NEWFOUNDLAND AND LABRADOR HYDRO

Generation Availability

March 2014

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EXECUTIVE SUMMARY

Newfoundland and Labrador Hydro (Hydro) has completed an extensive review of the events surrounding the supply disruptions on the Island Interconnected system during January 2 to 8, 2014. The review included investigation of the rotating outages that occurred between January 2 to 8, 2014[1] and the transmission/terminal station equipment failures that occurred on January 4 and 5, 2014.

This report outlines the results of the investigation/assessment of Hydro's generation assets availability leading up to, and during the January 2 to 8, 2014 system event. It is intended to summarize the results of Hydro's internal review of its generation availability, specifically addressing the following:

- Gas turbine availability
- Holyrood availability
- Hydro generation availability
- Wind generation availability

The Key Findings and Recommendations are provided in Section 5.

The main recommendations from this review are:

- Through the existing Critical Spares Council, follow-up on the critical spares program as is currently in Hydro's plan in early 2014.
- Create a senior position reporting to the Vice-President for Hydro whose accountability includes the oversight of asset management plans, maintenance standards and capital submissions related to gas turbines.

[1] Rotating outages occurred on January 2, 3, 5 and 8, 2014.

1 INTRODUCTION

This report outlines the results of the investigation/assessment of the Island Interconnected System generation assets availability before, leading up to, and during the January 2 to 8, 2014, system event.

The scope of this focus area/element involves an assessment of:

- Factors that contributed to unplanned unavailability.
- Long term asset management plans.
- Maintenance plans and execution thereof.
- Critical spares availability.
- Winter readiness, including availability of fuel.
- Scheduling of gas turbine overhauls/outages.

2 REVIEW PROCESS

The review process involved internal Hydro generation asset experts, as well as generation expertise support from AMEC Americas. The (AMEC) work included:

- Review of existing Hydro data relevant to historical generation asset availability.
- Review of information on generation availability and issues leading up to and during the January 2 to 8, 2014 system event.
- Discussions/interviews with Hydro staff.

3 BACKGROUND

3.1 Overview of Facilities

Planning on the Island Interconnected System is designed to address:

- Capacity planning criteria: The Island Interconnected System should have sufficient capacity to satisfy a Loss of Load Hours (LOLH) expected target of <2.8 hours per year.

- Energy planning criteria: The Island Interconnected System should have sufficient capability to supply all of its firm energy requirements with firm system capability.
- A Transmission Planning Criteria that establishes operating assumptions and the various transmission contingencies for which the system is planned to survive.

Other factors impacting Operational Planning include:

- Dispatch generation to maintain an "n-1" generation reserve.[2]
- Holyrood fuel use minimization is a priority but may be limited by available inflows, reservoir storages and by system security considerations, such as system capacity and voltage constraints.

Figure 1 provides a general overview of Hydro generating facilities and their in-service dates.

In addition, the Island Interconnected System has about 163 MW of non-dispatchable generation sources (the power system operator in the Energy Control Centre (ECC) cannot control and thereby set the level of output), as follows:

- 54 MW of wind generation, varies with wind conditions;
- 90 MW of run-of-river Exploits River generation (63 MW of output can be sustained by varying the flow out of Red Indian Lake; 27 MW is dependent on uncontrolled flows in the river);
- 4 MW of run-of-river generation at Rattle Brook, dependent on river flow; and
- 15 MW Corner Brook Pulp and Paper co-generation, dependent on the paper mill's steam requirements.

[2] "n-1" refers to having generation reserves readily available and able to be started quickly to replace the loss of the largest unit currently in-service in order to avoid a prolonged customer interruption. Operational planning will typically result in extended planned maintenance only occurring during non-winter periods. It is possible that during the winter peak period this criteria could be violated while still adhering to the 2.8 hour criterion.

Island System*

Year	Generating Units	Installed Capacity (MW)	Net Capacity (MW)
1968 -70	Bay d'Espoir Units 1-6	450	438
1971	Holyrood Units 1-2	300	285
1976	Stephenville Gas Turbine	50	50
1977	Hardwoods Gas Turbine	50	50
1977	Bay d'Espoir Unit 7	154	154
1979	Holyrood Unit 3	150	143
1980	Hinds Lake	75	75
1983	Upper Salmon	84	84
1985	Cat Arm	127	127
1988-89	Holyrood Upgrades	40	38
2003	Granite Canal	40	40

*Significant Generation Asset Additions

Figure 1: Overview of Generating Units on the Island System

Note:
1) The difference at Bay d'Espoir is not due to station service, but due to low water conditions.
2) Cat Arm generating units can produce > 63.5 MW each. Installed capacity closer to 67 MW.
3) Diesel units (Hawkes Bay and St. Anthony) provide approximately 15 MW of capacity and were important contributors to the system during rotating outages.

Hydro's generation planning assessments take into account this non-dispatchable nature and under most normal operating conditions, there is more than enough firm dispatchable generation available to meet peak loads. The current level of non-dispatchable generation has not affected Hydro's ability to meet its peak load. The non-dispatchable generation, when available, increases the level of generation potentially available as reserve. Actual dispatch is based on optimizing the generation mix to get the most cost effective power mix while meeting system reliability requirements.

Figure 2 provides a view of the Hydro generating facilities' age distribution.

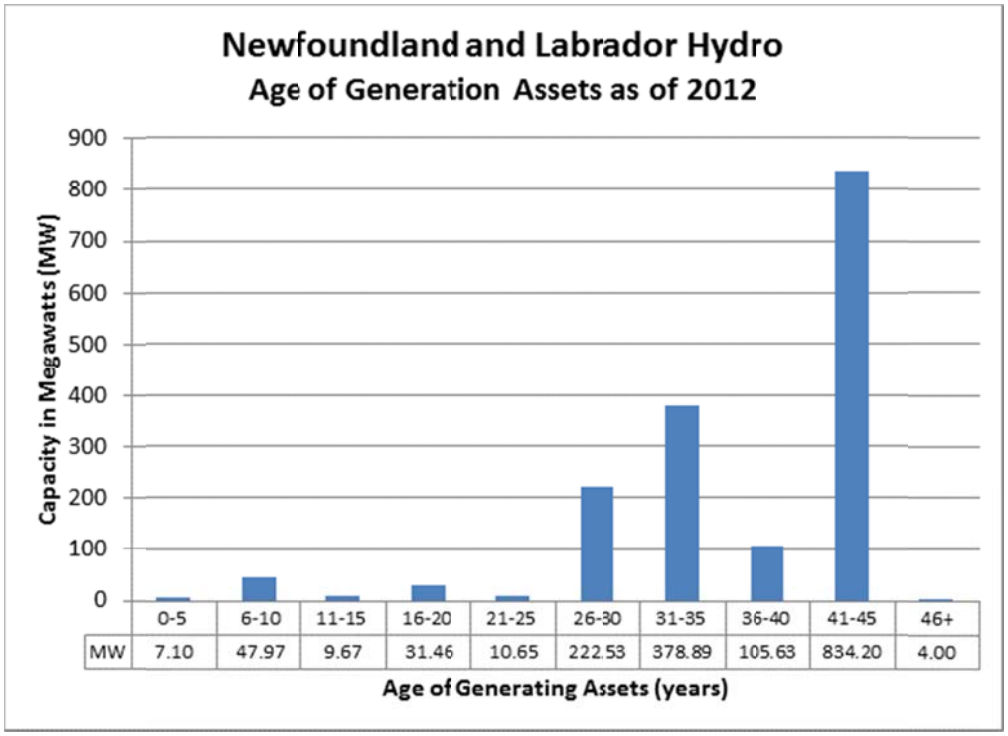

Figure 2: Age of Generation Assets as of 2012

Note: The ages are based on the facilities' original in-service dates. Some key assets within the plants have been renewed. The chart includes the diesel generators.

3.2 Generation Availability Metrics - CEA Benchmarks

Hydro utilizes the Canadian Electricity Association (CEA) membership database as one of its benchmarks for unit performance for equipment reliability – Capability Factor, De-rating Adjusted Forced Outage Rate (DAFOR), Failure Rate, and Utilized Forced Outage Probability (UFOP). Table 1 below highlights the various performance indices for Hydro's generation facilities for 2012 and 2013[3]. The average for the period 2008-2012 for comparison with the latest CEA national average findings for the same period are included as well.

[3] The Hydro data is based on the performance of all of Hydro's generation assets (excluding diesels) and not just those of the Island Interconnected system. The only unit in the data set outside of the Island Interconnected system is the Happy Valley GT. It therefore does provide a reasonable indicator of Island Interconnected facilities.

Table 1: Generation Performance Indices – CEA Benchmarks 2012-2013

Generation Performance Indices – CEA Benchmarks				
Index		**Hydro**	**Thermal**	**Gas Turbine**
Failure Rate (Forced Outages per 8,760 operating hours)	NLH 2013	1.42	8.84	144.46
	NLH 2012	1.78	8.22	231.67
	NLH '08-'12	2.62	6.38	137.89
	CEA '08-'12	2.06	7.11	22.30
Incapability Factor (Percent of Time)	NLH 2013	7.97	53.96	26.73
	NLH 2012	9.26	26.92	31.28
	NLH '08-'12	7.83	30.99	23.12
	CEA '08-'12	9.33	25.62	13.81
De-rating Adjusted Forced Outage Rate (Percent of Time)	NLH 2013	0.55	36.58	
	NLH 2012	0.95	5.98	
	NLH '08-'12	0.76	10.03	
	CEA '08-'12	3.66	9.23	
Utilization Forced Outage Probability (Percent of Time)	NLH 2013			28.07
	NLH 2012			56.33
	NLH '08-'12			22.64
	CEA '08-'12			11.84

Hydro Unit Performance

Hydro unit measures improved in 2013 when compared to 2012 and are better than the latest five year CEA national averages. Hydroelectric unit de-rating adjusted forced outage rate is significantly better than the latest five year CEA national average.

Thermal Unit Performance

Thermal unit performance deteriorated in 2013, particularly the Incapability Factor and De-rating Adjusted Forced Outage Rate measures. Performance in 2013 was worse than the CEA national five year average. The decline is primarily owing to the failure experienced on Holyrood Unit 1 in January 2013 and the lengthy outage that resulted. 2012 Hydro data is

similar to the CEA average, and the 2008- 2012 Hydro average values for its thermal units is consistent with the CEA benchmark. (Note: Hydro's data is comparable despite having less operating time because of its primary winter peak load period role as well as longer summer maintenance outages due to units not being required to meet system load. This is offset by the better availability during operating periods as a result of the additional maintenance and condition assessment activities in the summer months.

Gas Turbine Unit Performance

Hydro's gas turbine performance is much worse than the CEA national average, however it improved in 2013 in all areas. The Hydro Gas Turbine (GT) performance reflects their infrequent peaking role to provide system emergency support. A condition assessment was undertaken by Stantec in 2007-2008 and refurbishment work was carried out between 2010 and 2013. The Stephenville Unit was returned to service in June 2013 after a 20 month forced outage. A decision was made to allow for a longer outage period given planned system needs at the time. The improvements in some of the 2013 performance data were impacted by extended planned outages at Hardwoods for refurbishment and generator alternator replacement. The Utilization Forced Outage Probability is of particular importance to Hydro's use of gas turbines. It describes the degree to which a standby unit can be called upon to supply load when requested.

Table 3 further illustrates the poor gas turbine performance compared to other gas turbines in the CEA database[4]. It should be noted that the Hydro GTs also have a poor start performance. The roles and operating patterns of the gas turbines in the CEA database may include those operating more frequently.

[4] Capability Factor is defined as unit available time, the ratio of a unit's available time to the total number of unit hours. Incapability = 1 minus Capability Factor.
The Utilization Forced Outage Probability is the probability that a generating unit will not be available when required and measures performance of standby units with low operating time such as gas turbines.
Failure Rate is defined as the rate that a generating unit encounters a forced outage = the number of transitions from an operating to a forced outage state divided by the total operating time. It can be greatly influenced by limited operating time for gas turbines.

Table 3: Gas Turbine Performance

Unit	Five Year Average 2008-2012 - All Causes			
	Capability Factor (%)	UFOP (%)	Failure Rate	Number of Unit Starts
Hardwoods GT (2008-2012)	86.53	26.39	116.37	308
Stephenville GT (2008-2012)	37.55	38.68	90.29	97
CEA (2008-2012)	86.19	11.84	22.30	8420

3.3 Historical System Shortfalls Due to Generation Unavailability

In Hydro's operating history, there have been few recorded instances where the unavailability of generation capacity (due to weather conditions and equipment issues) resulted in Hydro being unable to supply the load of the Island Interconnected System. In the last ten years, there have been only two recorded instances of unavailability of generation capacity. The first occurred on January 23, 2006 from 11:25 to 12:30 hours. In that case, the Upper Salmon plant had experienced frazil ice, Holyrood Unit 2 was unavailable due to a boiler tube failure, the Hardwoods and Stephenville gas turbines were de-rated due to control system and fuel nozzle issues respectively, and the Holyrood gas turbine was de-rated due to an oil leak. There was 307 MW of generation capacity unavailable to the system with details as per the following Table 4.

Table 4: Generation Capacity – January 23, 2006

Generation Supply Issues - January 23, 2006			
Plant	Unit Rating (MW)	Unavailable Capacity (MW)	Notes
Holyrood Unit 2	170	170	Boiler tube failure (January 6, 2006)
Upper Salmon Unit	84	84	Frazil Ice blockage at intake
Hardwoods Gas Turbine[1]	54	24	Derated due to control system failures
Stephenville Gas Turbine[1]	54	27	Derated due to fuel nozzle failure on one End
Holyrood Gas Turbine	10	2	Derated due to oil leak and fire (unit ran with fire watch)
Total	372	307	

The second event occurred on January 11, 2013. There was an initial transmission system initiated outage that had a subsequent impact on generation unavailability. Severe weather resulted in failures in the Holyrood Terminal Station and 230 kV line outages that resulted in several generation units tripping, including all three Holyrood units. Unavailable capacity at the time is presented in the following table. Holyrood Unit 1 was damaged and as a result unavailable for much of 2013. This impacted Hydro being able to supply the load of the Island Interconnected System after the terminal station and transmission line repairs were completed.

Table 5: Generation Capacity – January 11, 2013

Generation Supply Issues - January 11, 2013 (as at 0743 hours)			
Plant	Unit Rating (MW)	Unavailable Capacity (MW)	Notes
Stephenville Gas Turbine	50	50	Unit unavailable due to work to rewind alternator
Holyrood Units 1-3	490	490	Units had tripped previously in the morning
Star Lake	18	18	Unit had tripped previously in the morning
Cat Arm Units 1 and 2	127	127	Units tripped due to high system frequency
Upper Salmon Unit	84	84	Unit tripped due to high system frequency
Granite Canal Unit	40	40	Unit tripped due to high system frequency
Other Purchases	83	21	NUGS reduction due to system upset
Total	892	830	

There have also been an average of approximately six under-frequency events per year on the Island Interconnected System from 2004 to 2013. The Island Interconnected System is an isolated system so that when there is a sudden loss imbalance between loads and generation (due to incidents, such as slow clearing transmission faults or sudden large loss of generation) some loads must be interrupted for short periods to bring generation output equal to demand. This automatic action of power system protection, referred to as under-frequency load shedding, is necessary to ensure the integrity and reliability of system equipment. Load interruptions are usually less than 30 minutes for these events because Hydro generally maintains an available reserve to cover off the failure of the largest unit. Details of these under-frequency events in 2004 to 2013 are presented in Appendix 6.

3.4 Generation Asset Readiness

3.4.1 Long Term Asset Management Plans

Hydro's long term asset management planning is comprehensive and consistent with good industry practices. The principles are used for Hydro's thermal, hydroelectric, and gas turbine facilities. Its focus is to achieve maximum value based on the required standard of service to current and future generations. For details of long term asset management plans and planning, the report *Asset Management Strategy and Practices* should be referenced. Condition assessment is a key tool in the development of Hydro's asset management plans, using methods such as those developed by the Electric Power Research Institute (EPRI).

Hydro has actively been undertaking priority condition assessments to better refine maintenance, refurbishment and replacement requirements and reflect those in short and long term work plans. The long term asset management plans are followed, except where unplanned and higher priority work are required or when changes in system production plans may occur. This results in reprioritization of annual plans and may require formal revisions to longer term plans. An example is the impact that the repair work to Holyrood Unit 1 in 2013 had on plans for Unit 2 maintenance work plans.

3.4.2 Maintenance Plans and Execution

Hydro's annual execution work plan is the key to its maintenance plans and their execution. The plan is intended to ensure that the activities, resources and outage window availabilities for all of its facilities converge into a viable overall program. The execution of the plan undertakes those elements to achieve the cost, schedule, performance, and environmental and regulatory goals associated with the work. Hydro has competent and skilled staff, including those in project management, planning, engineering, operations and skilled trades. Details of the maintenance planning and execution process are included in the report entitled *Asset Management Strategy and Practices*.

Hydro's maintenance execution largely reflects the maintenance, refurbishment and replacement activities in its annual execution plans. Plans do change due to reprioritization where unplanned and higher priority work is required. The example in Section 3.4.1 of the impact the repair work to Holyrood Unit 1 in 2013 had on plans for Unit 2 maintenance work applies here as well.

3.4.3 Critical Spares Management

Hydro maintains critical capital and consumable spares for all its facilities based on vendor recommendations, as well as operational experience, failure history and equipment condition assessments. Hydro has developed a strategy, framework and process that are consistent with good industry practice for its facilities.

The availability of generation asset critical spares did not impact the extent or duration of the large January 4 to 5, 2014 transmission/terminal station failure events. Issues at the generation facilities did, however, contribute to some of the rotating outages before the event on January 4, 2014 and during the system restoration activities. Two instances where equipment that might have been considered critical spares may have played a role in the rotating outages were: i) the outage of the Hardwoods GT due to the lack of an available spare fuel control valve; and ii) the de-rating of Holyrood Unit 3 due to lack of a spare 4 kV forced drive (FD) fan motor. The fuel valve was new and it would be a reasonable expectation that it should not fail during initial installation. A spare 4 kV FD fan motor had been suggested for procurement consideration in the 2011 Holyrood condition assessment. It was examined, costed and submitted as part of the 2012 capital approval process, but was not pursued further based on Hydro's capital prioritization process. The subsequent year, it was determined not to be a capital item and did not proceed further. A procurement decision would examine a number of factors, including spare motor cost, potential risk, generation contingency availability, time to repair, remaining generation life and the number of different 4 kV motors that would be required to cover off all of the 4 kV motor applications in the plant. Details of the overall critical

spares management program are presented in the report *Asset Management Strategy and Practices*.

3.4.4 Winter Readiness (including Availability of Fuel)

Winter readiness of generation facilities has been and continues to be a high importance area for Hydro with regular tracking and reporting of performance to bring a higher focus on this period than can be obtained using standard CEA measures. Up until the end of 2012, Hydro used an internal winter availability measure to track winter generation performance from December 1 to March 31 each year. In 2013, Hydro replaced this with a contingency reserve performance measure. The newer contingency reserve measure allows for minor maintenance in the winter period when demand permits while the older measure did not take the level of demand into consideration. This measure will continue to be a key performance indicator with which Hydro will establish targets to focus its efforts on.

In order to meet these targets, planned major project work and high priority corrective and preventive maintenance work on generation assets is planned to be completed so as to be winter ready. In the late fall of 2013, an external review was undertaken by AMEC which included a review of the winter readiness of Holyrood Unit 2 and its fuel systems review as well as Bay d'Espoir Unit 7 and its auxiliary systems. For Holyrood, it was identified that:

- the high priority Unit 2 outage maintenance work had been completed in shorter outages in late November and early December 2013, and
- fuel issues had been mitigated and additional spares procured to address potential fuel related maintenance issues.

Bay d'Espoir Unit 7 was considered to be in good condition for operation in the 2013/14 winter period. The external review did not identify any issues that were causal or contributing factors to the January 2 to 8, 2014 system event.

With the exception of the Stephenville and Hardwoods gas turbines, Hydro's generation assets were considered to be winter ready. The Hardwoods gas turbines would, to a large extent, have been winter ready by mid to late December if no issues had arisen at the end of its generator refurbishment. The failure of the fuel control valve at Hardwoods was unexpected and its extended return to service is the result of the time of year and limited service expertise in the market. The timeliness of the procurement and delivery of the Stephenville insulation blanket is an issue that may have been addressed sooner to minimize its potential impact. However, due to the very cold temperatures at the time of the low generation availability and the steps Hydro took at that time, the insulating blankets did not restrict the turbines output. On January 8, the Stephenville gas turbine experienced an unexpected bearing failure in the recently refurbished B end engine. Its impact could not likely have been prevented by additional inspection prior to the winter (for complete details, refer to Appendix 2).

Liquid fuel availability became an issue throughout the island of Newfoundland during the holiday period and the system event due to the nature of the fuel delivery contracting practices. Typically, fuel delivery in the province is done by contractors many of whom were on holiday in the period before the January 2 to 8, 2014 system event, and then unavailable due to the extreme weather during the rotating outages and system event. It did not, however, have an incremental impact on gas turbine availability. Hydro has a priority delivery contract, but manages its requirements so as not to impact other liquid fuel deliveries. It also undertook special efforts due to the short supply to secure 80,000 litres from the Canadian Coast Guard. The gas turbine fuel storage practice has been to maintain conservative levels of 60% of tank capacity to allow for plenty of room for fuel expansion, to increase the fuel inventory turnover, and to minimize the potential for environmental spills. An 80 to 90% storage volume could have been employed which would have allowed for longer operation without a delivery if necessary. This may have moderately reduced the requirements for some of the rotating outages if the gas turbines had been fully available during this period. It would not have had an impact on the larger January 4 and 5, 2014 transmission/terminal station failure events.

3.5 Winter Generation Capability

The following summarizes the total installed capacity for the Island Interconnected System.

Table 6: Island Interconnected System Supply

Island Interconnected System Supply	
Installed Capacity	
Hydro owned and operated	1,507.5 MW
Purchased	178.8 MW
Customer Owned	259.8 MW
Total Supply	1,946.1 MW

In more detail, it is composed of the following:

Table 6: Island Interconnected System Supply (Detailed)

		Firm (Dependable)						Non-Firm	Total	
Generation		Net Low Head	Low Supply Adjustments		Net High Head	Station Service	Gross High Head After Stn. Service*	Additional	Net Low Supply	Gross High Head After Stn. Service
			Nameplate	High Head						
Newfoundland and Labrador Hydro										
Owned	Hydroelectric	927.3	19.0	12.0	958.3		958.3		927.3	958.3
Owned	Holyrood	465.5			465.5	24.5	490.0		465.5	490.0
Owned	Gas Turbine	100.0			100.0		100.0		100.0	100.0
Owned	Diesel	14.7			14.7		14.7		14.7	14.7
Total Owned		1507.5	19.0	12.0	1538.5	24.5	1563.0	0.0	1507.5	1563.0
Purchased	Hydroelectric	78.0			78.0		78.0	31.8	109.8	109.8
Purchased	Co-Generation	8.0			8.0		8.0	7.0	15.0	15.0
Purchased	Wind				0.0		0.0	54.0	54.0	54.0
Total Purchased		86.0	0.0	0.0	86.0	0.0	86.0	92.8	178.8	178.8
Total NLH System		1593.5	19.0	12.0	1624.5	24.5	1649.0	92.8	1686.3	1741.8
Customer Owned										
Corner Brook Pulp and Paper	Hydroelectric	99.1			99.1		99.1	22.3	121.4	121.4
Newfoundland Power	Hydroelectric	78.7			78.7		78.7	18.2	96.9	96.9
Newfoundland Power	Gas Turbine	36.5			36.5		36.5		36.5	36.5
Newfoundland Power	Diesel	5.0			5.0		5.0		5.0	5.0
Total Customer Owned		219.3	0.0	0.0	219.3	0.0	219.3	40.5	259.8	259.8
Total Island Interconnected System		**1812.8**	**19.0**	**12.0**	**1843.8**	**24.5**	**1868.3**	**133.3**	**1946.1**	**2001.6**

The net capabilities are primarily used for long term generation planning. For long term planning purposes the more conservative Low Head capabilities are assumed. Short term operational planning uses gross capabilities and these can vary between the Low Head and High Head limits depending on actual reservoir conditions.

4 SEQUENCE OF EVENTS: RELEVANT TIME FRAME

4.1 Incident Review Process – January 2014

The review process of the sequence of events was carried out in a manner consistent with good industry practice in terms of working towards determining a root cause and actionable steps for the future. The methodology and detailed results are found in report *Root Cause Investigation of System Disturbances*.

No generation asset was identified as having been a root cause of the January 4 and 5, 2014 transmission/terminal station failure events. The generation assets responded appropriately to the faults occurring within the overall transmission system. The unavailability of some generation assets or de-rating of others did, however, contribute to the extent of some of the rotating outages leading up to the system event and during the restoration efforts.

4.2 Preceding Events Associated with the January 2014 System Incident

Several generation asset issues, which are identified below, arose prior to and early in January 2014 that resulted in the need for rotating outages on January 2 and 3, 2014. They were also present during the January 4 and 5, 2014 transmission/terminal station failure events, but they were not initiating factors. Some of these are discussed in more detail in the Appendices to this report.

DECEMBER 15, 2013		
DATE	**EVENT**	**COMMENT**
December 15, 2013	Exploits River reduced to 38 MW	The Exploits River generation reduced due to frazil ice accumulation in the water channels leading into the Grand Falls generating station Limited success to clear the ice. Resolved on January 15, 2014.

DECEMBER 16, 2013		
DATE	**EVENT**	**COMMENT**
December 16, 2013	Granite Canal reduced 8 MW to 32 MW	Reduced due to turbine axial vibration. No definitive cause identified (associated with extreme cold water and turbine ice accumulation). Further reviews are planned.

DECEMBER 21, 2013		
DATE	**EVENT**	**COMMENT**
December 21, 2013	Hardwoods GT (50 MW) unavailable	Failure of a new fuel control valve. Service provider staff unavailable during holiday period. Restored to service on January 12, 2014

DECEMBER 23, 2013		
DATE	**EVENT**	**COMMENT**
December 23, 2013	Stephenville GT de-rated from 50 to 25 MW	Series of issues (initially asbestos pipe couplings, later B engine bearing failure) result in de-rating through January 2- 8, 2014 period and beyond. Unit in service using vendor loaner engine for engine B at 40 MW.

DECEMBER 25, 2013		
DATE	**EVENT**	**COMMENT**
December 25, 2013	Holyrood Unit 2 de-rated 25 MW to 142 MW	Steam turbine valve issue. Inspections and repairs carried out. Keeping unit on- line (even in a de-rated state was important). On-line solution implemented January 3, 2014.

DECEMBER 26, 2013		
DATE	**EVENT**	**COMMENT**
December 26, 2013	Holyrood Unit 3 de-rate 100 MW to 50 MW	FD fan motor winding failure. Motor removed without outage. Rewound and re-installed. Returned to full capacity January 12, 2014.

4.3 Generation Capability - January 2 to 8, 2014 System Event

Hydro determined that it could not meet the forecast load on January 2, 2014. At that time, it enacted the final steps in its Generation Load Sequence and Generation Shortage protocol and planned for a customer conservation request and probable rotating outages.

The following charts show the generation reserve (the difference between the System Supply and System Demand) that was available. The charts prior to the transmission/terminal station equipment failure events on January 4 and 5, 2014, emphasize that the generation asset outages were an important element of the rotating outages. The issues raised suggest that the need for additional generation capacity may be a consideration, at least in the short term, before major new generating sources are added to the system. These include:

the increased system peak due to severe weather conditions;

- the impact of severe weather conditions on certain generating assets (Granite Canal, Exploits River);
- the availability of spares (Holyrood 4kV motors); and
- the age of some equipment within some of the generating assets (Holyrood Unit 3 FD fan motor).

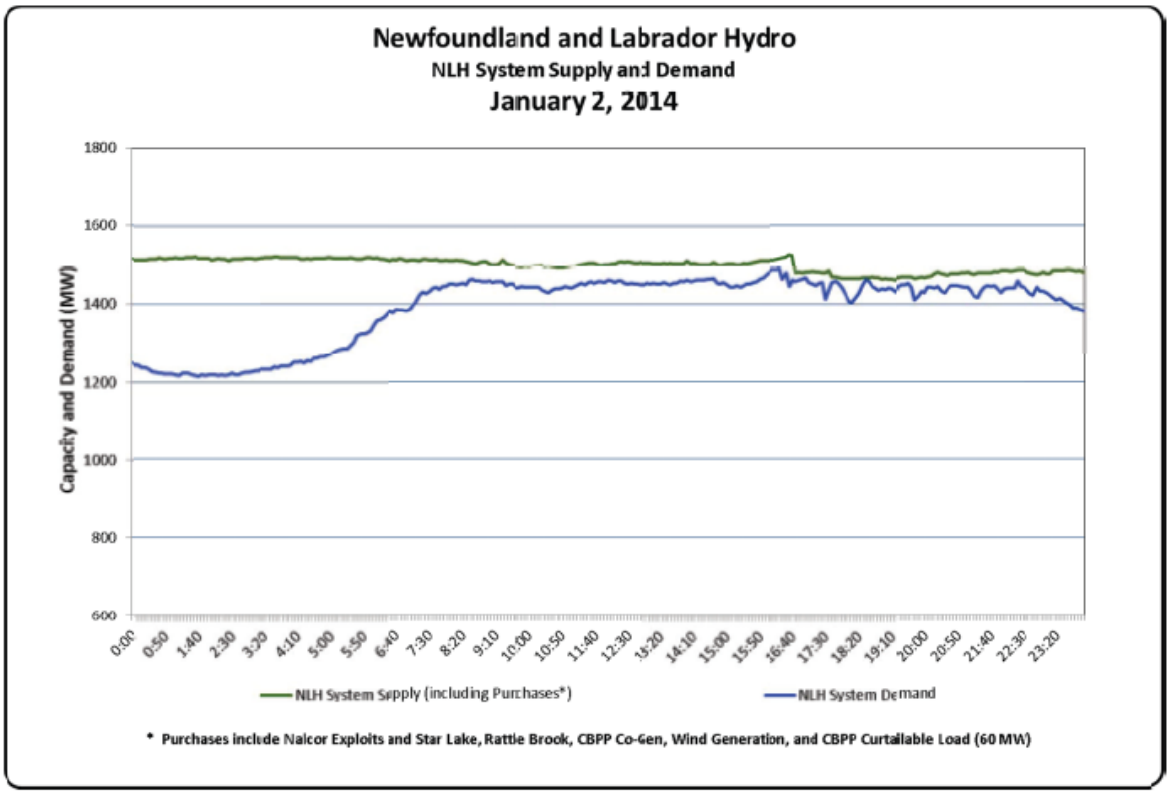

Figure 3: Hydro System Supply & Demand – January 2, 2014

JANUARY 3, 2014		
DATE	**EVENT**	**COMMENT**
January 3, 2014	Wind Turbine Out of Service of 54 MW	Wind turbine generators tripped due to high winds and transmission system conditions. Required manual reset. High winds and site access delayed restart. Returned to service January 6 to 8, 2014.

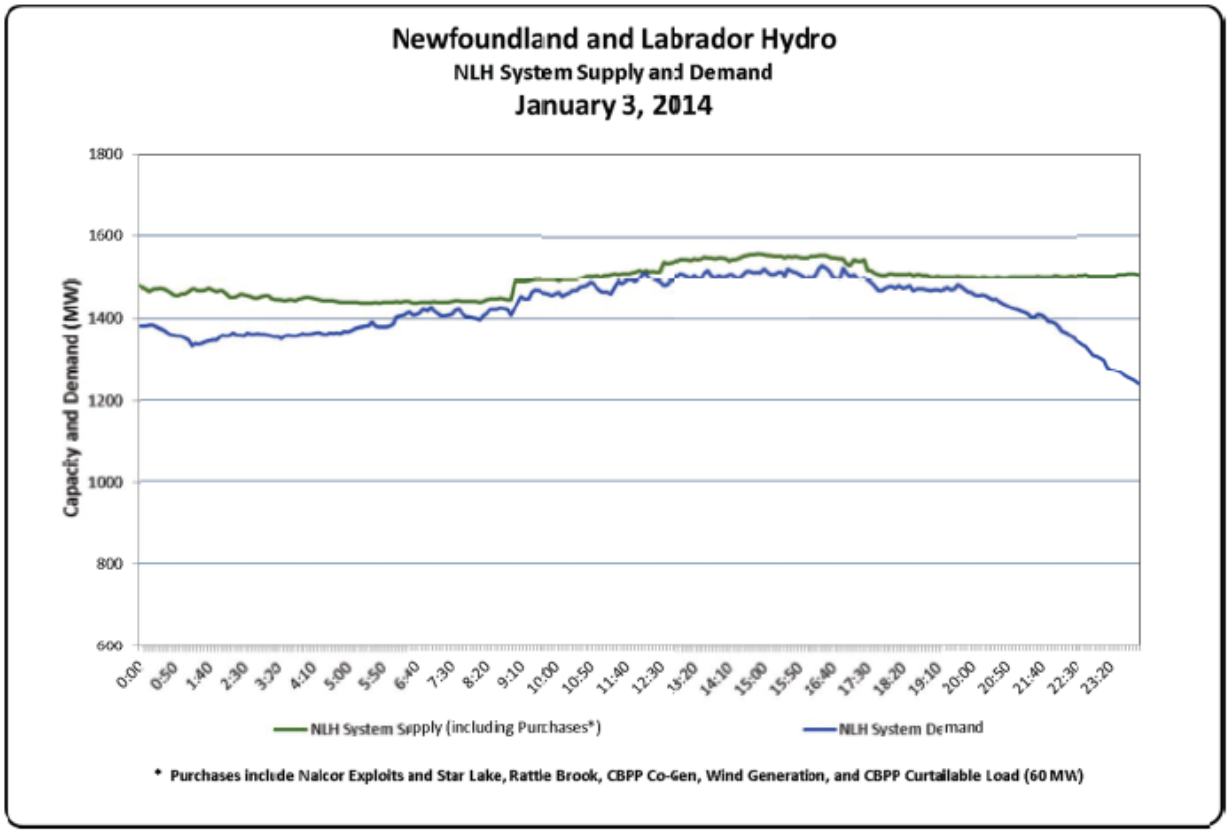

Figure 4: Hydro System Supply & Demand – January 3, 2014

The following charts show the system reserve on January 4 and January 5, 2014 during the system incident. The chart for January 4, 2014 shows the reducing reserve early in the morning up to the first system disruption. The January 5, 2014 chart shows that the reserve varied between a minimum of 30 MW at 0830 hours to a maximum of 438 MW following the separation of the east and west systems at 21:27 hours with the disturbance on the power system that originated at the Holyrood Terminal Station. The increased reserve immediately following the disturbance up to the end of the day was a result of the time required to restore generating equipment, transmission equipment and customer load. In particular, due to the limitations in transmission line power transfer capability serving the Avalon Peninsula, customer load could not be completely restored until generating equipment at Holyrood and transmission lines were restored over the next several hours.

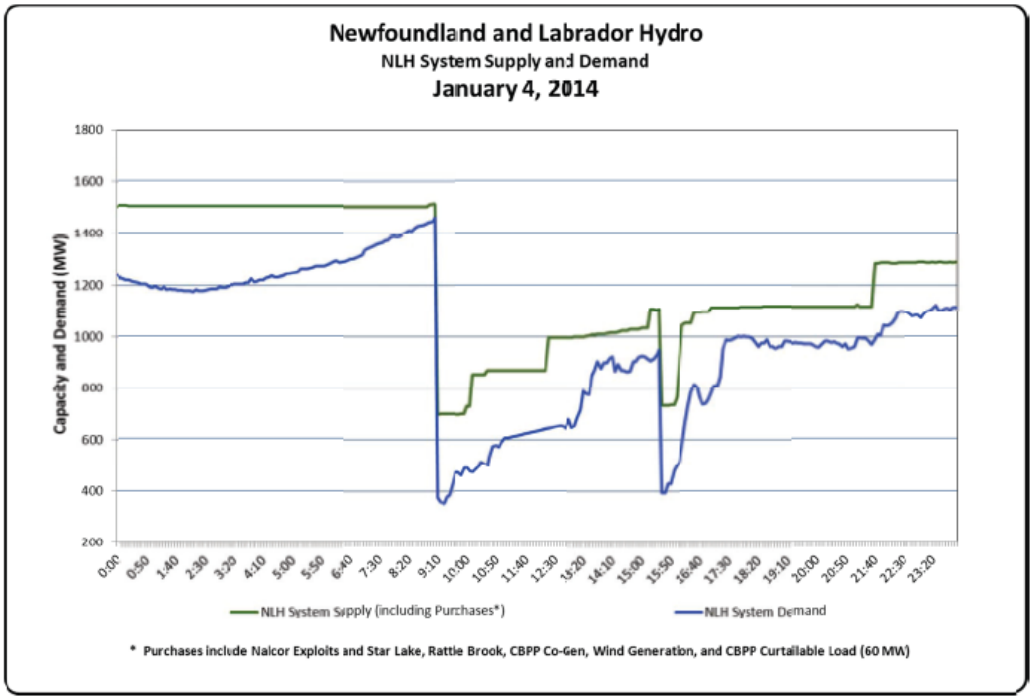

Figure 5: Hydro System Supply & Demand – January 4, 2014

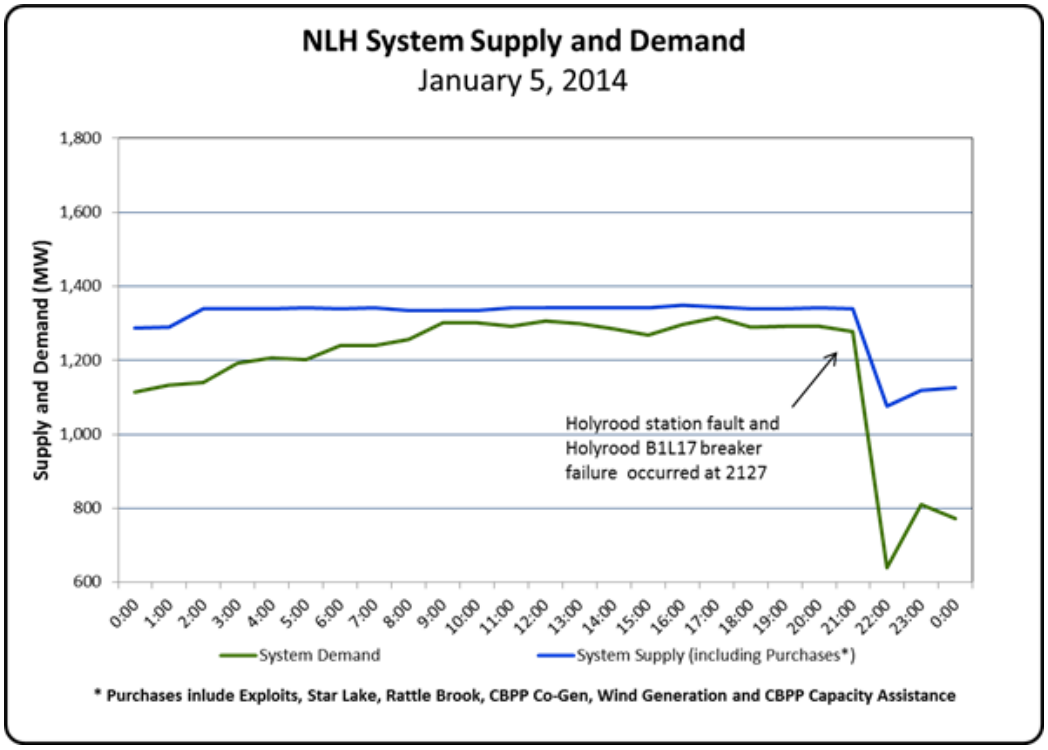

Figure 6: Hydro System Supply & Demand – January 5, 2014

1 The charts show the recovery of both the system supply and loads in the January 6 to 8, 2014
2 period.
3

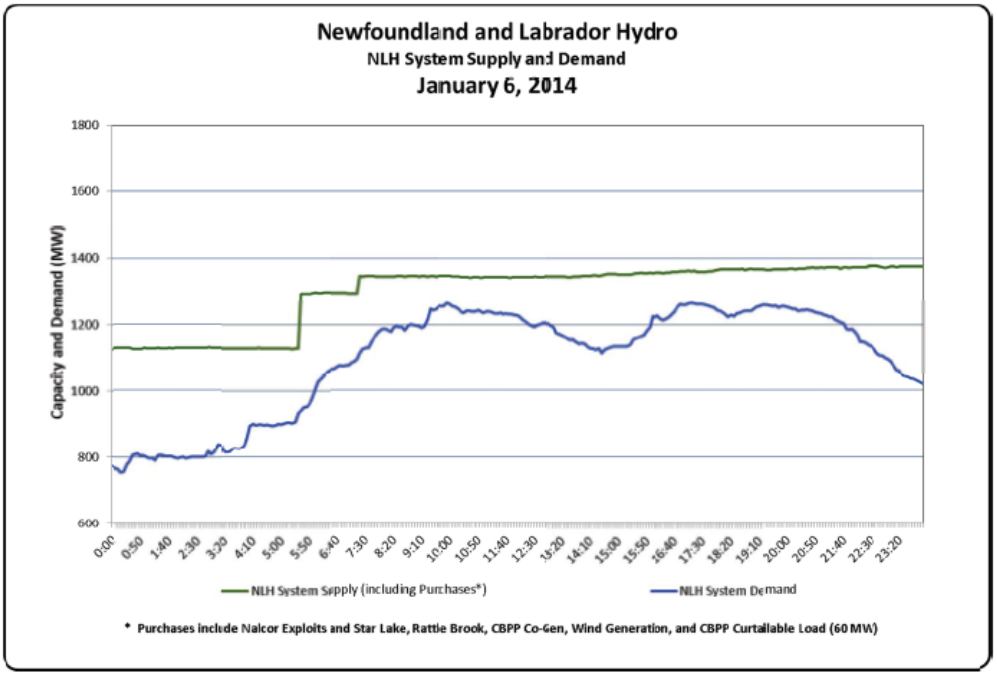

Figure 7: Hydro System and Demand – January 6, 2014

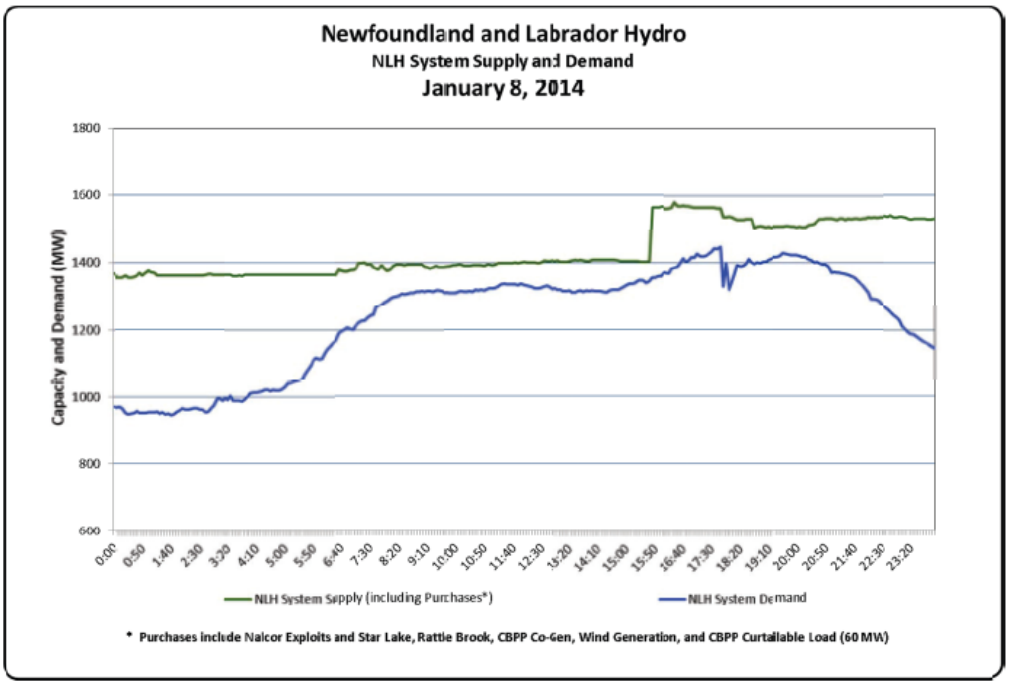

Figure 8: Hydro System Supply and Demand – January 8, 2014

Hydro's focus was to get and keep all generation available. As of noon on January 8, 2014 the status was as follows:

Plant/Unit	Issues	Generation	De-rate
• Holyrood Unit 1	Final checks. Returned to service	170 MW	0 MW
• Holyrood Unit 2	Minor de-rate	165 MW	5 MW
• Holyrood Unit 3	FD fan motor under repair (Jan 12)	50 MW	100 MW
• Hardwoods GT	Undergoing testing (Jan 12)	0 MW	50 MW
• Stephenville GT	Testing of B end (failed Jan 8)	25 MW	25 MW
• Exploits River	Severe frazil ice buildup	50 MW	13 MW
• Wind	System Jan 3 trip, manual reset delayed	50 MW	4 MW

5 KEY FINDINGS AND RECOMMENDATIONS

5.1 Overall Considerations

Many of Hydro's key generation assets were installed in the late 1960's into the 1970's. Over half of the Island Interconnected system generating capacity comes from assets that are more than 40 years old. Several of its hydroelectric assets are in or approaching typical mid-life age and as a consequence some elements would typically require refurbishment or overhaul. As condition monitoring detects issues, refurbishment requirements are integrated into asset plans and work plans and subsequently implemented. Hydro's thermal facilities (Holyrood, Hardwoods GT, Stephenville GT) are closer to their end-of-life major refurbishment or replacement period typical of similar facilities. Condition assessments have been undertaken and refurbishments or partial replacements have been evaluated and have been or are planned to be implemented as appropriate. Some parts are still likely to have a higher risk of failure despite predictive and preventative maintenance due to physical age and may fail without warning (such as the Unit 3 FD fan motor windings).

Hydro's critical spares tracking and management until 2011 has been done primarily on a local facility basis reflecting experience, condition assessments and vendor recommendations, and is constantly evolving over the past years and decades, and continues to do so. After an initial three year development and assessment period beginning in 2011, a comprehensive pilot project to the equipment level at Holyrood in 2013 of Hydro's asset criticality and critical spares tracking and management plans, provided valuable feedback at an initial "Lessons Learned" assessment that was undertaken January 30, 2014 event. This should be followed up on, as is Hydro's plan, in early 2014 following the work on the January 2014 incident. This will move the process towards a more comprehensive and cost effective approach consistent with industry practice and will address critical issues before winter 2014/15 as a part of the overall asset management program for the winter of 2014/15.

Recommendation		Status
GA1	Continue condition assessment and life management activities to identify timely refurbishment and replacement needs.	In Progress – ongoing
GA2	Through the existing Critical Spares Council, follow-up on the critical spares program as is currently in Hydro's plan in early 2014.	Planned - June 30, 2014

5.2 Gas Turbine Availability (For Availability Details – Appendix 2)

Hydro's Hardwoods and Stephenville gas turbine generating assets are in the final phase of a major overhaul period which has been undertaken to address the historic poor availability and performance compared to industry averages. The Hardwoods unit has been substantially refurbished. The Stephenville unit has been partially refurbished and the generator retaining rings replaced. It has two years remaining in its refurbishment plan. The actions to date should result in improved availability and performance going forward. The generator work should also enhance the unit life and safe operation in their synchronous condenser role.

Hardwoods and Stephenville gas turbines were unavailable or de-rated during the January 2 to 8, 2014 system event due to issues identified late in major planned generator refurbishments (Hardwoods fuel valve failure; Stephenville B end replacement of deteriorated asbestos pipe couplings and deteriorated insulating blankets). There was a subsequent Stephenville B engine failure on January 8, 2014. Their unavailability contributed to the size and duration of the rotating outages in the period between January 2 and 4, 2014 and during system restoration attempts between January 4 and January 8, 2014.

The unavailability or de-rating of the Hardwoods and Stephenville gas turbines were not a causal factor in, nor would their operation have mitigated, the January 4 to 5, 2014 transmission/terminal station failure events.

Hydro has a priority contract in place for its gas turbine fuel delivery, but managed its demands to minimize the delivery impacts on other liquid fuel users. Hydro's gas turbine fuel inventory levels were maintained below maximum available storage levels.

Recommendation		Status
GA3	Review the maintenance tactics of the Hardwoods and Stephenville gas turbines.	In Progress - Units refurbished. May 30, 2014
GA4	Assess the impacts of increasing the frequency of starting and running the GT's prior to severe weather to allow time to identify and correct issues.	In Progress – May 30, 2014
GA5	Identify repeat failure events on the GT units and address the root causes.	In Progress – Aug 30, 2014
GA6	Continue to review actual work completed on recent overhauls. Identify and plan for additional GT balance of plant equipment refurbishment not completed.	In Progress – April 30, 2014
GA7	Complete review of GT site fuel storage operating requirements, processes and procedures.	In Progress - April 30, 2014

5.3 Holyrood Availability (For Availability Details – Appendix 3)

Hydro's Holyrood thermal generating station assets availability and performance up to 2013 are consistent with industry averages. Its 2013 availability and performance was significantly poorer due to the time required to repair Unit 1 after it was damaged during tripping in the January 2013 extreme weather event and an extended planned outage on Unit 3 for some equipment replacements.

Hydro's Holyrood generating assets' availability and performance did not contribute to the initiation or duration of the January 4 to 5, 2014 transmission/terminal station failure events. They responded as they should have to the initial transmission system failures when the system separated the large hydroelectric supply in the west from the large load in the east. The Holyrood units could not sustain the load and so they tripped off. They were returned to service as the system was restored.

Holyrood Unit 1's first re-start was delayed due to turbine vibration issues related to the thermal shock of the trip and the pace at which it was re-started, as well as to remaining issues from the January 2013 failure trip and repairs. This was resolved by employing a slower, staged start-up approach.

Hydro's Holyrood generating assets unavailability and/or de-ratings did contribute to the number and/or duration of the rotating outages between January 2 to 4, 2014 and during the system restoration activities between January 4 to 8, 2014. The rotating outage impacts in the period January 6 to 8, 2014, were largely due to Unit 1 which was available to generate but unable to connect to the System due to a terminal station breaker issue. If some or all of the following had been avoided or resolved more quickly, some of the rotating outages might have been avoided or reduced:

- Holyrood Unit 3 was de-rated from 150 MW to about 50 MW from December 26, 2013 to January 12, 2014 due to an FD fan motor winding failure

- Holyrood Unit 2 had a steam turbine valve issue and was de-rated 25 MW to 142 MW from December 25, 2013 to January 2, 2014, when inspections and repairs were made. Keeping the unit on line even in a de-rated state was important and delayed the de-rate recovery until January 2, 2013.

Holyrood's 4 kV motors are subject to physical and operational aging and the station has no spare 4 kV motors. Although the motors were removed, repaired and re-installed expeditiously, the potential impact during repairs on available capacity is significant. The Unit 3 FD fan motor windings failure contributed significantly to the duration and extent of some of the rotating outages.

Recommendation		Status
GA8	Investigate improvements to Holyrood Unit 1 steam turbine generator to prevent future vibration issues and reduce starting times.	In Progress (May 30, 2014)
GA9	Review in early 2014 the cost-benefit analysis of one or more spare 4 kV motors for Holyrood.	In Progress (May 1, 2014)

5.4 Hydro Generation Availability (For Availability Details – Appendix 4)

Hydro's hydroelectric generating assets availability and performance up to 2013 are consistent with or better than industry averages.

Hydro's hydroelectric generating assets availability and performance did not contribute to the initiation or duration of the January 4 to 5, 2014 transmission/terminal station failure events. Hydroelectric generating facility unavailability and/or de-ratings did contribute to the number and/or duration of the rotating outages between January 2 to 4, 2014 and during the system restoration January 4 to 8, 2014.

Granite Canal tripped off on January 2, 2014 and was not available through that evening and was de-rated from 40 MW to 32 MW due to turbine vibrations (suspect water temperature, ice build-up issue) until January 3, 2014. Exploits River was de-rated from 63 MW to approximately 38 MW due to severe frazil ice build-up.

Recommendation		Status
GA11	Investigate further Granite Canal turbine vibration issues as/when they occur and develop mitigation plans.	In Progress (Dec 31, 2014)
GA12	Document Exploits River operational response to severe frazil ice buildup for future use as a best practice.	In Progress (May 30, 2014)

5.5 Wind Generation Availability (For Availability Details – Appendix 5)

Wind generation assets are not usually counted on to provide capacity due to the intermittent nature of wind energy. For example, in periods of very high wind or low/no wind, these units are not available for generation. Wind turbine generators (private power purchases of 54 MW) have been very reliable, with few low/high wind periods or extreme weather (icing) outages. They were, however, tripped out of service January 3, 2014 due to high winds and transmission system conditions. They required inspections up the towers and manual intervention by the private developers to be reconnected. Due to bad weather conditions and access road closures and conditions, this restart was delayed to between January 6 and 8, 2014. At noon on January 8, 2014, St. Lawrence wind was on at full capacity of 27 MW and Fermeuse was at 23 MW.

There are no recommendations related to the wind generators.

ACRONYMS

AC	Asset Criticality
AM	Asset Management
BDE	Bay d'Espoir
BOD	Board of Directors
CBC	Come-By-Chance
CBPP	Corner Brook Pulp & Paper
CEA	Canadian Electricity Association
CEO	Chief Executive Officer
CM	Corrective Maintenance
CS	Critical Spares
EPRI	Electric Power Research Institute
FD	Forced Draft
GS	Generating Station
GT	Gas Turbine
HRD/HTGS	Holyrood Thermal Generating Station
JDE	JD Edwards
OEM	Original Equipment Manufacturer
NLH	Newfoundland and Labrador Hydro
P&P	Pulp and Paper
PM	Preventive Maintenance
PUB	Board of Commissioners of Public Utilities
SOE	Sequence of Events
SSD	Sunnyside Terminal Station
T&D	Transmission and Distribution
TS	Terminal Station
WAV	Western Avalon Terminal Station

Appendices

Detailed Capability Comparison

The following tables indicate which facilities were available to produce generation at peak load on the days indicated.

Available Island Interconnected Generating Capacity (MW)

	Used for Planning Purposes (at Peak)	December 1, 2013 at 1715 hours	December 29, 2013 at 1705 hours
Hydraulic			
Bay d'Espoir	592	617	617
Cat Arm	127	138	138
Upper Salmon	84	88	88
Hinds Lake	75	78	78
Granite Canal	40	41	32
Paradise River & Mini Hydros	9	9	9
Total Hydraulic	**927**	**971**	**962**
Holyrood			
Holyrood Unit 1[3]	170	-	160
Holyrood Unit 2	170	145	140
Holyrood Unit 3	150	145	50
Total Holyrood	**490**	**290**	**350**
Standby GTs and Diesels			
Hardwoods GT	50	-	-
Stephenville GT	50	30	-
St. Anthony & Hawkes Bay Diesels	15	14	14
Total Standbys and Diesels	**115**	**44**	**14**
Purchases			
Exploits River Plants	91	88	48
Star Lake	18	18	18
Rattle Brook	3	4	-
Wind Generation	22	29	34
Corner Brook P & P Co-gen	15	8	8
Corner Brook P & P Interruptible	-	-	60
Total Purchases	**149**	**147**	**168**
Deer Lake Power[2]	**101**	**121**	**61**
Newfoundland Power	**97**	**127**	**120**
Total Island Capacity	**1,879**	**1,700**	**1,675**
Total NLH System Capacity (Including Purchases)	**1,681**	**1,452**	**1,494**
NLH System Peak Load		**1,214 at 1655 hours**	**1,418 at 1725 hours**
CBPP Interruptible actually taken[1]		**0**	**20**
Island Peak Load		**1,387 at 1715 hours**	**1,597 at 1705 hours**

(1) When CBPP Interruptible is used, to determine what the actual Island Peak Load would have been, the amount of Interruptible actually used should be added to the Island Peak Load.
(2) When CBPP Interruptible is available, Deer Lake Power available capacity is reduced to 61 MW.
(3) A unit at Holyrood was out-of-service on Dec 01, as it was not required in service due to system demands being lower.

Available Island Interconnected Generating Capacity (MW)

	January 4, 2014 at 0905 hours	January 4, 2014 at 2355 hours	January 15, 2014 at 1715 hours
Hydraulic			
Bay d'Espoir[3]	617	617	540
Cat Arm	138	138	138
Upper Salmon	88	88	88
Hinds Lake	78	78	78
Granite Canal	32	32	-
Paradise River & Mini Hydros	9	-	9
Total Hydraulic	**962**	**953**	**853**
Holyrood			
Holyrood Unit 1	165	-	165
Holyrood Unit 2	165	165	165
Holyrood Unit 3	50	-	150
Total Holyrood	**380**	**165**	**480**
Standby GTs and Diesels			
Hardwoods GT	-	-	50
Stephenville GT	30	30	25
St. Anthony & Hawkes Bay Diesels	14	14	14
Total Standbys and Diesels	**44**	**44**	**89**
Purchases			
Exploits River Plants	38	38	70
Star Lake	18	18	18
Rattle Brook	-	-	4
Wind Generation	-	-	49
Corner Brook P & P Co-gen	2	-	7
Corner Brook P & P Interruptible	60	60	60
Total Purchases	**118**	**116**	**208**
Deer Lake Power[2]	**61**	**61**	**61**
Newfoundland Power	**128**	**128**	**124**
Total Island Capacity	**1,693**	**1,467**	**1,815**
Total NLH System Capacity (Including Purchases)	**1,504**	**1,278**	**1,630**
NLH System Peak Load	**1,464* at 0905 hours**	**1,122* at 2325 hours**	**1,041 at 1720 hours**
CBPP Interruptible actually taken[1]	**60**	**60**	**0**
Island Peak Load	**1,529* at 0810 hours**	**1,233* at 2355 hours**	**1,243 at 1715 hours**

*Peak occurred prior to the Sunnyside event, when Holyrood Unit 1 was online

(1) When CBPP Interruptible is used, to determine what the actual Island Peak Load would have been, the amount of Interruptible actually used should be added to the Island Peak Load.

(2) When CBPP Interruptible is available, Deer Lake Power available capacity is reduced to 61 MW.

(3) A unit at Bay d'Espoir was out-of-service on Jan 15, as it was not required in service due to system demands being lower.

Events Preceding the January 2014 System Event

- December 11, 2013 The Hardwoods GT jacking oil pump failed. Stephenville GT jacking oil pump was temporarily removed and installed at Hardwoods. Stephenville GT was temporarily unavailable while replacement pump obtained and installed. No resulting customer supply issue.

- December 15-16, 2013 The Exploits River generation was reduced to 38 MW from typical 63 MW in winter due to frazil ice (substantial amounts of ice to accumulate in the water channels leading into the Grand Falls generating station, resulting in a reduction in available capacity of approximately 50 MW from 88 MW at the time). Returned to full service January 14, 2014.

- December 16, 2013 The Granite Canal generating unit was de-rated to 32 MW due to axial vibration (likely caused by extreme cold water or turbine ice accumulation)

- December 19, 2013: Hardwoods Gas Turbine out of service for overhaul and alternator replacement. Scheduled return to service date.

- December 21, 2013: Hardwoods GT (50 MW) unit unavailable until January 12, 2014. Final testing after overhaul revealed failure of newly acquired fuel control valve.

- December 23, 2013: The Stephenville Gas Turbine was restored to 25 MW with the installation of a new jacking oil pump that replaced the part removed on December 11, 2013 for use at Hardwoods. End B was unavailable until January 3, 2014 for the replacement of

deteriorated asbestos pipe couplings. The recovery of the remaining 25 MW capacity was pending the delivery and installation of new insulating blankets, scheduled for early January, but on January 5, 2014, it was determined that colder ambient temperatures would allow for increased output without the blankets. On January 8, 2014, the B end of gas turbine failed and tripped reducing the output of the machine to 25 MW. (See Appendix 2 for more detail.)

- December 25, 2013: Holyrood Unit 2 was de-rated by 25 MW, to 142 MW due to a control valve issues. Careful assessment required to recover lost capacity without removing unit from service and delayed the de-rate recovery until about January 2, 2014.

- December 26, 2013: A Holyrood Unit 3 forced draft fan motor failure resulted in a 100 MW de-rating to approximately 50 MW from 150 M. The motor was removed over the next two days, without requiring Unit 3 to be taken out of service. It was repaired in St. John's and returned to service January 12, 2014.

- December 26, 2013: Minor de-rate of Granite Canal (Corrected Jan 2, 2014).

The following tables provide an account of the events and actions each day related to generation leading up to the rotating outages on January 2, 2014. They also identify where discussions on the Generation Loading Sequence and Shortage Protocol were held.

Date	Event	Actions	Supply and Demand (at Peak)
Thursday, December 26	Holyrood unit 3 de-rated to 50 MW due to FD fan motor failure.	• Implemented Generation Loading Sequence and Generation Shortages protocol up to Step 8 (with the exception of Step 7) • Communications with Newfoundland Power as to the status of generation assets, load forecasts and protocols. • Communications internally to ensure awareness of the situation.	Demand: 1,385 MW Supply: 1,426 MW
Friday, December 27		• Generation Loading Sequence and Generation Shortages not required. • Communications with Newfoundland Power as to the status of generation assets, load forecasts and protocols.	Demand: 1,331 MW Supply: 1,456 MW

Date	Event	Actions	Supply and Demand (at Peak)
Saturday, December 28	Bay d'Espoir Unit 2 removed from service due to air supply issue with breaker B1T2. No customer impact. The unit was restored by 1138.	• Generation Loading Sequence and Generation Shortages not required. • Forecast peak for December 29 of 1410 MW. Communications with Newfoundland Power regarding this. Preparations made between both utilities to prepare as per the Generation shortage protocol. • Customer conservation message was discussed to potentially be required for December 29. Decision to be made early on December 29.	Demand: 1,354 MW Supply: 1,456 MW

Date	Event	Actions	Supply and Demand (at Peak)
Sunday, December 29	Stephenville Gas Turbine failed to start. Crews dispatched and corrected the problem at 2224.	• Implemented Generation Loading Sequence and Generation Shortages protocol up to Step 13. This included asking Corner Brook Pulp and Paper to shed approximately 28 MW of processing load. • Continued to discuss the potential of issuing a public conservation message but determined it was not required. • Forecast peak for December 30 of 1,420 MW. Continued communications with Newfoundland Power regarding the continuing need to implement the Generation Loading Sequence and Generation Shortages protocol.	Demand: 1,425 MW Supply: 1,470 MW (including load reduction from Corner Brook Pulp and Paper).

Date	Event	Actions	Supply and Demand (at Peak)
Monday, December 30	None	• Implemented Generation Loading Sequence and Generation Shortages protocol up to Step 13. This included asking Corner Brook Pulp and Paper to shed approximately 30 MW in the morning and 52 MW in the evening. • Internal meeting to discuss progress on generation and preparations going forward. • Discussions with Corner Brook Pulp and Paper regarding a more formal capacity assistance arrangement. • Forecast peak for December 31 of 1,400 MW. Continued communications with Newfoundland Power regarding the continuing need to implement the Generation Loading Sequence and Generation Shortages protocol.	Demand: 1,417 MW (morning). 1,420 MW (evening) Supply: 1,458 MW (including load reduction from Corner Brook Pulp and Paper).

Date	Event	Actions	Supply and Demand (at Peak)
Tuesday, December 31 (New Years Eve)	None	• Generation Loading Sequence and Generation Shortages protocol not required. • Capacity Assistance agreement reached with Corner Brook Pulp and Paper for 20, 40 or 60 MW blocks of power. • Forecast peak for January 1 of 1,450 MW. Continued communications with Newfoundland Power regarding the continuing need to implement the Generation Loading Sequence and Generation Shortages protocol.	Demand: 1,393 MW Supply: 1,453 MW
Wednesday, January 1, (New Years Day)	None	• Generation Loading Sequence and Generation Shortages protocol implemented up to Step 13. This also includes capacity assistance from Corner Brook Pulp and Paper for 40 MW during peak. • Forecast peak for January 2 of over 1,500 MW. Continued communications with Newfoundland Power regarding the continuing need to implement the Generation Loading Sequence and Generation Shortages protocol.	Demand: 1,440 MW Supply: 1,484 MW (including load reduction from Corner Brook Pulp and Paper).

Generation Availability During the January 2 to January 8 2014 System Event

The following tables summarize the generation unavailability for January 2 to January 8, 2014 during periods when customer interruptions were occurring, either due to the restoration process following the transmission/terminal station failure events on January 4 and 5, or while the rotating outages were occurring to ration the available supply.

Rotating Outages - January 2-8, 2014						
Plant	Unit Rating (MW)	Jan-2 Unavailable Capacity (MW)	Jan-3 Unavailable Capacity (MW)	Jan-5 Unavailable Capacity (MW)	Jan-6 Unavailable Capacity[1] (MW)	Jan-8 Unavailable Capacity[2] (MW)
Hardwoods Gas Turbine	50	50	50	50	50	50
Stephenville Gas Turbine	50	20	20	20	20	25
Holyrood Unit 3	150	100	100	100	150	100
Holyrood Unit 2	170	5	5	5	170	5
Holyrood Unit 1	170	5	5	170	170	170
Granite Canal Unit	40	8	8	-	-	-
Exploits Generation	63	25	24	26	21	14
Total	693	213	212	371	581	364

Notes:

1. On January 6, HRD Unit 2 (165 MW) and HRD Unit 3 (50 MW) were brought on-line during the period of feeder interruptions. The additional generation, as it became re-established, helped to minimize the duration and impact.
2. On January 8, HRD Unit 1 (165 MW) was brought on-line during the period of feeder interruptions. The additional generation, as it became re-established, helped to minimize the duration and impact.

Generation Supply Issues - January 4, 2014 (as at 0906 hours)			
Plant	Unit Rating (MW)	Unavailable Capacity (MW)	Notes
Hardwoods Gas Turbine	50	50	Unit unavailable due to fuel valve issue
Holyrood Units 1-3	490	490	Units tripped during the system disturbance[1]
Stephenville Gas Turbine	50	50	Unit tripped during system disturbance[2]
St. Anthony and Hawkes Bay Diesels	15	15	Units tripped during system disturbance
Cat Arm Units 1 and 2	127	127	Units tripped during system disturbance
Upper Salmon Unit	84	84	Unit tripped during system disturbance
Hinds Lake Unit	75	75	Unit tripped during system disturbance
Granite Canal Unit	40	40	Unit tripped during system disturbance
Purchases	59	59	Units tripped during system disturbance
Total	990	990	

Notes:

1. Unit 3 derated to 50 MW prior to this event due to forced draft fan failure.
2. Unit previously derated to 30 MW prior to this event due to cooling issues.

The following tables for January 1, January 5 and January 8, 2014 present some additional detail of the generation unavailability during the January 2 to 8, 2014 system event.

January 1, 2014

Generation	Location	Equipment	Reason for Unavailability
	Hardwoods	Gas Turbine	Unit unavailable as assessment and work were underway to correct the fuel valve issues discovered during final testing following the unit alternator replacement and overhaul.
	Stephenville	Gas Turbine	End A was available at 25 MW. Turbine End B was unavailable as it was not tested after new pipe couplings were installed on December 31. There was a concern of tripping End A during these tests and making it unavailable. End B was not restored until after the testing on January 3.
	Holyrood	Unit No. 3	Forced derating to 50 MW (100 MW unavailable) due to a forced draft fan motor failure. Awaiting the replacement coils in order to rewind the motor prior to re-installation.
	Granite Canal	Granite Canal Unit	Unit was derated to 32 MW due to vibration issues experienced above this generation level.
	Exploits	Exploits generation	Exploits generation reduced to 40 MW from 63 MW due to frazil ice issues. The ice removal process was ongoing.

January 5, 2014

Generation	Location	Equipment	Reason for Unavailability
	Hardwoods	Gas Turbine	Unit unavailable as assessment and work were underway to correct the fuel valve issues discovered during final testing following the unit alternator replacement and overhaul.
	Stephenville	Gas Turbine	End A available at 25 MW. It was determined that Turbine End B could be run at full capacity (25 MW) due to the cold ambient temperatures. The installation of Insulating blankets was still required for the longer term.
	Holyrood	Unit No. 3	Forced derating to 50 MW (100 MW unavailable) due to a forced draft fan motor failure. Awaiting the replacement coils in order to rewind the motor prior to re-installation.
	Holyrood	Unit No. 1	the trip during the Sunnyside issues on January 4, 2014 at 0905 hours. The unit was ran up several times and ready to re-sync during the evening hours on January 5.
	Granite Canal	Granite Canal Unit	The unit was operated at 40 MW with personnel on site to monitor. No vibration issues were experienced and ice issues (which had since cleared) were suspected.
	Exploits	Exploits generation	Exploits generation reduced to 37 MW from 63 MW due to frazil ice issues. The ice removal process was ongoing.

January 8, 2014

Generation	Location	Equipment	Reason for Unavailability
	Hardwoods	Gas Turbine	Unit unavailable as assessment and work were underway to correct the fuel valve issues discovered during final testing following the unit alternator replacement and overhaul. Available in synchronous condenser mode.
	Stephenville	Gas Turbine	Both ends underwent testing on this day. End B tripped at 0830 hours. After an assessment later that evening, it was determined that both ends were unavailable. End A became available again in the afternoon on January 9. An assessment of End B was underway.
	Holyrood	Unit No. 3	Forced derating to 50 MW (100 MW unavailable) due to a forced draft fan motor failure. Work to re-wind the motor was ongoing.
	Holyrood	Unit No. 1	Unit outaged (165 MW unavailable) due to switchyard equipment issues experienced during the attempted re-start on January 5, 2014 at 2127 hours. Unit No. 1 was restored to service on January 8, 2014.
	Exploits	Exploits generation	Exploits generation reduced to 45 MW from 63 MW due to frazil ice issues. The ice removal process was ongoing.

Generation Availability after the January 2014 System Event

The following table for January 15, 2014 presents a picture of generation availability after the January 2 to January 8, 2014 system event.

January 15, 2014

Generation	Location	Equipment	Status Update
	Hardwoods	Gas Turbine	Both ends returned to service on January 12 at 1800 hours
	Stephenville	Gas Turbine	End A available at 25 MW. End B unavailable since the trip on January 8. Work is ongoing with the OEM to assess the extent of the damage and repairs.
	Holyrood	Unit No. 3	Unit restored to full capacity January 12 at 1615 hours
	Holyrood	Unit No. 1	Unit returned to service January 8 at 1539 hours
	Granite Canal	Granite Canal Unit	Unit had tripped the previous day (January 14) due to problems with a pressure switch on the governor system. Repairs were made and the unit was returned to service at 2107 hours on January 15 at full capacity (40 MW).
	Exploits	Exploits generation	Generation restored on January 14 (70 MW)

Details – Gas Turbine Availability

Hardwoods Gas Turbine

Plant Information

The 50 MW Hardwoods gas turbine installation, located in the St. John's area, is operated as a synchronous condenser for voltage support of the transmission system on the Avalon Peninsula, and to generate power under system peak and Avalon Peninsula emergency/contingency conditions. The unit is also utilized to enable efficient loading and dispatch of the Holyrood Thermal Generating Station by being available to respond to a contingency which would otherwise have to be provided by having an additional unit operating at Holyrood at inefficient loads.[1]

The Hardwoods gas turbine was installed in 1977 and has been in-service for about 37 years. Between 1993 and 2013, the unit operated in generating mode an average of 69 hours per year (1456 hours over the period) and in synchronous condensing mode an average of 3,057 hours per year (64,196 hours over the period).

In 2007-2008, Hydro hired Stantec consulting engineers to undertake a condition assessment of the Hardwoods and Stephenville gas turbines. Given their age, a number of issues were identified and a four- year refurbishment program was identified. Hardwoods refurbishment was initiated in 2010 for completion in 2013. Some balance of plant work may not have been completed due to resources (i.e. junction boxes and wiring termination replacement/upgrade due to possible corrosion issues).

Gas Turbine Incident Availability

In January 2013, it was determined that the Hardwoods unit should be operated in emergency

[1] The Holyrood generating units cannot be quickly turned on and off like gas turbine units to respond to a system problem. Therefore, to provide the same response as a gas turbine, a Holyrood unit must be placed on line and operated at its minimum output level of 70 MW in order to be available to quickly respond to a problem. As problems are unpredictable, this would result in a Holyrood unit being on for many days consuming large amounts of fuel when there would otherwise be no requirement for the unit to operate.

conditions only. This restriction was based on the recommendations from Brush GMS (Brush), the alternator original equipment manufacturer (OEM), due to conditions identified during an inspection of its sister unit in Stephenville in 2012. During this inspection, it was discovered that the rotor retaining rings on the Stephenville unit had cracks that could have led to a catastrophic failure of the unit if it had continued to operate. Based on these findings, and the fact that the Hardwoods and Stephenville alternators were both installed in 1976-77, in service for over 35 years and have never had the rotor retaining rings replaced, Brush recommended that the Hardwoods unit be restricted to run only in emergency conditions until a repair/refurbishment of the unit (including replacement of the retaining rings) could be carried out.

This unforeseen repair caused Hydro to re-evaluate its 2013 planned generation outage schedule. Project planning proceeded with the evaluation of the available options for the repair/refurbishment of the Hardwoods unit. After considering the options, it was decided that the most cost efficient and optimal approach was to replace the alternator. The earliest project implementation start date was October 1, 2013, even with aggressive expedited delivery of the replacement alternator from Brush, and involved a 2.5 month outage to the unit.

Hydro also considered the operating forecast for December 2013 which indicated at the time that there were appropriate reserves on the system to accommodate the outage and still meet forecast demand. Furthermore, once this outage window for Hardwoods was set, Hydro considered the unavailability of this unit in the scheduling and outage planning of the remaining generation to continue to provide for safe and reliable operation of the power system. It has been past practise, if required, to allow a generation outage to extend into December if the operating load forecast can accommodate it.

Hydro submitted an application to the PUB on April 24, 2013 for the approval of the recommended least cost option which was subsequently approved in May 2013.

The scope of work for the alternator replacement was significant including:

- An asphalt crane pad for removal and installation of the alternator assemblies;
- Relocation of the main lube oil cooler to allow crane access;
- Disassembly of the alternator enclosure, air treatment system and stator canopy;
- Disconnection of all auxiliary systems - electrical, mechanical, and fire protection;
- Removal of existing alternator and site assembly of new alternator (rotor and stator);
- Installation and alignment of the new alternator in the enclosure;
- Reassembly of the alternator enclosure;
- Reconnection of auxiliary systems and recertification of the fire protection system; and
- Commissioning.

The outage began on October 3, 2013, once Holyrood Unit 2 was in full operation. Work proceeded on a six day per week, ten hour per day schedule and the unit was placed on- line for testing on December 17, 2013. The unit tested successfully to full load (50 MW) on December 19, 2013. However, during run-up tests for remote operation on December 20, 2013 there was an unexpected failure of a fuel control valve that made the unit unavailable again. Given the holiday period and the unavailability of the required vendor equipment and service expert, repairs on the Hardwoods gas turbine were delayed and the unit was not restored to full service until January 12, 2014.

Hydro exercises their peaking GT units once per month to maintain availability. The Hardwoods GT generally runs well once it is on line. Similar to many vintage gas turbines, reliable start-up can sometimes be an issue, but is usually overcome by one or more restarts. The following table documents 32 start failures of the Hardwoods units between January 2000 and January 2013. This is fairly low average of approximately 2.5 per year.

Gas Turbine Starting Failures from January 1, 2000 to December 31, 2013

Unit	Start_Date	Finish_Date	State Code
HWDT	2000/03/03 11:42	2000/03/03 16:23	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2000/03/11 9:18	2000/03/11 9:52	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2000/06/27 11:18	2000/06/27 11:25	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2000/10/10 11:52	2000/10/10 12:02	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2000/12/04 16:39	2000/12/04 17:19	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2000/12/07 22:07	2000/12/07 22:47	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2000/12/10 9:12	2000/12/10 11:08	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2000/12/24 17:00	2000/12/25 14:40	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2000/12/24 17:01	2000/12/25 14:40	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2001/06/02 13:09	2001/06/02 17:46	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2001/08/31 8:08	2001/08/31 8:17	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2002/01/24 11:31	2002/01/24 13:45	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2002/01/31 8:28	2002/01/31 8:32	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2002/01/31 8:32	2002/01/31 10:26	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2002/02/13 7:36	2002/02/13 8:42	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2002/05/22 13:26	2002/05/22 14:22	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2004/09/19 22:46	2004/09/19 23:43	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2005/09/02 12:18	2005/09/02 13:35	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2006/01/23 6:58	2006/01/23 7:02	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2007/03/09 4:37	2007/03/09 6:13	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2007/04/03 7:19	2007/04/03 15:37	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2007/04/03 15:48	2007/04/03 15:56	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2007/11/08 12:55	2007/11/08 13:06	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2007/12/21 15:11	2007/12/21 15:44	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2008/07/11 15:18	2008/07/11 15:41	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2009/01/08 8:12	2009/01/08 10:13	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2009/07/20 15:58	2009/07/21 11:38	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2009/09/26 17:56	2009/09/27 10:59	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2011/01/31 11:43	2011/02/01 15:03	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2012/02/15 13:12	2012/02/21 20:53	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2012/02/29 10:56	2012/03/10 13:32	21 (4)-FO-4 : Forced Outage - Starting Failure
HWDT	2013/02/09 11:09	2013/02/09 12:24	21 (4)-FO-4 : Forced Outage - Starting Failure

Stephenville Gas Turbine

Plant Information

The Stephenville gas turbine is operated as a synchronous condenser for voltage support of the transmission system on the west coast, and to generate power under system peak and emergency/contingency conditions. Like Hardwoods, there are two ends to the Stephenville

gas turbine (A and B), both rated at 25 MW each.

The gas turbine was installed in 1976 and has been in-service for approximately 38 years. Between 1993 and 2013, the unit operated in generating mode an average of 29 hours per year (607 hours over the period) and in synchronous condensing mode an average of 2,461 hours per year (51,679 hours over the period).

In 2007- 2008, Stantec undertook a condition assessment. Given the unit's age and operating history a number of issues were identified and a refurbishment program was put in place with two years remaining before completion.

Gas Turbine System Incident Availability

The planned major overhaul at the Stephenville Gas Turbine was completed in the summer of 2013 after completion of an alternator refurbishment (a stator and rotor rewind). In June 2013, the unit was released for service. At this time, it was determined that there was deterioration of the insulation blankets (to prevent excessive heat build-up and a potential trip) on End B, and it was limited to an output of 15 MW, a de-rating of 10 MW from the engine's rated output of 25 MW. It was limited to 30 MW when both ends were operating due to the requirement to keep the output on each end equal. The unit was also released for full synchronous condenser capability.

The blankets on End B required replacement to restore the unit to its original operating condition. These were the original blankets on the unit and specifications had to be developed before a quotation could be obtained. On-site inspections and data collection were required to develop the specification in consultation with the supplier. A quotation for the supply and installation of the insulating blankets on October 18, 2013 would not meet Hydro's date for winter readiness so another supplier quote was received on December 3, 2013 and a purchase order placed. The blankets were received at the end of the first week of January 2014.

End A remained fully available until Dec 11, 2013 when a jacking oil pump was temporarily removed to replace a failed pump at Hardwoods in order to maintain the return to service schedule at Hardwoods. Because of the critical nature of the Hardwoods Gas Turbine, due to its location on the Avalon Peninsula to provide both transmission and system capacity backup during transmission and generation contingencies, there was a very high focus on returning this unit to service. On December 23, a new jacking oil pump was installed on the Stephenville Gas Turbine. Synchronous condenser capability and End A were restored to 25 MW. End B was unavailable pending the replacement of deteriorated asbestos pipe couplings on the unit.

On December 29, 2013, a frozen airline prevented End A from being started. This was repaired that day and the unit was restored by the evening to End A at 25 MW. End B at 0 MW and synchronous condenser capability. On December 31, 2013, the pipe couplings were installed. The repairs were not tested until January 2, 2014, due to the risk of tripping the entire unit during the test. On January 3, 2013, End B was tested and once again became available for generation at 15MW. On January 5, 2014, End A was shut down to check the oil level and look for a leak. Given the cold external temperatures, it was determined that End B could be run up to 25 MW resulting in the unit being restored to its full capacity of 50 MW. On January 8, 2014, End B tripped, making the end unavailable and resulting in a de-rating of the Stephenville Gas Turbine to 25 MW.

A representative from Alba Power, who previously overhauled the unit, travelled to the site on January 9, 2014. The Alba representative along with Hydro carried out an initial visual inspection, including an internal bore scope inspection, and determined that End B suffered a major failure and would require further investigation to determine the root cause.

As of January 27, 2014, the gas turbine was available in generate mode with End A at 25 MW and End B at 0 MW. The unit is also available for synchronous condenser operation. The End B engine is currently with Alba at their facility in the United Kingdom being repaired The B end

engine has been replaced with a vendor engine and the unit is currently operational at up to 40 MW capacity.

Hydro exercises their peaking GT units once per month to maintain availability. The Stephenville GT like Hardwoods generally runs well once it is on line. The following table shows the 17 start failures of the Stephenville unit between January 2000 and December 2013, for a fairly low average of approximately 1.3 per year.

Gas Turbine Starting Failures from January 1, 2000 to December 31, 2013

Unit	Start_Date	Finish_Date	State Code
SVLT	2001/05/28 4:13	2001/05/29 12:02	21 (4)-FO-4 : Forced Outage - Starting Failure
SVLT	2001/05/28 4:16	2001/05/28 16:51	21 (4)-FO-4 : Forced Outage - Starting Failure
SVLT	2001/10/27 9:52	2001/10/27 10:05	21 (4)-FO-4 : Forced Outage - Starting Failure
SVLT	2001/12/04 8:03	2001/12/04 8:14	21 (4)-FO-4 : Forced Outage - Starting Failure
SVLT	2004/09/30 10:57	2004/09/30 11:05	21 (4)-FO-4 : Forced Outage - Starting Failure
SVLT	2004/12/13 17:18	2004/12/14 7:36	21 (4)-FO-4 : Forced Outage - Starting Failure
SVLT	2005/10/21 0:07	2005/10/21 0:51	21 (4)-FO-4 : Forced Outage - Starting Failure
SVLT	2005/10/25 22:05		21 (4)-FO-4 : Forced Outage - Starting Failure
SVLT	2006/01/23 6:57	2006/01/23 9:01	21 (4)-FO-4 : Forced Outage - Starting Failure
SVLT	2006/08/17 17:22	2006/08/18 0:28	21 (4)-FO-4 : Forced Outage - Starting Failure
SVLT	2007/08/07 13:24	2007/08/07 13:43	21 (4)-FO-4 : Forced Outage - Starting Failure
SVLT	2007/09/26 13:19	2007/09/26 13:35	21 (4)-FO-4 : Forced Outage - Starting Failure
SVLT	2007/11/01 7:12	2007/11/01 7:19	21 (4)-FO-4 : Forced Outage - Starting Failure
SVLT	2008/10/30 6:19	2008/10/30 6:22	21 (4)-FO-4 : Forced Outage - Starting Failure
SVLT	2008/10/30 6:22	2008/10/30 6:30	21 (4)-FO-4 : Forced Outage - Starting Failure
SVLT	2008/10/31 12:12	2008/10/31 15:09	21 (4)-FO-4 : Forced Outage - Starting Failure
SVLT	2010/01/20 9:11	2010/01/20 14:18	21 (4)-FO-4 : Forced Outage - Starting Failure

Factors that contributed to unplanned unavailability

Essentially three factors contributed to the unplanned unavailability of the Hardwoods and Stephenville gas turbines:

- Age and condition of the turbines and generators, particularly the retaining rings in this case (no recent major overhaul/refurbishment/replacement) and the January 8 failure of End B;
- Replacement equipment initial installation failure (fuel valves); and

- Timing of component deliveries, insulation blankets in this case, and expert availability in critical periods.

The only aspect that could have been significantly different would have been the earlier identification and procurement of the Stephenville insulation blankets. Special efforts were made to expedite higher priority work (temporary removal of jacking oil pump from Stephenville to Hardwoods and new alternator procurement for Hardwoods).

Scheduling of GT overhauls/outages

The generator end ring issue was unexpected, and was found during refurbishment of Stephenville in 2012. As indicated, the scheduling of the repairs as originally planned, took into account the extension into the normal winter readiness period, the priority requirements of other outage requirements (Holyrood Units), and the expected generation/load match. The equipment would have been ready for service for winter readiness purposes and the January 2014 system event had other issues not occurred. It is possible that some of the equipment issues, particularly the insulation blanket, could have been recognized and addressed earlier.

Details – Holyrood Availability

Plant Information

Holyrood Thermal Generating station is a three unit 1969-1979 vintage heavy oil fuelled power plant. Units 1 and 2 are rated at 170 MW (originally 150 MW) commissioned in 1970-71 and uprated in 1988-89. Unit 3 is a 150 MW unit that entered service in 1979 and was retrofitted with additional equipment to enable it to run as a synchronous condenser.

The plant typically runs seasonally base loaded in winter with minimal cycling impacts due to the modest band of operation from 70 to 150 MW most of the time. Unit 3 generator runs as a synchronous generator in other parts of year, typically summer.

Factors that contributed to unplanned unavailability

Holyrood's early life availability was strongly influenced by the high sulphur, high vanadium heavy fuel oil that it consumed. Frequent winter shutdowns for boiler cleaning and tube leak repairs were the norm. A switch to a higher quality oil in 2006 through 2009 greatly reduced the winter unavailability due to fuel causes. In 2013, a new fuel contract resulted in a more erosive ash, with a propensity to precipitate out heavier liquids/solids in storage and handling systems. This has resulted in some equipment failures/repairs requiring short outages and significant cost issues with the fuel storage and handling systems, particularly in early to mid-2013. Through additional maintenance and parts and fuel quality adjustments with the supplier, Hydro has reduced the impacts for the 2013-14 winter period.

Given that the plant typically runs winter seasonally base loaded with minimal cycling impacts (due to the modest band of operation from 70 to 150 MW most of the time), the equipment is largely in reasonable to good condition. The equipment that deteriorates with time, as opposed to use, is approaching end of life and being replaced. Some of the major equipment, such as the generators, are reaching a life stage where issues may arise. Advanced and more frequent monitoring will help. Refurbishment may become desirable as condition assessments indicate further deterioration, but the expected generation life of between 2017, and in a standby role to 2021, also makes any significant investment more difficult to justify. This would include

significant investments in large, expensive major spares, such as large 4kV motor spares, that would have a very limited useful life.

Hydro carried out extensive condition assessment on Holyrood in 2011 to 2013, and continues to do so, particularly of the critical at-risk systems. This includes the high pressure, high temperature steam and water boiler components to reduce the risk of major steam system failures that could have major facility and safety impacts. The ongoing assessments have resulted in some in-situ repairs, but generally have found conditions to be consistent with operating to the expected end of generation operation. Major turbine and generator and auxiliary testing and overhauls continue on their regular schedule for reliability and maintainability purposes. Routine preventative maintenance and corrective work also continues.

The unavailability of 100 MW from Holyrood Unit 3 due to the failure of a Unit 3 FD fan motor on December 26, 2013 was the most significant generation capacity de-rating during the period of the rotating outages on January 2 to January 8, 2014. While its unavailability would not have caused the larger transmission/terminal station failure events on January 4 and January 5, 2014, the 100 MW loss was a major factor in the rotating outages prior to and during the restoration from those failure incidents. The motor was removed, shipped to a local supplier and returned and reinstalled on January 12, 2014.

A spare 4 kV FD fan motor had been suggested for procurement consideration in the 2011 condition assessment. It was examined and costed and submitted as part of the 2012 capital approval process, but was not pursued further based on Hydro's capital prioritization process. The subsequent year it was determined not to be a capital item and has not proceeded further as yet. Given the quick turnaround in the significant repair, a prioritization decision to procure a spare is a difficult one. One spare to address all the 4kV motors on Units 1 to 3 would be difficult to implement due to different sizes. Unit 1 and 2 have larger motors than Unit 3 and BFP motors are a different size from FD fan motors. Given the recent failures, the issues of spares versus the timeliness and impacts of repairs should be revisited.

Details – Hydroelectric Generation Availability

Granite Canal – Turbine Generator Vibration

In mid-December, 2013, the Granite Canal unit was de-rated from 40 MW to 32 MW, as axial vibration was being experienced when the unit was run past that limit. The cause of the vibration was unknown. This unit experienced a similar vibration issue in February 2012. Neither Hydro nor the OEM was able to determine a definite cause of the vibration. One theory at the time was related to the cold temperature of the water.

Given the very high system demand through the end of December 2013, it was decided to leave the unit operating on a de-rated basis until the system load came back down and a maintenance outage could be scheduled. At approximately 16:30 on January 2, 2014, the unit tripped due to a suspected vibration issue.

On January 3, 2014, crews arrived on site and returned the unit to service at approximately 30 MW. Vibration issues with the unit remained at over 32 MW. The work crew stayed with the unit through the weekend to ensure a timely response to any further issues given the pending weather and the system generation issues.

On January 4, 2014, the unit tripped again. This time it was due to the system imbalance caused by the issues at Sunnyside and elsewhere. The unit was brought back in service in less than one hour to approximately 32 MW. The crew remained with the unit.

On January 5, 2014, due to system demand, the crew ran the unit to 40 MW, maximum capacity, and the vibration issue was no longer present. It was suspected that there could have been ice formations causing the vibration and that the ice had come off the unit. Crews stayed with the unit through to January 8, 2014, and the system demand was reduced.

Exploits River – Frazil Ice Build-Up

Exploits River generation was initially reduced to 38 MW below the typical 63 MW obtained in winter due to frazil ice [1] buildup. There was a significant shift of a substantial amount of ice that accumulated in the water channels leading into the Grand Falls generating station, ultimately resulting in a reduction in available capacity of approximately 50 MW (from 88 MW at the time). Crews quickly responded to try to clear out the ice to the extent possible. Crews continued to work to remove the ice until January 14, 2014, when, through a combination of milder temperatures and the efforts of ice removal, the plant was restored to normal.

[1] Frazil ice is a collection of loose, randomly oriented needle-shaped ice crystals, sometimes resembling slush that are formed in turbulent water. It sporadically forms in open, turbulent, supercooled water, which means that it usually forms in rivers, lakes and oceans, on clear nights when the weather is colder.

Details – Wind Generation Availability

Wind generation is provided from two sites. St Lawrence Wind Project (ENEL Green Energy Power Canada Inc.) produces about 27 MW from nine Vestas V90 3.0 MW wind turbines. The project has produced on average over the last four years about 104,000 MWh/Year and thus operates at over 43% capacity factor. Fermeuse Wind is also a 27 MW wind project. The average production over the last three years has been about 87,300 MWh/Year and thus operates at about a 37% capacity factor. These are both excellent values and reflective of both good wind sites and good turbine availability.

St Lawrence Wind Project in 2012 was available 8566.4 hours of 8784 hours or an availability of about 97.5%. The facility experienced seven occurrences where it had to be restarted from offline. It had a total of 138 hours due to forced outages from balance of plant (BOP) equipment. There were no full day low wind days or no full day excessive wind days. Extreme wind and icing caused one day off associated with its substation. There were visual observations of thirteen lightning related days, and two freezing air/icing storms. There was 6.7 hours of outage due to extreme weather on one day attributable to Hurricane Leslie. All told, there were six extreme weather days in 2012 affecting the turbines or their associated substations, all in December through February.

Factors that contributed to unplanned unavailability

Extreme weather and system interruptions are the primary causes of unplanned unavailability. Prior to the January 2014 event, extreme weather related specifically to the turbines and auxiliaries was low. For example, it was just six days in 2012 for 50% of the installed capacity.

In the January 2014 system event, the St. Lawrence wind farm came off line at approximately 19:00 on January 3, 2014, due to weather conditions and high winds. On January 4, 2014, the wind farm lost grid power early in the morning due to the system events. The farm was subsequently unavailable until January 6, 2014. This was a result of icing conditions on the

turbines and the requirements to complete inspections on the turbines. The inspections required climbing the towers which could not be done for periods due to high winds. The return to service was also delayed by the inability of crews to get to the site due to road closures and bad road conditions.

The Fermeuse wind farm came off line on January 3, 2014, related primarily to the weather conditions and high winds. These turbines came back in service between January 5 to January 8, 2014, at various levels of production. Issues were similar to those at the St Lawrence wind farm.

A key issue is that the units have to be manually reset on site when tripped. In the January 2014 system event, extreme weather, as well as system issues on January 3, 2013, resulted in the shutdown of the 54 MW of wind generation facilities. The weather and access closures limited access to the facilities by the private developer's staff to inspect and reset the units. This extended the time to get to the units back in service -- between January 6 and January 8, 2014. At noon on January 8, 2014, St. Lawrence wind was on at full capacity of 27 MW and Fermeuse was at 23 MW.

Details – Under Frequency Event History 2004 to 2013

Details of Under-Frequency Events 2004-2013 as per Section 3.3 are presented below.

Year	Event	Date/Time	Generation Loss (MW)	Number of Customers Affected				Initiating Event
				Total	NF Power	Industrial	Hydro	
2004	1	Feb 20, 2004 09:15 AM	115	11,030	8,849	2	2,179	Holyrood Unit 2 - Exciter Problem
	2	Mar 07, 2004 10:03 PM	143	13,181	11,000	2	2,179	Holyrood Unit 2 - Loss of Station Service
	3	Apr 13, 2004 08:37 PM	125	13,996	11,814	3	2,179	Holyrood Unit 3 - Fuel System
	4	Aug 15, 2004 02:42 AM	45	1	0	1	0	Cat Arm Unit 2 - Fire System Failure
	5	Sep 21, 2004 01:43 PM	141	17,920	13,411	3	4,506	Bay d'Espoir Unit 7 - Exciter testing
	6	Oct 07, 2004 12:30 PM	100	12,646	8,138	2	4,506	Holyrood Unit 1 - DCS Testing
	7	Dec 21, 2004 03:53 PM	81	24,218	23,006	2	1,210	Holyrood Unit 1 - Inadvertent Trip
2005	1	Mar 22, 2005 12:54 PM	61	3,527	2,306	1	1,220	Hinds Lake Unit - Trip during testing
	2	May 09, 2005 06:26 PM	N/A	31,243	29,180	3	2,060	Problem with governor on Bay d'Espoir Unit 6 caused a significant drop in system frequency
	3	Jul 20, 2005 03:16 PM	80	2	0	2	0	Cat Arm Units 1 and 2 - Lightning Strike to TL247
	4	Sep 02, 2005 12:00 PM	N/A	71,011	64,566	3	6,442	A significant frequency disturbance resulted after all on-line units responded to a frequency oscillation.
	5	Sep 10, 2005 10:51 AM	80	10,205	8,698	3	1,504	Holyrood Unit 3 - Station Service Issues
2006	1	Jan 06, 2006 09:32 AM	110	10,818	8,763	2	2,053	Holyrood Unit 2 - Boiler Tube Leak
	2	Apr 12, 2006 01:11 PM	70	7,254	6,035	1	1,218	Holyrood Unit 3 - Inadvertent Trip
	3	May 15, 2006 11:44 AM	55	7,253	6,034	1	1,218	Cat Arm Unit 1 - Fire System Failure
	4	May 17, 2006 09:20 AM	67	7,253	6,034	1	1,218	Bay d'Espoir Unit 1 - High Bearing Temp
	5	Dec 15, 2006 12:55 AM	50	6,319	5,482	1	836	Holyrood Unit 3 - Fuel Oil Controls
	6	Dec 20, 2006 06:57 PM	62	2,258	2,257	1	0	Bay d'Espoir Unit 1 - Spherical Calve Closed
2007	1	Feb 10, 2007 01:46 PM	120	24,047	21,987	1	2,059	Cat Arm Units 1 and 2 - TL247 Trip (Icing)
	2	Mar 23, 2007 09:53 AM	75	7,169	6,328	2	839	Upper Salmon Unit - Fault at Intake
	3	Jun 19, 2007 01:28 PM	50	6,007	5,167	2	838	Holyrood Unit 1 - Loss of Station Service
	4	Oct 12, 2007 12:28 PM	77	8,208	7,369	1	838	Holyrood Unit 3 - Fuel Oil Controls
	5	Nov 25, 2007 12:08 PM	133	29,139	27,592	2	1,545	Holyrood Unit 1 - Boiler Trip
	6	Dec 28, 2007 02:21 PM	120	13,592	12,046	1	1,545	Holyrood Unit 1 - Lube Oil Pump Failure
2008	1	Jan 01, 2008 12:28 AM	70	8,465	7,504	1	960	Holyrood Unit 3 - Phase wire down on unit transformer
	2	Feb 14, 2008 04:26 PM	145	19,014	16,941	2	2,071	Holyrood Unit 3 - Station Service Issues
	3	Feb 20, 2008 03:57 AM	69	8,266	7,304	2	960	Bay d'Espoir Unit 3 - Stator Ground Fault
	4	Jul 03, 2008 12:31 PM	62	5,250	4,287	1	962	Cat Arm Units 1 and 2 - Lightning Strike to TL247
	5	Jul 29, 2008 10:26 PM	120	49,787	43,775	2	6,010	Cat Arm Units 1 and 2 - Lightning Strike to TL247
	6	Jul 29, 2008 06:09 PM	57	5,136	4,291	1	844	Hinds Lake Unit - High Bearing temp
2009	1	Mar 05, 2009 05:14 PM	90	10,881	9,633	1	1,247	Holyrood Unit 1 - High Drum Level
	2	Jul 29, 2009 10:26 AM	N/A	11,309	10,061	1	1,247	67 MW of generation was removed from system at Corner Brook Pulp and Paper. An overload occurred on the Deer Lake Power system after TL248 was taken out of service for maintenance, while Deer Lake Power Line 1 was also out of service.
	3	Aug 24, 2009 03:21 AM	N/A	5,425	5,424	1	0	Slow clearing fault on TL202 resulting in a drop in system frequency (tree contact)
	4	Aug 24, 2009 03:33 AM	N/A	18,188	16,941	0	1,247	Another slow clearing fault on TL202 resulting in a drop in system frequency (tree contact)
	5	Nov 06, 2009 07:41 PM	98	16,397	15,149	1	1,247	Holyrood Unit 1 - High Drum Level
	6	Dec 02, 2009 12:33 AM	N/A	15,676	12,537	1	3,138	70 MW of generation was removed from system at Corner Brook Pulp and Paper. Deer Lake Power Lines 1 and 2 tripped and resulted in an overload on transformer T1 at Deer Lake Terminal Station.
	7	Dec 06, 2009 04:27 PM	56	4,879	4,879	0	0	Holyrood Unit 1 - High Drum Level

Year	Event	Date/Time	Generation Loss (MW)	Number of Customers Affected				Initiating Event
				Total	NF Power	Industrial	Hydro	
2010	1	Jul 13, 2010 12:30 PM	N/A	3,560	3,560	0	0	A slow clearing fault on TL233 resulting in the operation of the rate of change under frequency protection.
	2	Jul 18, 2010 07:18 PM	N/A	3,530	3,530	0	0	A slow clearing fault on NP Line 363L resulting in the operation of the rate of change under frequency protection.
	3	Jul 18, 2010 10:54 PM	50	6,488	6,488	0	0	Hinds Lake Unit - Lightning Strike to TL243
	4	Nov 14, 2010 10:33 PM	53	5,057	5,057	0	0	Bay d'Espoir Unit 3 - Inadvertent Trip
	5	Dec 22, 2010 09:19 PM	75	5,273	5,272	1	0	Upper Salmon Unit - Governor trip
	6	Dec 30, 2010 12:57 PM	70	5,273	5,272	1	0	Holyrood Unit 3 - Cooling water flow issues
2011	1	Jan 14, 2011 02:33 PM	70	5,487	5,487	0	0	Holyrood Unit 3 - Trip during testing
	2	May 12, 2011 05:13 PM	73	6,485	6,485	0	0	Holyrood Unit 1 - Low Drum Level
	3	Oct 27, 2011 12:04 AM	66	5,346	5,346	0	0	Upper Salmon Unit - Unit transformer trip
2012	1	Jan 14, 2012 01:15 PM	142	21,141	18,940	1	2,200	Holyrood Units 1 and 2 - Station Service Problems
	2	May 22, 2012 01:12 PM	60	6,046	6,046	0	0	Cat Arm Unit 1 - Fire System Failure
	3	Oct 17, 2012 07:11 PM	71	17,824	16,546	0	1,278	Holyrood Unit 1 -False trip from DCS
	4	Nov 21, 2012 02:38 PM	98	12,872	11,594	0	1,278	Holyrood Unit 2 -Low Drum Level
	5	Nov 25, 2012 11:24 AM	60	6,660	6,660	0	0	Holyrood Unit 2 -Inadvertent Trip
2013	1	Jan 16, 2013 11:35 PM	121	17,498	15,299	0	2,199	Holyrood Unit 3 - False Vacuum Trip Alarm
	2	Jan 18, 2013 09:40 PM	68	4,309	4,309	0	0	Bay d'Espoir Unit 4 - False Protection Signal
	3	Mar 01, 2013 03:06 AM	52	6,256	6,256	0	0	Bay d'Espoir Unit 1 - Exciter Trip
	4	Mar 10, 2013 04:33 PM	69	6,041	6,041	0	0	Holyrood Unit 3 - Fuel Pump failure
	5	Apr 16, 2013 11:35 AM	91	15,711	14,430	0	1,281	Holyrood Unit 2 - Low Bearing oil pressure
	6	Apr 17, 2013 07:00 AM	146	49,164	42,502	0	6,662	Bay d'Espoir Units 3 and 5 - Bus B3 lockout and Breaker failure protection issues
	7	Nov 29, 2013 06:13 PM	119	6,764	6,764	0	0	Holyrood Unit 1 - Inadvertent Trip