

NEWFOUNDLAND AND LABRADOR HYDRO

Remedial Actions

From the January 11, 2013 System Events

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1 INTRODUCTION

The impact of the events on January 11, 2013 were similar to those experienced on January 4 and 5, 2014, in that they each had system wide customer impacts with significant terminal station problems affecting the Avalon Peninsula. During each event, the Holyrood units were tripped offline, and the restoration time of these units impacted the duration of customer outages. Both had incidents originating at the Holyrood Terminal Station (HRD TS) that involved a failure of the 230 KV breaker, B1L17 but the causes of these breaker failures are unrelated. Following is a summary of each of the events.

2 JANUARY 11, 2013 SYSTEM EVENTS

The system outages on January 11, 2013, were primarily weather related. There were electrical faults experienced in the HRD TS, caused by wet and salt contaminated snow. One of these electrical faults was the result of the failure of the insulation on the 230 KV breaker B1L17. The disturbances in the HRD 230 kV switchyard resulted in the shutdown of all three Holyrood generating units and a trip of one of the two 230 kV transmission lines from the Western Avalon Terminal Station (WAV TS) to the major load centers on the Avalon Peninsula. There was an extended outage to Unit 1 due to mechanical equipment failures and a fire resulting from a bearing lubrication oil system failure. Restoration of the Holyrood plant was greatly hampered by blizzard conditions preventing station maintenance crews from arriving at the station. While crews worked to access the station, there was no power system connection either in or out of the Holyrood Generating Station. This resulted in delays in restarting the units at Holyrood and in supplying customer demand. Station service into the Holyrood plant was not re-established until late in the afternoon on January 11, 2013. The first Holyrood unit did not come online until the next morning (22 hours after the initial trip).

Later in the morning of January 11, 2013, the remaining in-service line out of WAV TS (TL201) faulted and tripped due to a jumper issue. This resulted from the high winds. The loss of this line interrupted the load on the Avalon Peninsula and resulted in a high system frequency in the

central and western areas of the Island. The high frequency caused protection relay mis-operations, resulting in multiple transmission line trips, de-energization of terminal stations and the significant loss of generation in these areas. This severely hampered the restoration efforts which were to take place during the remainder of the day. In particular, the terminal stations at Stony Brook, Buchans, Massey Drive, Bottom Brook, Doyles and Stephenville all required re-energization before customer restoration could occur. Further aggravating the situation were RTU communications issues at the Stony Brook terminal station which resulted in additional abnormal events and additional equipment outages during the restoration by Hydro's Energy Control Centre personnel. The last station (Massey Drive) was not restored until the early afternoon hours (more than five hours following the triggering event). In addition, the hydraulic generation was restored throughout the day with the last plant (Cat Arm) not back on line until nearly 19 hours after the initial trip. Some of the delays in the restoration were the result of the time to dispatch crews to the stations. There were also station service issues at Cat Arm which hampered the restoration efforts at this remote station.

3 JANUARY 4 AND 5, 2014 SYSTEM EVENTS

The weather has not been identified as a causal factor in the January 4 and 5, 2014 system events. The initial outage at the Sunnyside Terminal Station (SSD TS) on January 4, 2014, was the result of a failure to transformer T1. A breaker failure at the terminal station escalated this event and resulted in an outage to the 230 kV transmission to the Avalon Peninsula and a trip of all three units at Holyrood. There was a significant loss of generation in the central and western areas (similar to the January 11, 2013 events); however, in this case, the 230 kV lines and terminal stations in these regions remained in service.

Additionally, the issues with RTU communications at Stony Brook or any other individual station did not reoccur. There was however, a loss of the Energy Control Centre's Energy Management System (EMS) for a period of less than one hour during this event. Transmission into the HRD TS was restored in just over an hour, facilitating the re-establishment of station service and earlier restoration of the Holyrood units. The generating units at Holyrood shut down safely during the

trip event and were able to be restarted normally, post event. A vibration issue on Unit 1 delayed its return to service and was resolved by a slower than typical start up. The hydraulic generating stations (with the exception of Hinds Lake) were back on line in just over three hours due to crews being dispatched to these sites in preparation of the storm. The unit at Hinds Lake was delayed in starting due to a unit breaker issue.

The second outage at the Sunnyside Terminal Station (SSD TS) on January 4, 2014, occurred during the restoration efforts following the events earlier in the morning. Personnel were in the process of restoring transformer T4 and the transmission supply to the Burin Peninsula when temporary protection modifications adversely affected the 230 kV bus lockout. It was determined that a trip condition associated with the failed transformer T1 was still active, resulting in this trip. This event resulted in another major system disturbance, with the loss of 230 kV transmission from SSD TS to WAV TS and to the Bay d’Espoir Terminal Station, and a trip of some generation in the central and western areas (Cat Arm, Granite Canal, and Units 5 and 6 at Bay d’Espoir). Restoration following this event occurred in an expedient manner. The transmission into the HRD TS was restored in 30 minutes, again facilitating the re-establishment of station service and unit restarting. The hydraulic generating units were restored in less than an hour. The first Holyrood unit was restored in 12 hours and 30 minutes following the initial trip during the morning events at SSD TS.

The outage at the HRD TS during the evening hours on January 5, 2014, occurred when personnel were restoring Unit 1 following the trip on the previous day. A failed breaker at the HRD TS resulted in the shutdown of Holyrood Units 2 and 3 and the trip of the 230 kV transmission line from Western Avalon to Holyrood (TL217). This was primarily a HRD TS event and the impact was largely confined to the Avalon Peninsula. Transmission into the HRD TS was restored in less than an hour, facilitating the re-establishment of station service and the unit restart process. The first Holyrood unit, Unit 2, was restored the next morning (eight hours after the initial trip).

4 MITIGATING ACTIONS TAKEN FOLLOWING THE JANUARY 11, 2013 EVENTS

Following the events on January 11, 2013, a report; *January 11, 2013 Power System Outage Report*, was written. It includes a summary of all the actions taken to the time of its preparation, in addition to presenting numerous recommendations for future action to help avoid or lessen the impact of such events in the future. The recommendations were identified by area of responsibility and covered all the issues which led to the significant power system events on this day, including areas such as:

- Review of preventative maintenance procedures and schedules
- High voltage breaker replacement, inspections and repairs
- Protection and control circuitry - function testing and enhancements
- Digital protective relay firmware and setting changes
- System stability studies
- System voltage/frequency studies and control enhancements
- Development and enhancement of procedures

A number of these recommendations were implemented prior to the end of 2013, some of which helped to mitigate or lessen the customer impact resulting from the January 2014 events. They are summarized as follows:

Action Item(s)

The application of appropriate settings for the load encroachment feature on all SEL 321 relays should be done to prevent operation during off-frequency events. A review of SEL's final recommendation report (pending) should also be carried out. A setting of 100 ohms primary for all lines is recommended based on the protection settings for the longest line on the system, TL206. This setting will accommodate a load of 529 MVA before blocking. The angles settings are PLAF=90, NLAf=-90, PLAR=90, NLAR=270. This approach is

1 *preferred over the setting of the 50PP1 current monitor as it is independent of minimum*
2 *fault levels.*

3
4 *The recommended firmware upgrades should be implemented in the LPRO2100 relays.*
5 *Testing should be done on the relays following the firmware upgrades to verify that the*
6 *relays will no longer operate for these events. This can be performed by testing the*
7 *relays with the file captured on January 11 as the input to control the test set.*

8 9 **Discussion**

10 During the events on January 4 and 5, 2014 there was significant customer load loss on
11 the Avalon Peninsula with over frequency conditions resulting on the remainder of the
12 system. However, unlike the events on January 11, 2013, these conditions did not result
13 in protection relay mis-operations, multiple transmission line trips, and the de-
14 energization of terminal stations, thus providing for a much more expedient restoration.
15 The implementation of the relay setting changes indicated above helped to mitigate the
16 impact of the high frequency conditions.

17 18 **Action Item**

19 *An investigation was required into the communication issue which occurred at Stony*
20 *Brook between the Stony Brook RTU and EMS. During the restoration efforts, the status*
21 *of this terminal station stopped updating due to a buffer overflow problem with the*
22 *routers between the EMS and Stony Brook.*

23 24 **Discussion**

25 During the events on January 4 and 5, 2014, as a result of the solution implemented
26 following the investigation above, there were no communication issues affecting
27 specific remote terminal units (RTU's). This helped to avoid potential operator
28 confusion which could have resulted in additional abnormal events and equipment
29 outages.

Following the failure of Unit 1 during the January 11, 2013 event, a root cause investigation was completed into its failure which resulted in recommendations related to the routine testing of the DC lube oil pump operation. Recommendations implemented during and after the investigation ensured the proper operation of the DC lubrication systems during the 2014 event.

Action item(s)

Recommendations were made to design and install new DCS displays and to create new test procedures to ensure the proper operation of the lubricating oil system.

Discussion

During the events on January 4 and 5, 2014, all three generating units tripped and shut down safely using the DC lubricating oil pumps. As a result of the implementation of the recommended changes, the pumps operated as designed and provided sufficient oil to the bearings to enable safe shut down of the units.

In addition to these equipment related recommendations, Hydro strengthened its storm readiness procedures following the January 11, 2013 events. In particular, prior to the events on January 4, 2014, crews were specifically deployed to generating stations that were remote in nature and it was known that travel would be difficult or impossible during a storm. Existing crews were supplemented by having additional staff on site, specifically at the Holyrood Generating Station, prior to the event. Hydro also took into consideration recent operating experience when deploying crews to Granite Canal and Cat Arm. Leading into the January 4, 2014, event, the Granite Canal unit had known vibration issues and Cat Arm had known issues with the station service breakers. By deploying crews to these sites in advance of the weather, any potential issues that arose could be mitigated as quickly as possible. In the case of Cat Arm (and unlike during the events on January 11, 2013), manual switching of the station service breakers prevented the plant from going black and allowed the units to go back in service as soon as the system was restored and capable of having them back online.

1 Also in relation to storm readiness and lessons learned from the January 2013 event, Hydro
2 ensured that access routes to major facilities would be maintained during the event by ensuring
3 routes were clear prior to the storm, and by having plans in place for keeping routes clear
4 during the storm as required.

5
6 There have been a number of other key recommendations completed since the January 2013
7 events (e.g., breaker repairs and RTV coatings, shortening of transmission line jumpers,
8 additional protection and control modifications, etc.) that may not necessarily have lessened
9 the impact of the events on January 4 and 5, 2014, as they targeted causal factors which were
10 not present during the 2014 events.