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

AND IN THE MATTER OF an Application by Newfoundland and Labrador Hydro pursuant to Subsection 41(3) of the *Act*, for the approval of the purchase of replacement equipment resulting from the Sunnyside T1 Transformer Failure.

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

THE APPLICATION OF NEWFOUNDLAND AND LABRADOR HYDRO (Hydro) STATES THAT:

1. Hydro is a corporation continued and existing under the *Hydro Corporation Act, 2007*, is a public utility within the meaning of the Act and is subject to the provisions of the *Electrical Power Control Act, 1994*.

2. The Sunnyside Terminal Station is one of Hydro's major terminal stations. Located on the western end of the isthmus of the Avalon in the community of Sunnyside, it is the termination point for the 230 kV transmission lines TL-202 and TL-206 from Bay d'Espoir and is the focal point for transmission of power to the Avalon Peninsula, the Burin Peninsula, Clarenville and surrounding areas and the Come By Chance oil refinery.

3. On January 4, 2014 an internal fault (caused by a bushing failure) occurred on Sunnyside T1 transformer and resulted in a fire on the transformer. As a result of the fire, the T1 transformer and associated equipment, including the 138 kV breaker (B2T1), 230 kV disconnect switch (B1T1), station service transfer switch and power and control cables, were damaged and require replacement. In addition, modification to the relay protection system, relocation of the station service transfer switch and the addition of a 230 kV breaker are recommended as a result of Hydro's root cause analysis completed as part of Hydro's investigation and report entitled "*Review of Supply Disruptions and Rotating Outages: January 2-8, 2014.*"

4. Hydro's transmission planning criteria for the 230/138 kV looped systems, including the Stony Brook to Sunnyside system, is based upon being able to supply peak load during loss of the largest transformer in the loop. This is consistent with N-1 contingency planning. Currently, with the Sunnyside T1 transformer removed from service, Hydro is not meeting the N-1 criteria.

5. The Sunnyside T1 transformer, and associated damaged equipment, are required to be returned to service to meet transmission planning criteria in the event of another transformer failure in the Sunnyside Terminal Station. In discussions with transformer manufacturers, Hydro was able to determine that a 75/100/125 MVA, 230/138 kV transformer could be delivered to site by September 2014. Based on this delivery date, the transformer could be installed

and in service before the winter 2014 season, restoring the N-1 contingency planning and ensuring reliable power is available to Hydro's customers for the 2014 winter season and beyond. Further, the implementation of the protection modifications, in addition to the installation of a 230 kV breaker for the T1 transformer, will increase the overall reliability of the Hydro system and reduce the likelihood of customer outages.

6. Hydro is recommending: 1) the purchase and replacement of the T1 transformer and the associated equipment, including the 138 kV breaker, 230 kV disconnect switch and the station service transfer switch where damaged as a result of the fire on the Sunnyside T1 transformer; and 2) modifications to the protection relay system and the addition of a 230 kV breaker as these are the least cost options over the long term. Details regarding Hydro's proposal are contained in the attached project proposal document.

7. The replacement of the T1 transformer and associated damaged equipment, along with installation of a new 230 kV breaker and modifications to the protection relays at the Sunnyside Terminal Station, are required to ensure that Hydro can continue to provide safe, reliable and adequate service from this essential facility.

8. This project will be carried out over a two year period (2014/2015). The total estimated cost of this project is $8,424,200 ($7,197,800 in 2004 and $1,266,400

in 2015).

9. The Applicant submits that the proposed capital works and expenditures are necessary to ensure that this generation facility can continue to provide service which is safe and adequate and just and reasonable as required by Section 37 of the Act.

10. Therefore, Hydro makes Application that the Board make an Order approving, pursuant to Subsection 41(3) of the Act, the capital expenditure of $8,424,200 for the 1) purchase and replacement of the T1 transformer and associated equipment, including the 138 kV breaker, 230 kV disconnect switch and the station service transfer switch and 2) modification to the protection relay system and the addition of a 230 kV breaker as set out in this Application and in the attached project description and justification document.

DATED at St. John's, in the Province of Newfoundland and Labrador, this 19th day of June, 2014.

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

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

AND IN THE MATTER OF an Application by Newfoundland and Labrador Hydro pursuant to Subsection 41(3) of the *Act*, for the approval of the purchase of replacement equipment resulting from the Sunnyside T1 Transformer Failure.

AFFIDAVIT

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

1. I am Vice-President of Newfoundland and Labrador Hydro, the Applicant named in the attached Application.

2. I have read and understand the foregoing Application.

3. I have personal knowledge of the facts contained therein, except where otherwise indicated, and they are true to the best of my knowledge, information and belief.

SWORN at St. John's in the Province of Newfoundland and Labrador this 19 day of June 2014, before me:)

Barrister – Newfoundland and Labrador

Robert J. Henderson

A REPORT TO
THE BOARD OF COMMISSIONERS OF PUBLIC UTILITIES

	Electrical
	Mechanical
	Civil
	Protection & Control
	Transmission & Distribution
	Telecontrol
	System Planning

Replacement of Equipment Resulting From Sunnyside T1 Transformer Failure

Newfoundland and Labrador Hydro

June 2014

newfoundland labrador hydro
a nalcor energy company

SUMMARY

This proposal is for the purchase and installation of a new transformer to replace the failed T1 transformer at the Sunnyside Terminal Station (SSD). On January 4, 2014 a fault on the Sunnyside T1 transformer resulted in a fire. An internal inspection, performed in consultation with the Original Equipment Manufacturer (OEM), confirmed that the transformer was destroyed and would need to be replaced. As a result of the fire, associated equipment such as the station service transfer switch, the transformer's 138 kV breaker and its 230 kV disconnect switch were also damaged and are in need of replacement. In addition, improvements to the relay protection system, relocation of the station service transfer switch and the addition of a 230 kV breaker are being recommended as a result of the findings of Hydro's root cause analysis completed as part of Hydro's investigation and report titled "*Review of Supply Disruptions and Rotating Outages: January 2-8, 2014."*

This proposal requests approval for a two year project (2014/2015) for Sunnyside for the following:

Sunnyside 2014

Replace Transformer T1

- Install a new concrete foundation at Sunnyside to accommodate the new transformer;
- Purchase and install a new 230/138 kV 75/100/125 MVA autotransformer. This new transformer will become Sunnyside T1;
- Purchase and install new transformer power and protection/control wiring;
- Purchase and install new modern digital relay protection for Sunnyside T1;
- Modify the non-conventional breaker failure protection applications for Sunnyside T1 transformer as it applies to the breaker failure protection retrip function in the SEL-501 relay; and

- Modify breaker failure protection applications for Sunnyside T1 transformer protection designs such that all protection systems on both sides of the transformer initiate breaker failure protection systems for all breakers in the tripping zone.

Addition of 230 kV Breaker (Purchase)

- Purchase of a new 230 kV breaker complete with Current Transformers (CTs) and support structure to be numbered B1T1;
- Install a new concrete foundation for the new 230 kV breaker; and
- Purchase and install new power and protection/control wiring for the 230 kV breaker.

Replacement of 230 kV Disconnect Switch (B1T1)

- Purchase and install a new 230 kV disconnect switch (to replace existing B1T1 and numbered B1T1-1) complete with support structure;
- Install a new concrete foundation for new 230 kV disconnect switch (B1T1-1); and
- Purchase and install new power and protection/control wiring for new 230 kV disconnect switch (B1T1-1).

Replacement of 138 kV Breaker (B2T1)

- Purchase and install a new 138 kV breaker (B2T1) complete with current transformers and support structure;
- Install a new concrete foundation for 138 kV breaker (B2T1); and
- Purchase and install new power and protection/control wiring for 138 kV breaker (B2T1).

Replacement of Station Service Transfer Switch

- Purchase and install a new station service transfer switch;
- Purchase and install new conduit and associated power cables for the redundant station service; and

- Purchase and install new High Voltage (HV) bus work, risers, station post insulators and connectors to complete the installation of the above equipment.

Sunnyside 2015

Addition of 230 kV Breaker (Installation)

- Install new 230 kV breaker complete with Current Transformers (CTs) and support structure (purchased in 2014);
- Modify protection panels for the addition of the 230 kV breaker; and
- Modify breaker failure protection for the Sunnyside Terminal Station to include the installation of a new 230 kV breaker.

The total cost associated with the above scope of work is estimated at $8,424,200. This cost will be net of insurance proceeds.

TABLE OF CONTENTS

1 INTRODUCTION

The Sunnyside Terminal Station is one of Hydro's major terminal stations and is located on the western end of the Isthmus of the Avalon in the community of Sunnyside. It is the termination point for the 230 kV transmission lines TL-202 and TL-206 from Bay d'Espoir and the focal point for transmission of power to the Avalon Peninsula. Figure 1 below depicts the location of the Sunnyside Terminal Station.

Figure 1: Sunnyside Terminal Station Location

On January 4, 2014 Sunnyside T1 transformer faulted, with the most probable cause being a bushing failure that initiated inside the transformer. As a result of this fault, a fire developed leading to the irreparable damage of the transformer and associated equipment.

The transmission planning criteria for the 230/138 kV looped systems including the Stony Brook to Sunnyside system is based upon being able to supply peak load with the largest transformer in the loop out of service, referred to as N-1 contingency planning. At present Hydro is able to supply the peak load with Sunnyside T1 out of service. However, should there be a second transformer failure within the Stony Brook – Sunnyside Loop (i.e. N-1-1), Hydro would not be able to supply the peak load. Therefore it is necessary to replace the failed transformer so that the transformer capacity criterion is met.

1.1 Power Transformers

Power transformers are a critical component of the power system. At generating stations transformers are referred to as step up transformers. These transformers step up the voltage for power transmission from the generation source voltage to the line voltage. A higher transmission voltage yields a lower transmission current and lower transmission line losses. At a terminal station or a substation, step down power transformers are used to convert the voltage down to an intermediate or a distribution voltage level suitable for delivery to end users. Figure 2 shows a picture of the failed 75/100/125 MVA, 230/138 kV power transformer T1 at Sunnyside Terminal Station. As a result of the fire in the Sunnyside T1 transformer, it has been damaged beyond repair and needs to be replaced.

Figure 2: Sunnyside T1 Transformer

1.2 Circuit Breakers

Circuit breakers are a critical component of the power system. Located in a terminal station or substation, each circuit breaker performs switching actions to complete, maintain, and interrupt current flow under normal or fault conditions. The reliable operation of all circuit breakers through their fast response and complete interruption of current flow is essential to protect the power system and to maintain the stability of the system. The existing 138 kV breaker (B2T1) for the T1 transformer was damaged as a result of its proximity to the T1 fire and is in need of replacement. Figure 3 shows a picture of B2T1 at the Sunnyside Terminal Station.

Figure 3: Sunnyside 138 kV B2T1 Breaker

The existing design of the Sunnyside Terminal Station, like all Hydro 230 kV stations containing multiple 230/138 kV transformers, does not have a dedicated 230 kV breaker whose sole purpose is to operate in the event of a 230/138 kV transformer fault. This design was based upon the fact that failure of power transformers is viewed as a rare event and subsequently total costs could be reduced by eliminating dedicated 230 kV circuit breakers, having the 230/138 kV transformers share a common bus and circuit breaker(s), and employing remote controlled motor operated disconnect switches to isolate the faulted transformer and restore the unfaulted unit(s) in a timely manner. At Sunnyside Terminal Station the current design requires that two 230 kV circuit breakers and three 138 kV circuit breakers (five breakers in total) operate to isolate a fault on the T1 transformer. Figure 4 provides a simplified single line diagram of the Sunnyside circuit breaker arrangement.

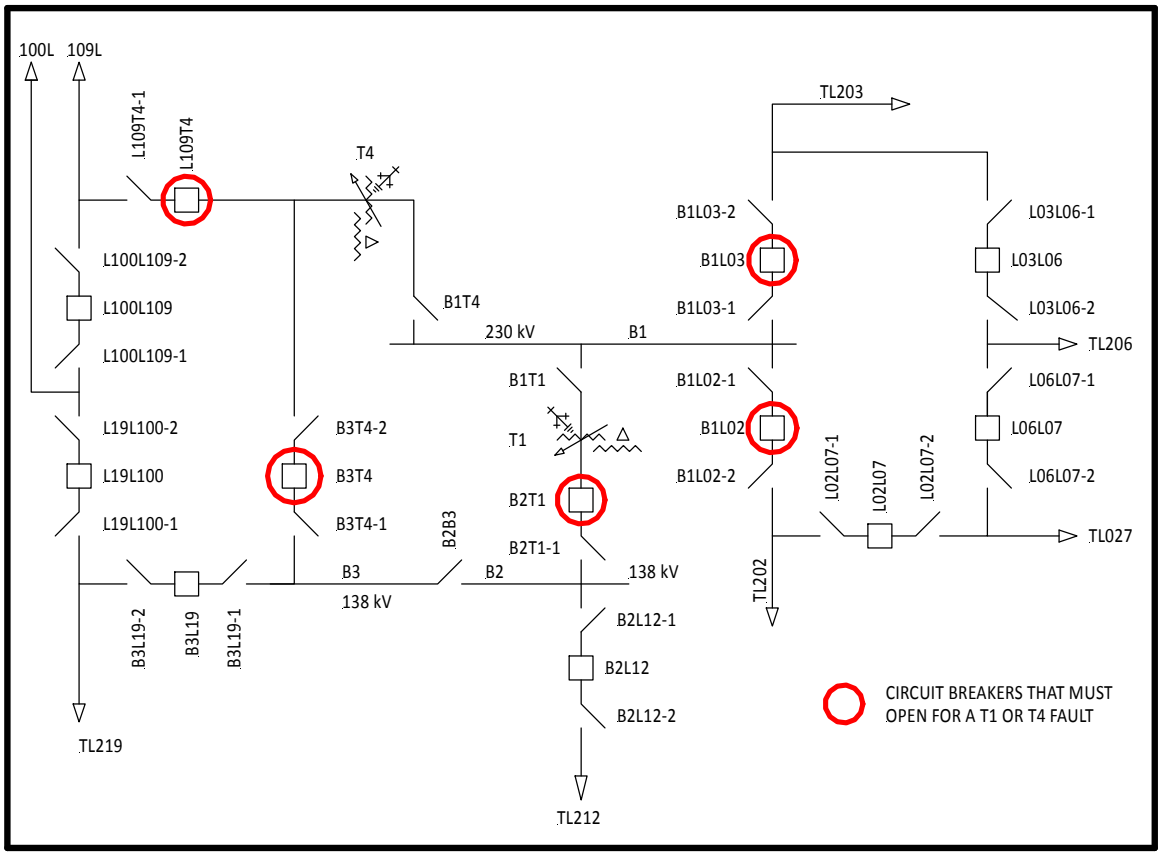

Figure 4: Sunnyside Terminal Station – Circuit Breaker Layout

With the addition of a 230 kV breaker on the high side of the T1 transformer, only two breakers would be required to operate to isolate a fault on the transformer (i.e. the dedicated 230 kV and 138 kV circuit breakers – See Figure 5). Also, with the installation of this 230 kV circuit breaker, a fault on the T1 transformer could be isolated with no outages to customers. The addition of a 230 kV breaker for the T1 transformer reduces the complexity of the protection scheme and increases the reliability of power system. However, it must be noted that a fault on Sunnyside T4 would still require operation of five circuit breakers to isolate the transformer.

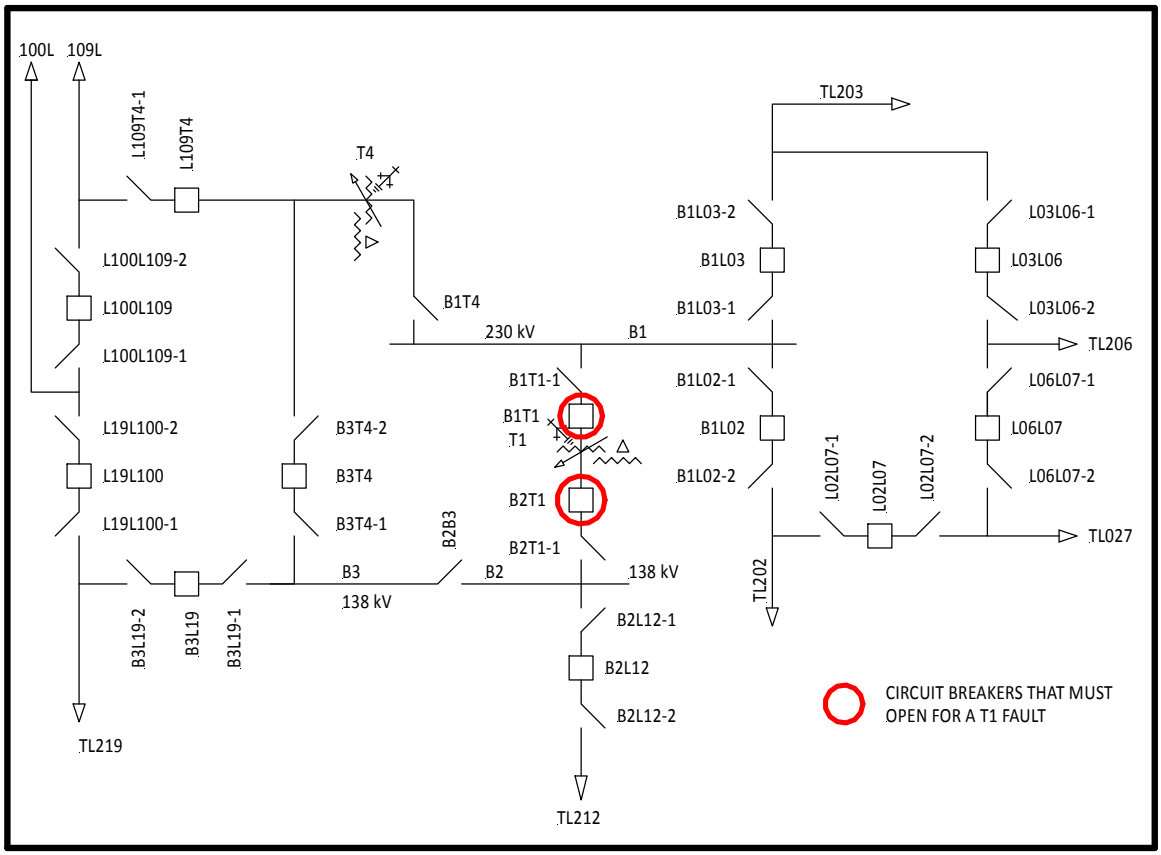

Figure 5: Sunnyside Terminal Station with 230 kV Circuit Breaker Added to T1

1.3 Disconnect Switch

Disconnect switches are used to isolate or bypass equipment and provide a visual air gap to ensure the circuit is open when performing work on adjacent equipment. The existing 230 kV disconnect switch for the T1 transformer (B1T1) was damaged as a result of its proximity to the T1 fire and in need of replacement. Figure 6 shows a picture of B1T1 at the Sunnyside Terminal Station.

Figure 6: Sunnyside 230 kV B1T1 Disconnect Switch

1.4 Transfer Switch

The manual transfer switch transfers the supply of electrical power from a normal electrical supply to a secondary or emergency electrical supply when the normal supply becomes unavailable. The Sunnyside Terminal Station transfer switch is connected to the tertiary windings of the T1 and T4 transformers. The existing station service transfer switch for the Sunnyside Terminal Station was damaged as a result of its proximity to the T1 fire and is in need of replacement. Figure 7 shows a picture of the station service transfer switch at the Sunnyside Terminal Station.

Figure 7: Sunnyside Station Service Transfer Switch

As a result of Hydro's investigation titled "*Review of Supply Disruptions and Rotating Outages: January 2-8, 2014"* several recommendations were made to improve the reliability of the power system. These recommended improvements, as they relate to the installation of the equipment in this proposal, include the following:

- Relocate the station service transfer switch to inside the Sunnyside control building[1];
- Modify the non-conventional breaker failure protection application for Sunnyside T1 transformer as it applies to the breaker failure protection 'retrip function' in the Schweitzer Engineering Laboratories type SEL-501 relay[2];

[1] Refer to Appendix 9, page 2, NEWFOUNDLAND AND LABRADOR HYDRO, "A Review of Supply Disruptions and Rotating Outages: January 2-8, 2014", Volume II, Schedule 8, "Root Cause Investigation of System Disturbances On January 4 and 5, 2014" dated March 24th, 2014.

[2] Refer to pages 16 and 17, NEWFOUNDLAND AND LABRADOR HYDRO, "A Review of Supply Disruptions and Rotating Outages: January 2-8, 2014", Volume II, Schedule 9, "Protection Systems Impacts on 4 January 2014 Supply Disruptions" dated March 24th, 2014.

- Modify breaker failure protection applications for Sunnyside T1 transformer protection designs such that all protection systems on both sides of the transformer initiate breaker failure protection systems for all breakers in the tripping zone[3];
- Replace the Sunnyside T1 protection with modern digital protection[4]; and
- Consider conducting a formal risk/reward review of system design to determine whether 230 kV transformers require their own 230 kV breaker in all terminal stations, as this would reduce complexity and increase reliability.[5]

[3] Refer to pages 16 and 17, NEWFOUNDLAND AND LABRADOR HYDRO, "A Review of Supply Disruptions and Rotating Outages: January 2-8, 2014", Volume II, Schedule 9, "Protection Systems Impacts on 4 January 2014 Supply Disruptions" dated March 24th, 2014.

[4] Refer to pages 14 and 15, NEWFOUNDLAND AND LABRADOR HYDRO, "A Review of Supply Disruptions and Rotating Outages: January 2-8, 2014", Volume II, Schedule 9, "Protection Systems Impacts on 4 January 2014 Supply Disruptions" dated March 24th, 2014.

[5] Refer to page 21, NEWFOUNDLAND AND LABRADOR HYDRO, "A Review of Supply Disruptions and Rotating Outages: January 2-8, 2014", Volume II, Schedule 8, "Root Cause Investigation of System Disturbances On January 4 and 5, 2014" dated March 24th, 2014.

2 PROJECT DESCRIPTION

On January 4, 2014 an internal fault (with the most probable cause being a bushing failure) occurred on Sunnyside T1 transformer and resulted in a fire on the transformer and was the initiating event that resulted in wide-spread customer outages. As a result of the fire, the T1 transformer and associated equipment such as the 138 kV breaker, 230 kV disconnect, station service transfer switch, and power and control cables were damaged and require replacement. This proposal will address the replacement of the damaged equipment required to return a 75/100/125 MVA 230/138 kV transformer to service before the 2014 winter season. In addition, recommendations from the "*Review of Supply Disruptions and Rotating Outages: January 2-8, 2014",* as they relate to the installation of Sunnyside T1 transformer, are also being considered under this project.

Hydro, like many North American utilities, has been working to maximize the life of its in-service power transformer units. However, unexpected failures do happen and a transformer may have to be replaced to ensure reliable power is supplied to customers while meeting system planning criteria.

The transmission planning criteria used by the System Planning Department of Newfoundland and Labrador Hydro and reviewed by the Public Utilities Board of Newfoundland and Labrador considers:

- NLH's bulk transmission system (i.e. 230 kV and 138 kV loops) is planned to be capable of sustaining the single contingency loss of any transmission element without loss of system stability;
- In the event a transmission element is out of service, power flow in all other elements of the power system should be at or below normal rating;
- Transformer additions at all major terminal stations (i.e. two or more transformers per voltage class) are planned on the basis of being able to withstand the loss of the largest unit; and

- For single transformer stations there is a back-up plan in place which utilizes Hydro's and/or Newfoundland Power's mobile equipment to restore service.

With respect to the Stony Brook - Sunnyside 138 kV loop, there are two 75/100/125 MVA transformers at each station (Sunnyside and Stony Brook) for a total installed transformer capacity of 500 MVA. The transmission planning criteria requires that there be sufficient transformer capacity to supply the peak load with one of the four 125 MVA transformers out of service.

In consultation with transformer manufacturers, it was determined that a new transformer could be delivered to site by September of 2014 and be in-service before the start of the next winter season. Based on this information, the decision to purchase and install a new transformer in 2014 to replace the existing failed T1 transformer is being recommended in this proposal.

2.1 2014 Work Scope for Sunnyside Transformer (T1)

The major steps in the 2014 work scope associated with the installation of a new transformer in the Sunnyside Terminal Station, to replace the failed T1 transformer, are as follows:

- Install a new concrete foundation for the T1 transformer;
- Install new transformer at the Sunnyside Terminal Station;
    - Perform acceptance testing on new transformer as required (i.e. SFRA Test);
    - Dress Transformer (i.e. install conservator tank, bushings, radiator etc.);
    - Vacuum and fill transformer with oil;
    - Perform electrical tests as required; and
    - Connect electrical components (i.e. high voltage risers, lightening arresters etc.).
- Purchase and install new transformer power and protection/control wiring;

- Modify the non-conventional breaker failure protection application for Sunnyside T1 transformer as it applies to the breaker failure protection 'retrip function' in the Schweitzer Engineering Laboratories type SEL-501 relay;
- Modify breaker failure protection applications for Sunnyside T1 transformer protection designs such that all protection systems on both sides of the transformer initiate breaker failure protection systems for all breakers in the tripping zone;
- Replace the Sunnyside T1 transformer relay protection with modern digital protection; and
- Purchase and install new high voltage bus work, risers, station post insulators and connectors, as required, to complete the installation.

2.2 2014/2015 Work Scope for Sunnyside 230 kV Breaker

The major steps in the two year plan 2014/2015 work scope associated with the installation of a new 230 kV breaker at Sunnyside are as follows:

2014

- Install a new concrete foundation for 230 kV breaker;
- Install new concrete cable trench as required;
- Purchase a new 230 kV breaker complete with current transformers and support structure;
- Engineering design and modifications to bus work to accommodate new 230 kV breaker;
- Purchase and install temporary station post insulators on breaker foundation[6];
- Purchase and install new power and protection/control wiring for 230 kV breaker; and
- Purchase and install new high voltage bus work, risers, station post insulators and connectors, as required, to complete the installation.

[6] The temporary station post insulators are required in 2014 to support the new bus work prior to installation of the new breaker in 2015.

2015

- Removal of temporary station post insulators;
- Install a new 230 kV breaker complete with current transformers and support structure (purchased in 2014);
- Engineering design of protection schemes for the Sunnyside Terminal Station to accommodate the addition of the 230 kV Breaker. Figure 8 below depicts a portion of the Sunnyside Terminal Station with the proposed addition of a new 230 kV breaker; and
- Modify protection panels for the addition of the new 230 kV breaker.

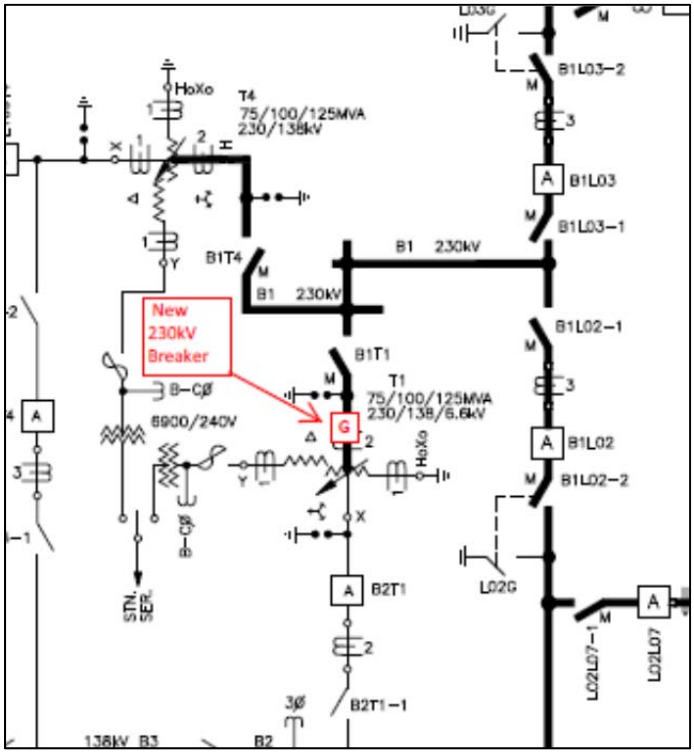

Figure 8: Portion of Sunnyside Terminal Station Showing New 230 kV Breaker

2.3 2014 Work Scope for Sunnyside 230 kV Disconnect Switch (B1T1)

The major steps in the 2014 work scope associated with the installation of a 230 kV disconnect switch at Sunnyside are as follows:

- Install a new concrete foundation for 230 kV disconnect switch;

- Purchase and install a new 230 kV disconnect switch complete with support structure;
- Purchase and install new power and protection/control wiring for the 230 kV disconnect switch; and
- Purchase and install new high voltage bus work, risers, station post insulators and connectors, as required, to complete the installation.

2.4 2014 Work Scope for Sunnyside 138 kV Breaker (B2T1)

The major steps in the 2014 work scope associated with the installation of a 138 kV breaker at Sunnyside are as follows:

- Install a new concrete foundation for the 138 kV breaker;
- Purchase and install a new 138 kV breaker complete with current transformers and support structure;
- Purchase and install new power and protection/control wiring for the 138 kV breaker; and
- Purchase and install new high voltage bus work, risers, station post insulators and connectors, as required, to complete the installation.

2.5 2014 Work Scope for Sunnyside Station Service Transfer Switch

The major steps in the 2014 work scope associated with the installation of the station service transfer switch at Sunnyside are as follows:

- Engineering design to determine optimal location for transfer switch;
- Engineering design for the new supply from the Newfoundland Power distribution system;
- Purchase and install new conduit and associated power cables for the redundant station service supply; and
- Purchase and install new station service transfer switch.

3 JUSTIFICATION

3.1 Existing System

The Sunnyside Terminal Station is one of Hydro's major terminal stations. It is the termination point for the 230 kV transmission lines TL-202 and TL-206 from Bay d'Espoir. It is the focal point for transmission of power to the Avalon and Burin Peninsulas. The 230 kV transmission line TL-203 originates at Sunnyside and transmits power to the Western Avalon Terminal Station. The 230 kV transmission line TL-207 transmits power from Sunnyside to the Come By Chance oil refinery and TL237 connects the Come By Chance oil refinery to Western Avalon Terminal Station. Electrical power to the Burin Peninsula is supplied from the Sunnyside Terminal Station via 138 kV transmission lines TL-212 and TL-219. Also, Sunnyside supplies power to Clarenville and surrounding north eastern area via Newfoundland Power's 138 kV transmission system. Figure 9 shows a portion of the Island Interconnected System and indicates the location of the Sunnyside Terminal Station.

Figure 9: Portion of the Island Interconnected System showing Sunnyside

3.1.1 Sunnyside Transformer (T1)

On January 4, 2014 Sunnyside T1 transformer failed with the most probable cause being a bushing failure. As a result of this fault, a fire developed leading to the failure of the transformer and associated equipment. The Sunnyside T1 transformer is required to be returned to service to meet system planning criteria in the event of another transformer failure in the Sunnyside Terminal Station. In discussions with transformer manufacturers, Hydro was able to determine that a 75/100/125 MVA, 230/138 kV transformer could be delivered to site by September of 2014. Based on this delivery date, the transformer could be installed and in-service before the winter 2014 season. This would restore the Stony Brook – Sunnyside 138 kV Loop to full transformer capacity and ensure that the total load in the loop can be supplied for loss of a single 125 MVA transformer for the 2014/15 winter season.

The Sunnyside T1 replacement transformer has been sized at 75/100/125 MVA, identical to the original unit, after consideration of the load growth in the Stony Brook – Sunnyside 138 kV Loop. The 138 kV loop supplies loads including the Burin Peninsula, the north east coast from Clarenville to Gander, central Newfoundland from Gander west to Deer Lake (including the Baie Verte Peninsula and White Bay) and the Great Northern Peninsula. The Stony Brook – Sunnyside Loop is connected to the 230 kV network at Deer Lake via a single 230/138 kV, 45/60/75 MVA transformer (Deer Lake T2). Under normal operation the connection at Deer Lake provides a voltage control point for the 138 kV transmission system on the Great Northern Peninsula and a transmission path for Hinds Lake and Deer Lake Power generation to the 230 kV network. During transformer contingencies at Stony Brook or Sunnyside, the Deer Lake T2 transformer provides approximately 2 MVA of support to the Stony Brook – Sunnyside Loop due to its remote location and relative size. This capacity support offsets approximately 1.2 MVA of transformer capacity that is lost between Stony Brook and Sunnyside due to transformer impedance mismatch. Within this loop Hydro operates the 75 MW Hinds Lake Generating Station and the 8 MW Paradise River Generating Station. In addition, Hydro maintains two standby diesel plants at Hawke's Bay

(5 MW) and St. Anthony (9.7 MW). The non-utility generator Rattle Brook (4 MW) is connected to this loop as well as the Newfoundland Power standby combustion turbines at Wesleyville and Greenhill. The St. Lawrence wind farm is also connected to the loop, however, the wind farm capacity is not relied upon for firm capacity calculations.

In determining the transformer capacity requirements within the Stony Brook – Sunnyside Loop, the total load to be supplied is derived from the latest load forecast (Newfoundland Power's 2013 Infeed Load Forecast in this case). Next the total available generation (including standby generation capacity) within the loop is calculated and subtracted from the total load to be supplied to yield the total load to be supplied by the Stony Brook and Sunnyside 230/138 kV transformers. The load to be supplied by the transformers is then compared to the firm transformer capacity (i.e. 3 x 125 MVA or 375 MVA) to determine if the loss of the largest unit criteria is maintained or exceeded. This mathematical calculation provides the planning engineer with a high level tool to ascertain when more detailed analysis is required to pinpoint a required in-service date for additional transformer capacity considering factors such as load distribution throughout the loop, voltage constraints, transmission line ratings, etc.

A review of the Stony Brook – Sunnyside Loop installed transformer capacity revealed that with four 125 MVA transformers installed, in other words 375 MVA of firm transformer capacity in place, the transformers will be loaded to 77% of rating in 2014, 78% of rating in 2016 and 76% of rating in 2018 for loss of the largest unit. Given that Newfoundland Power is forecasting a load decrease in the area for the 2017-2018 time period, it is apparent that maintaining adequate firm transformer capacity with three 125 MVA transformers in service will meet the transmission planning criteria for the foreseeable future.

An increase in the Sunnyside T1 rating from 75/100/125 MVA to a larger size such as 150/200/250 MVA would require the replacement of two 75/100/125 MVA units in the loop. Replacing only Sunnyside T1 with a 250 MVA unit would increase the total installed

transformer capacity to 625 MVA (1 x 250 + 3 x 125 MVA). However, the single 250 MVA unit would be the largest transformer in the loop, thereby requiring the remaining 3 x 125 MVA units to support the load for loss of the largest unit. In order for the addition of a 250 MVA rated transformer to have an impact on the firm transformer capability of the Stony Brook – Sunnyside Loop there must be a minimum of two 250 MVA units in service with two 125 MVA units, such that loss of a 250 MVA units nets 500 MVA of firm transformer capacity (1 x 250 MVA + 2 x 125 MVA). Based upon the analysis presented, there is no apparent requirement to increase the Sunnyside T1 rating beyond 75/100/125 MVA at this time.

3.1.2 Sunnyside 138 kV Breaker (B2T1)

This project is justified on the requirement to replace failing or deteriorated infrastructure in order for Hydro to provide safe, reliable electrical service. Because of the proximity of the 138 kV breaker B2T1 to the fire on Sunnyside T1 transformer, the breaker has sustained damage that could lead to a premature failure if it is returned to service. Breaker B2T1 has been in service for 43 years and is approaching its end of life. Hydro's current long term plan for the replacement/overhaul of circuit breakers had the 138 kV breaker B2T1 scheduled for overhaul in 2014. Due to the proximity of this breaker to the fire and to ensure safe and reliable delivery of power to customers, it is recommended that the 138 kV breaker B2T1 be replaced in 2014.

3.1.3 Sunnyside 230 kV Disconnect Switch (B1T1)

Proper operation of disconnect switches is essential for a safe work environment and for reliable and secure system operation. Faulty and/or malfunctioning disconnect switches that do not operate properly could impact on reliable and secure system operation and create a safety hazard. The close proximity of the 230 kV disconnect switch B1T1 to the fire on Sunnyside transformer T1 has resulted in damage that could lead to a failure of the disconnect switch if it is returned to service. To ensure a safe work environment for its

employees, Hydro recommends that the 230 kV disconnect switch B1T1 be replaced in 2014.

3.1.4 Sunnyside Transfer Switch

An alternate station service power supply is essential at the Sunnyside Terminal Station to ensure that auxiliary systems such as battery chargers and compressed air systems are operating in the event that they are called upon and to allow for routine maintenance to be performed on equipment. Due to the close proximity of the existing station service transfer switch to the T1 transformer, it has sustained damage that could lead to its failure if not replaced. In addition, the close proximity of the existing transfer switch to the T1 transformer resulted in the inability to restore station service in an expedient manner during the events on January 4, 2014. The replacement of the existing station service transfer switch will provide a reliable redundant power supply for the station and ensure the safe delivery of power to customers. Based on the recommendations of Hydro's investigation "*Review of Supply Disruptions and Rotating Outages: January 2-8, 2014"* it is also recommended that the station service transfer switch be relocated to inside the Sunnyside control building.

3.1.5 Sunnyside 230 kV Breaker and Protection Upgrades

The reliable operation of protection relays and associated circuit breakers through their fast response and complete interruption of current flow are essential to protect equipment and to maintain the stability of the system. Because of the present design at the Sunnyside Terminal Station, the protection and isolation scheme is complicated in part due to the fact that there is no 230 kV breaker dedicated to the isolation of the T1 transformer in the event of a fault. Based on the recommendations of Hydro's report "*Review of Supply Disruptions and Rotating Outages: January 2-8, 2014"* it is recommended that modifications to the protection systems as part of this project. At present there is no 230 kV circuit breaker dedicated to either T1 or T4 at Sunnyside Terminal Station. Both T1 and T4 share a common 230 kV bus and a fault on either transformer requires the operation of five circuit breakers

(two 230 kV breakers and three 138 kV breakers) to isolate the faulted transformer. This arrangement results in the loss of two 230/138 kV transformers and potentially customer load until the faulted transformer has been isolated and the un-faulted unit returned to service. While Hydro has not completed the recommended "formal risk/reward review of system design to determine whether 230 kV transformers require their own 230 kV breaker in all terminal stations", the required replacement of Sunnyside T1 transformer provides the opportunity to add a dedicated 230 kV circuit breaker for T1 protection. With a dedicated circuit breaker on both the high (230 kV) and low (138 kV) voltage windings of the transformer, a fault occurring with Sunnyside T1 in the future will require the operation of only two circuit breakers. The implementation of the protection modifications and the installation of a 230 kV breaker for the T1 transformer will increase the level of reliability and selectivity in the equipment protection systems and reduce the likelihood of customer outages.

4 CONCLUSION

An internal inspection of the Sunnyside T1 transformer has verified that this transformer has received significant damage and cannot be returned to service. Based on the availability of a 75/100/125 MVA, 230/138 kV autotransformer by September of 2014, Hydro has determined that the best option is to purchase and install a new transformer in 2014 to replace the failed Sunnyside T1 transformer. This would return the Sunnyside Terminal Station to a status that meets the transmission planning criteria with respect to transformer capacity in the Stony Brook – Sunnyside 138 kV loop.

To facilitate the in-service of the new transformer at Sunnyside in 2014, associated equipment such as the 138 kV breaker, 230 kV disconnect switch and station service transfer switch will also require replacement.

Based on the recommendations of Hydro's investigation "*Review of Supply Disruptions and Rotating Outages: January 2-8, 2014"* the installation of a 230 kV breaker and several protection modification have also been proposed.

Implementation of the recommendations from this proposal will ensure reliable power to customers for the 2014/2015 winter season and beyond. In addition, the modifications to the protection relays and installation of a 230 kV breaker at the Sunnyside Terminal Station will increase the overall reliability of the Hydro system.

4.1 Budget Estimate

The class three budget estimate is shown in Table 1.

Table 1: Budget Estimate

Project Cost:*($ x1,000)*	**2014**	**2015**	**Beyond**	**Total**
Material Supply	2,817.2	110.0	0.0	2,927.2
Labour	1,331.6	401.9	0.0	1,733.6
Consultant	86.4	28.8	0.0	115.2
Contract Work	1,586.4	329.5	0.0	1,915.9
Other Direct Costs	79.5	89.6	0.0	169.1
Interest and Escalation	116.6	74.5	0.0	191.1
Contingency	1,180.2	192.0	0.0	1,372.2
TOTAL	**7,197.8**	**1,226.4**	**0.0**	**8,424.2**[7]

4.2 Project Schedule

The anticipated project schedule is shown in Table 2.

Table 2: Project Schedule for 2014/2015

Activity	Milestone
Initial Planning and Equipment Ordering Tendering (Transformer, Breakers , Disconnect and Protective Devices)	April/June 2014
Equipment Delivery 2014 Equipment Delivery 2015	July 2014 June 2015
Equipment Installations and Commissioning 2014 Equipment Installations and Commissioning 2015	Aug - Nov 2014 June - Aug 2015
Project In Service 2014 Project In Service 2015	November 2014 September 2015
Project Completion and Close Out	September 2015

[7] This cost will be net of insurance proceeds.

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

AN ORDER OF THE BOARD

NO. P.U. __ (2014)

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

AND IN THE MATTER OF an Application by Newfoundland and Labrador Hydro pursuant to Subsection 41(3) of the *Act*, for the approval of the purchase of replacement equipment resulting from the Sunnyside T1 Transformer Failure.

WHEREAS Newfoundland and Labrador Hydro ("Hydro") is a corporation continued and existing under the *Hydro Corporation Act, 2007*, is a public utility within the meaning of the Act, and is subject to the provisions of the *EPCA;* and

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

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

without prior approval of the Board; and

WHEREAS in Order No. P.U. 42(2013) the Board approved Hydro's 2014 Capital Budget; and

WHEREAS on June 19, 2014 Hydro applied to the Board for approval to 1) purchase and replace the T1 transformer and the associated equipment, including the 138 kV breaker, 230 kV disconnect switch and the station service transfer switch where damaged as a result of the fire on the Sunnyside T1 transformer; and 2) modify and improve the protection relays and purchase and install an additional 230 kV breaker purchase at the Sunnyside Terminal Station (the "Application"); and

WHEREAS the Board is satisfied that the 2014 supplemental capital expenditure for the 1) purchase and replacement of T1 transformer and the associated equipment, including the 138 kV breaker, 230 kV disconnect switch and the station service transfer switch where damaged as a result of the fire on the Sunnyside T1 transformer; and 2) modification to the protection relay system and the addition of a 230 kV breaker at the Sunnyside Terminal Station are necessary to allow Hydro to provide service and facilities which are reasonably safe and adequate and just and reasonable.

IT IS THEREFORE ORDERED THAT:

1. The proposed capital expenditure of $8,424,200 for the: 1) purchase and replacement of T1 transformer and the associated equipment, including the 138 kV breaker, 230 kV disconnect switch and the station service transfer switch where damaged as a result of the fire on the Sunnyside T1 transformer; and 2) modification to the protection relays and addition of a 230 kV breaker at the Sunnyside Terminal Station is approved.

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

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

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