term Analysis Value (%)	Resource Planning Analysis Value (%)
Hydraulic	DAFOR	0.9	2.60	3.50	1.93
Thermal	DAFOR	9.64	14.00	15.00	N/A
Gas Turbines:					
Happy-Valley	DAUFOP	-	15.00	13.92	12.59
Hardwoods, Stephenville	DAUFOP	-	30.00	30.00	N/A
Holyrood	DAUFOP	-	5.00	3.06	2.24

The generating unit performance presented previously in this report is again presented in Tables 13 to 17 with comparison to the previous assumptions as well as the recently revised values. No table is provided for the UFOP performance, as Hydro does not plan to use this metric in future for reliability assessments.

Table 13: Hydraulic Weighted DAFOR Performance Comparison

Generating Unit	Maximum Continuous Unit Rating (MW)	12 months ending December 2017 (%)	12 months ending December 2018 (%)	May 2018		November 2018	
				Base Planning Assumption (%)	Near-term Planning Assumption (%)	Near-Term Planning Analysis Value (%)	Resource Planning Analysis Value (%)
All Hydraulic Units - weighted	954.4	2.29	0.21	0.9	2.6	3.50	1.93
Hydraulic Units							
Bay D'Espoir 1	76.5	9.33	0.07	0.90	3.90	3.50	1.93
Bay D'Espoir 2	76.5	14.11	0.64	0.90	3.90	3.50	1.93
Bay D'Espoir 3	76.5	0.03	0.00	0.90	3.90	3.50	1.93
Bay D'Espoir 4	76.5	0.27	0.15	0.90	3.90	3.50	1.93
Bay D'Espoir 5	76.5	0.00	0.00	0.90	3.90	3.50	1.93
Bay D'Espoir 6	76.5	1.48	0.54	0.90	3.90	3.50	1.93
Bay D'Espoir 7	154.4	1.80	0.00	0.90	3.90	3.50	1.93
Cat Arm 1	67	0.22	0.94	0.90	0.70	3.50	1.93
Cat Arm 2	67	0.09	0.00	0.90	0.70	3.50	1.93
Hinds Lake	75	0.89	0.07	0.90	0.70	3.50	1.93
Upper Salmon	84	0.81	0.15	0.90	0.70	3.50	1.93
Granite Canal	40	0.11	0.45	0.90	0.70	3.50	1.93
Paradise River	8	1.70	0.00	0.90	0.70	3.50	1.93

Table 14: Thermal Unit DAFOR Performance Comparison

Generating Unit	Maximum Continuous Unit Rating (MW)	12 months ending December 2017 (%)	12 months ending December 2018 (%)	May 2018		November 2018	
				Base Planning Assumption (%)	Near-term Planning Assumption (%)	Near-Term Planning Analysis Value (%)	Resource Planning Analysis Value (%)
All Thermal Units - weighted	490	14.91	28.97	9.64	14.00	15.00	N/A
Thermal Units							
Holyrood 1	170	19.35	36.66	9.64	15.00	15.00	-
Holyrood 2	170	19.14	24.03	9.64	10.00	15.00	-
Holyrood 3	150	5.84	22.80	9.64	18.00	15.00	-

Table 15: Hardwoods/Stephenville Gas Turbine DAUFOP Performance Comparison

				May 2018		November 2018	
Gas Turbine Units	**Maximum Continuous Unit Rating (MW)**	**12 months ending December 2017 (%)**	**12 months ending December 2018 (%)**	**Base Planning Assumption (%)**	**Near-term Planning Assumption (%)**	**Near-Term Planning Analysis Value (%)**	**Resource Planning Analysis Value (%)**
Gas Turbines (HWD/SVL)	100	19.72	21.67	N/A	30.00	30.00	N/A
Stephenville	50	40.06	47.48	N/A	30.00	30.00	N/A
Hardwoods	50	10.86	8.28	N/A	30.00	30.00	N/A

Table 16: Happy Valley Gas Turbine DAUFOP Performance Comparison

				May 2018		November 2018	
Gas Turbine Units	**Maximum Continuous Unit Rating (MW)**	**12 months ending December 2017 (%)**	**12 months ending December 2018 (%)**	**Base Planning Assumption (%)**	**Near-term Planning Assumption (%)**	**Near-Term Planning Analysis Value (%)**	**Resource Planning Analysis Value (%)**
Happy Valley	25	22.18	2.11	N/A	15.00	13.92	12.59

Table 17: Holyrood Gas Turbine DAUFOP Performance Comparison

				May 2018		November 2018	
Gas Turbine Units	**Maximum Continuous Unit Rating (MW)**	**12 months ending December 2017 (%)**	**12 months ending December 2018 (%)**	**Base Planning Assumption (%)**	**Near-term Planning Assumption (%)**	**Near-Term Planning Analysis Value (%)**	**Resource Planning Analysis Value (%)**
Holyrood	123.5	2.02	0.00	N/A	5.00	3.06	2.24