NLSO STANDARD

Transmission Planning Criteria

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newfoundland labrador hydro
a nalcor energy company

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1 PURPOSE

The purpose of this document is to present the NLSO Transmission Planning Criteria to be applied to the interconnected transmission system within the Province of Newfoundland and Labrador. These criteria shall be applied in accordance with NLSO Standard TP-S-003 - Annual Planning Assessment.

2 TERMS, ABBREVIATIONS AND ACRONYMS

The NERC glossary of terms utilized in the development of reliability standards can be found on the NERC website at www.nerc.com under the "Standards" tab. In addition, the NPCC glossary of terms can be found on the NPCC website at www.npcc.org. This guide utilizes the NERC and NPCC definitions where appropriate. A summary of the key terms, abbreviations and acronyms used in this guide have been compiled below for reference.

Bulk Electric System or **NERC BES**: Unless modified by the lists shown below, all **Transmission Elements** operated at 100 kV or higher and **Real Rower** and **Reactive Power** resources connected at 100 kV or higher. This does not include facilities used in the local distribution of electric energy. (This definition includes five inclusion clauses and four exclusion clauses.) (As per the NERC Glossary of Terms)

Bulk-Power System or **NERC BPS**: Bulk-Power System:

(A) facilities and control systems necessary for operating an interconnected electric energy transmission network or any portion thereof); and

(B) electric energy from generation facilities needed to maintain transmission system reliability. The term does not include facilities used in the local distribution of electric energy. (Note that the terms "Bulk- Power System" or Bulk Power System" shall have the same meaning.) (As per NPCC Glossary of Terms)

Bulk Power System or **NPCC BPS**: The interconnected electrical systems within northeastern North America comprised of system **elements** on which **faults** or **disturbances** can have a **significant adverse impact** outside the **local area**. (As per NPCC Glossary of Terms) Note that for NPCC **BPS elements** are determined through application of NPCC Document A-10 "Classification of Bulk Power System Elements".

For greater clarity, the term **BPS** or **Bulk Power System** (with upper case letters) when used by the **NLSO** is in reference to the **NPCC** definition. The term **bulk power system** (all lower case) is in reference to the **NERC** definition.

Cascading: The uncontrolled successive loss of **System Elements** triggered by an incident at any location. **Cascading** results in widespread electric service interruption that cannot be restrained from sequentially spreading beyond an area predetermined by studies. (As per NERC Glossary of Terms)

Consequential Load Loss: All Load that is no longer served by the Transmission system as a result of Transmission Facilities being removed from service by a Protection System operation designed to isolate the fault. (As per NER Glossary of Terms)

Disturbance: Severe oscillations or severe step changes of current, voltage and/or frequency usually caused by **faults**. (As per NPCC Glossary of Terms)

ECC: The **NLSO** Energy Control Centre.

Element: Any electrical device with terminals that may be connected to other electrical devices such as generator, transformer, circuit breaker, bus section or transmission line. An **element** may be comprised of one or more components. (As per NERC Glossary of Terms)

Extra High Voltage (EHV) Transmission: Transmission system with a nominal operating voltage greater than 300 kV.

Facility[1]: A set of electrical equipment that operates as a single **element** (e.g. a line, generator, transformer, shunt device, etc.).

Facility Rating: The maximum or minimum voltage, current, frequency or real or reactive power flow through a **facility** that does not violate the applicable equipment rating of any equipment comprising the **facility**. (As per NERC Glossary of Terms)

Fault: An electrical **short circuit**. (As per NPCC Glossary of Terms)

High Voltage (HV) Transmission: Transmission system with a nominal operating voltage up to 300 kV.

Hydro: Newfoundland and Labrador Hydro.

HVdc: High Voltage direct current.

Interconnected Reliability Operating Limit (IROL) is a **System Operating Limit**, that if violated, could lead to instability, uncontrolled separation, or **Cascading** outages that adversely impact the reliability of the **Bulk Electric System**.

Interruptible Load or Interruptible Demand: Demand that the end-use customer makes available to its Load-Serving Entity via contract or agreement for curtailment.

[1] Modified from NERC definition to remove reference to NERC BES in the context of this document.

Load: An end-use device or customer that receives power from the electric system. (As per NERC Glossary of Terms)

Local Area: An electrically confined or radial portion of the system. The geographic size and number of system elements contained will vary based on system characteristics. A local area may be relatively large geographically with relatively few buses in a sparse system, or be relatively small geographically with a relatively large number of buses in a densely networked system. (As per NPCC Glossary of Terms)

Local Network (LN)[2]: A group of contiguous transmission **elements** operated at less than 300 kV that distribute power to load rather than transfer bulk power across the interconnected system. **LN**'s emanate from multiple points of connection at 100 kV or higher to improve the level of service to retail customers and not to accommodate bulk power transfer across the interconnected system. The **LN** is characterized by all of the following:

- Limits on connected generation:
    - The **LN** and its underlying **elements** do not include generation resources that:
        - The high side of the generator step-up transformer(s) are connected at 100 kV or above with:
            - Gross individual nameplate rating greater than 20 MVA. Or
            - aggregate capacity of nonretail generation greater than 75 MVA (gross nameplate rating);
        - Blackstart Resources identified in the Transmission Operator's restoration plan
- Real Power flows only into the **LN** and the **LN** does not transfer energy originating outside the **LN** for delivery through the **LN**; and
- Not part of a transfer path: The **LN** does not contain any part of a monitored Facility included in an **Interconnection Reliability Operating Limit (IROL)**.

Long-Term Transmission Planning Horizon: Transmission planning period that covers years six through ten or beyond when required to accommodate any known longer lead time projects that may take longer than ten years to complete. (As per NERC Glossary of Terms)

Near-Term Transmission Planning Horizon: The transmission planning period that covers Year One through five. (As per NERC Glossary of Terms)

Newfoundland and Labrador Interconnected System: The interconnected transmission systems in both Newfoundland and Labrador with a rated voltage of 46 kV and above including the Labrador – Island HVdc Link.

[2] NERC Glossary of Terms modified for NL context.

Newfoundland and Labrador System Operator (NLSO): **Newfoundland and Labrador Hydro** operating in its role as the system operator. This is synonymous with the role of Hydro's Energy Control Centre (**ECC**) and corresponding support staff.

NL: Newfoundland and Labrador

NL Subtransmission System: Those transmission facilities located in **NL**, operating at a voltage level above 66 kV but below 230 kV. This is a term used in commercial agreements.

NL Transmission District: The **NL Transmission District** is comprised of the Labrador – Island HVdc Link and the bulk 230 kV AC portion of the Island Interconnected System, including all equipment and radial lines rated at 230 kV and above used to connect the bulk system to NL generating plants or to equipment rated at lower voltage levels to supply NL Native Load. The NL Transmission District also includes all reactive devices whether static or synchronous, including associated dedicated transformers connected directly to the 230 kV or higher voltage equipment. It does not include generator step-up transformers or transformers stepping down to voltages below 230 kV. This is a term used in commercial agreements for determination of losses.

NL Transmission System: The transmission facilities located in **NL**, primarily operating at a voltage level of 230 kV or higher, including, without limitation, the Labrador-Island Link, the Labrador Transmission Assets and Island Interconnected System but excluding the high voltage direct current portion of the Maritime Link transmission line owned by NSP Maritime Line Incorporated. This is a term used in commercial agreements.

Non-Consequential Load Loss: Non-Interruptible Load loss that does not include: (1) Consequential Load Loss, (2) the response of voltage sensitive Load, or (3) Load that is disconnected from the System by end-user equipment. (As per NERC Glossary of Terms)

North American Electric Reliability Corporation (NERC): A not-for-profit international regulatory authority whose mission is to assure the reliability and security of the **bulk power system** in North America. **NERC** develops and enforces Reliability Standards; annually assesses seasonal and long-term reliability; monitors the **bulk power system** through system awareness; and educates, trains, and certifies industry personnel. **NERC**'s area of responsibility spans the continental United States, Canada, and the northern portion of Baja California, Mexico.

Northeast Power Coordinating Council (NPCC): A not-for-profit corporation in the state of New York responsible for promoting and enhancing the reliability of the international, interconnected **bulk power system** in Northeastern North America.

OLTC: on load tap changer. This is a device that adjusts the tap ratio of a power transformer to maintain a predefined bus voltage while the transformer is under load.

Planning Authority: The responsible entity that coordinates and integrates transmission Facilities and service plans, resource plans, and Protection Systems. (As per NERC Glossary of Terms)

Planning Coordinator: See Planning Authority (As per NERC Glossary of Terms)

Primary Transmission System or **PTS**: Given that **Hydro** is not a registered entity within **NERC** and/or **NPCC**, it would be inappropriate to describe **elements** within the **Newfoundland and Labrador Interconnected System** as **BES** or **BPS**. As a result the term **Primary Transmission System** is used to define the bulk transmission facilities within the **NLSO** jurisdiction to which the **NLSO** transmission planning criteria will be applied to ensure reliable operation of the **bulk power system**. The **PTS elements** form the basis of the **NSLO's** future **BES**.

PUB: The Board of Commissioners of Public Utilities – Newfoundland and Labrador

Radial systems[3]**:** A group of contiguous transmission **elements** that emanates from a single point of connection and:

- Only serves load. Or.
- Only includes generation resources that are not:
    - Including the generator terminals through the high side of the step-up transformer(s) connected at a voltage of 100 kV or above with:
        - Gross individual nameplate rating greater that 20 MVA. Or,
        - Gross plant/facility aggregate nameplate rating greater than 75 MVA.
    - Blackstart resources identified in the Transmission Operator's restoration plan.
    - Dispersed power producing resources that aggregate tot a total capacity greater than 75 MVA (gross nameplate rating), and that are connected through a system designed primarily for delivering such capacity to a common point of connection at a voltage of 100 kV or above.
- Where the radial system serves load and includes generation resources, not identified above, with an aggregate capacity of non-retail generation less than or equal to 75 MVA (gross nameplate rating).

Reactive Power: The portion of electricity that establishes and sustains the electric and magnetic fields of alternating-current equipment. Reactive Power must be supplied to most types of magnetic equipment, such as motors and transformers. It also must supply the reactive losses on transmission

[3] NERC Glossary of Terms BES definition Exclusion E1 – the voltage of 100 kV or higher removed for this definition.

facilities. Reactive Power is provided by generators, synchronous condensers, or electrostatic equipment such as capacitors and directly influences electric system voltage. It is usually expressed in kilovars (kvar) or megavars (Mvar). (As per NERC Glossary of Terms)

Real Power: The portion of electricity that supplies energy to the **Load**. (As per NERC Glossary of Terms)

Significant Adverse Impact[4]: With due regard for the maximum operating capability of the affected systems, one or more of the following conditions arising from faults or disturbances, shall be deemed as having **significant adverse impact**:

a. instability;
- any instability that cannot be demonstrably contained to a well-defined local area.
- any loss of synchronism of generators that cannot be demonstrably contained to a well-defined local area (such as synchronous machines at a paper mill)

b. unacceptable system dynamic response;
- an oscillatory response to a contingency that is not demonstrated to be clearly positively damped within 30 seconds of the initiating event.

c. unacceptable equipment tripping
- tripping of an un-faulted bulk power system element under planned system configuration due to operation of a protection system in response to a stable power swing

d. voltage levels in violation of applicable limits;
e. loadings on transmission facilities in violation of applicable limits.

Short Circuit: An abnormal connection (including an arc) of relatively low impedance, whether made accidentally or intentionally, between two points of different potential. *Note:* The term **fault** or short-circuit **fault** is used to describe a short circuit.

Substation: An electrical station owned by Newfoundland and Labrador Hydro with a maximum operating voltage of 25 kV, or an electrical substation owned by one of Hydro's customers (i.e. Newfoundland Power, Deer Lake Power).

Switchyard: An electrical station generally containing high voltage circuit breakers and disconnect switches, but generally no transformation. Within the Newfoundland and Labrador Interconnected System the 230/735 kV station at Churchill Falls is referred to as the Churchill Falls Switchyard.

[4] Modified from the NPCC Glossary of Terms. For the purposes of this definition local area is taken to mean a confined area within the Newfoundland and Labrador Interconnected System such as a regional system such as GNP, or a single industrial customer. Contingency is taken as a Hydro defined contingency. Bulk Power System is taken in the general sense and not the NPCC defined BPS. Operation of Special Protection Systems have been deleted. Emergency limits have been replaced with applicable limits as Hydro does not have defined "emergency" limits.

System Operating Limit (SOL) is the value (such as MW, MVAR, amperes, frequency or volts) that satisfies the most limiting of prescribed operating criteria for a specified system configuration to ensure operation within acceptable reliability criteria. System Operating Limits are based upon certain operating criteria. These included, but are not limited to:

- Facility Ratings (applicable pre- and post-Contingency Equipment Ratings or Facility Ratings)
- transient stability ratings (applicable pre- and post-Contingency stability limits)
- voltage stability ratings (applicable pre- and post-Contingency voltage stability)
- system voltage limits (applicable pre- and post-Contingency voltage limits)

Terminal Station: A Newfoundland and Labrador Hydro electrical station having equipment with a rated voltage of 46 kV and above.

Transmission: An interconnected group of lines and associated equipment for the movement or transfer of electric energy between points of supply and points at which it is transformed for delivery to customers or is delivered to other electric systems. (As per NERC Glossary of Terms)

Transmission Planner: The entity that develops a long-term (generally one year and beyond) plan for the reliability (adequacy) of the interconnected bulk electric transmission systems within its portion of the Planning Authority area. (As per NERC Glossary of Terms)

3 INTRODUCTION

A key function of the NLSO Transmission Planning Department is to ensure the coordinated development of a safe, reliable and economical transmission system for the benefit of users within the Province of Newfoundland and Labrador.

The transmission planning process requires the use of computer software to perform power system studies in order to demonstrate that the power system meets planning criteria for the present and future states of the system. When the simulations of the power system indicate that the system is not meeting the stated planning criteria, the transmission planning process is used to develop cost effective transmission system enhancements to ensure the system meets the planning criteria. The adherence to stated transmission planning criteria is critical in ensuring a long term reliable transmission system.

Within the electric utility industry, North American Electric Reliability Corporation (NERC) and Northeastern Power Coordinating Council (NPCC) standards provide the North American and regional reliability standards and criteria, respectively. While not a registered member of either entity, the NLSO Transmission Planning Department aligns its planning criteria with the recognized reliability organizations where practicable for the Newfoundland and Labrador Interconnected System.

This NLSO Transmission Planning Criteria sets out the specific acceptable pre- and post-contingency responses of the elements within the Newfoundland and Labrador Interconnected System rated 46 kV and above.

4 COMPLIANCE REQUIREMENTS

Newfoundland and Labrador Hydro and subsequently the NLSO, is not a registered entity with the North American Electric Reliability Corporation (NERC) or the Northeast Power Coordinating Council (NPCC). However, recognizing that the neighbouring jurisdictions are registered entities with respect to system reliability, the NLSO must make provisions for regional compliance. To this end the NLSO Transmission Planning Department participates in the Maine Atlantic Technical Planning Committee (MATPC) and in studies with neighbouring jurisdictions to ensure that there are no adverse impacts across the interfaces.

4.1 NERC Criteria

The NLSO Transmission Planning Department will assist its neighbouring jurisdictions to ensure that its interconnections meet the applicable criteria set out in the NERC Reliability Standards as they pertain to transmission planning. Note that these standards are applicable to the power system elements which are considered to be part of the **Bulk Electrical System** (**BES**) within the neighbouring jurisdiction. Information pertaining to the standards is available on the NERC website (www.nerc.com).

4.2 NPCC Criteria

The NLSO Transmission Planning Department will assist its neighbouring jurisdictions to ensure that its interconnections meet the applicable criteria set out in the NPCC Document Directory #1 “Design and Operation of the Bulk Power System”. Note that these criteria are applicable to the power system elements which are considered to be part of the **Bulk Power System** (**BPS**) as set out in the NPCC Document A-10 “Classification of Bulk Power System Elements” within the neighbouring jurisdiction. For new additions to the Newfoundland and Labrador Interconnected System the A-10 test shall be used to determine if a **BPS** element exists. Information pertaining to the standards is available on the NPCC website (www.npcc.org).

5 TRANSMISSION PLANNING CRITERIA

This NLSO Transmission Planning Criteria defines the specific acceptable pre- and post-contingency response of the power system for all elements 46 kV and above.

5.1 Computer Based Power System Models

The NLSO Transmission Planning Department uses the Power System Simulator for Engineers (PSS®E) program for completing its transmission planning/power system analysis studies. The Transmission Planning Department maintains system models in the current version of PSS®E used by NPCC for performing studies to ensure effective data exchange with neighbouring entities.

5.2 Pre Contingency Criteria

With all equipment in service under normal operation, power flow in all elements should be at or below normal rating and voltages shall be within acceptable limits. The ratings are defined in the NLSO Standard TP-S-001 - Transmission Facilities Rating Guide. This criterion applies to radial, local networks and primary transmission system elements within the Newfoundland and Labrador Interconnected System.

5.3 Single Contingency (N-1) Criteria

From normal system conditions, the Newfoundland and Labrador Interconnected System shall be able to withstand a single contingency. Historically a single contingency has been considered as an event that leads to the loss of a system element. The historical definition of a single element loss on the Newfoundland and Labrador Interconnected System has been the loss of a:

- Transmission line
- Generator/synchronous condenser
- Transformer
- Shunt Reactive device (capacitor or reactor)

Given the configuration of the terminal station equipment in many of the original 230 kV stations, loss of a bus section was known to cause loss of load and excluded from the list. With the Transmission Planning's requirement for new 230 kV and above stations being configured in breaker-and-one-half (ring buses as a minimum for four elements), all new 230 kV and above stations shall meet the requirement for no loss of load for loss of a bus.

With respect to ac transmission lines, loss of a double circuit tower would result in the loss of two transmission circuits as a single contingency. To avoid this condition on the Newfoundland and Labrador Interconnected System, it is required that double circuit transmission lines be limited to no more than five structures at terminal station entrances for right of way congestion purposes only.

With respect to HVdc transmission lines, the loss of a pole is considered as the single contingency event.

The single element loss for the Newfoundland and Labrador Interconnected System assumes the loss of:

- A Transmission line
- Double circuit transmission lines excluding double circuit lines extending no more than five structures from terminal station entrances
- A Generator
- A Synchronous Condenser
- A Transformer
- A Shunt Reactive device (capacitor or reactor)
- A Bus section
- One pole of an HVdc bipole system
- An entire monopolar HVdc system

The ability to withstand a single contingency means that the contingency will not result in a violation of the applicable voltage and MVA limits, or cause system instability. In addition, all firm load that was interrupted due to the contingency can be restored within a reasonable time by either switching action, system reconfiguration, repair of equipment or the installation of temporary/mobile equipment.

In order to demonstrate that the Newfoundland and Labrador Interconnected System is planned to meet the N-1 criteria, adequate power system studies will be completed. These studies will include the simulation of the loss of an element:

- Without a fault
- With a line-to-ground fault having due consideration for successful and unsuccessful single pole automatic reclosing
- With a three phase to ground fault

5.4 Voltage Limits for Normal and Contingency Conditions

The voltage limits for planning purposes are defined in terms of steady state and transient criteria.

5.4.1 Steady State Voltage Criteria

The steady state voltage levels shall be as follows:

- Pre-contingency limits: For normal operations all bus voltages shall be maintained between 95% and 105%
- Post-contingency limits: For contingency or emergency situations all bus voltages be maintained between 90% and 110%
- Minimum 230 kV bus voltage of 212 kV at Come By Chance Terminal Station

5.4.2 Transient Voltage Criteria

Post fault recovery voltages on the ac system shall be as follows:

- Transient under voltages following fault clearing should not drop below 70%
- The duration of the voltage below 80% following fault clearing should not exceed 20 cycles

When planning studies determine that pre- or post-contingency voltage limits are violated, mitigation plans must be developed. The mitigation plans must alleviate bus voltage violations at all voltage levels.

5.5 MVA Limits

The applicable MVA limits for the Newfoundland and Labrador Interconnected System are described in the NLSO Transmission Planning document "NLSO Facilities Rating Guide".

For planning purposes, the pre- and post-contingency MVA rating limits cannot be exceeded. When studying the post-contingency, there must be flexibility in the system to reduce equipment loading following the contingency to acceptable levels using a combination of:

- transformer OLTC movement
- changes in generation dispatch (i.e. start of stand by generation)
- changes in system configuration (i.e. opening of loops)
- non-firm export reductions
- non-firm load reductions

Note these measures must be considered as reasonable actions within the power system operational timeframe.

When planning studies determine that pre- and/or post-contingency MVA limits are violated, mitigation plans must be developed.

5.6 Acceptable Voltage Change for Switching of Reactive Power Elements

The switching of a shunt reactive device (shunt reactor, capacitor or filter bank) shall result in a voltage change not to exceed 2.5% as per IEEE Std 141 – 1993 Figure 3.8 at the customer level. At no time should the switching of a reactive device result in a voltage change of more than 5%, before transformer OLTC operation, on the Newfoundland and Labrador Interconnected System.

5.7 Loss of Maritime Link

With the Labrador – Island HVdc Link out of service, export on the Maritime Link to Nova Scotia shall be limited in order to avoid excessive over frequency and subsequent tripping of generation on the Island portion of the Newfoundland and Labrador Interconnected System.

5.8 Loss of Load

Consequential load loss is accepted for radial portions of the Newfoundland and Labrador Interconnected System when the contingency involves loss of an element within the radial system.

There shall be no Non-Consequential load loss for a single element contingency.

- In steady state removal of a generator, transformer (except single transformer station), transmission line (except radial transmission lines) or shunt reactive power element shall not result in over load of the remaining elements, overload of the remaining elements or loss of customer load.
- With the Labrador – Island HVdc Link out of service, load loss due to loss of a generator on the Island portion of the system is acceptable provided it is well controlled (i.e. Under Frequency Load Shedding).

5.9 Contingencies for Study

The NLSO Transmission Planning Department will maintain a list of contingencies for study purposes. This list of contingencies will include events that demonstrate the ability of the system to remain within acceptable voltage and MVA limits and to maintain system stability.

The existing contingency list includes:

- Tripping of a single transmission line, transformer, generator, synchronous condenser, shunt capacitor bank, shunt reactor or series compensation device without a fault
- Successful single pole reclosing on line to ground faults
- Unsuccessful single pole reclosing on line to ground faults
- Three phase faults except a three phase fault on, or near, the Bay d'Espoir 230 kV bus with tripping of a 230 kV transmission line
- Loss of the largest generator on line on the Island System with and without fault
- Line to ground or three phase fault with tripping of a synchronous condenser
- Fault and tripping of a series compensated 230 kV transmission line with the series compensation device out of service on the in service parallel 230 kV transmission line
- Temporary pole fault on HVdc system
- Permanent pole fault on HVdc system
- Temporary bipole fault on HVdc system

5.9.1 Transmission Line Contingencies

Where there are parallel lines between stations, the study need only simulate the fault and subsequent tripping of one line. The selection of the line to be faulted and tripped is based upon the line rating, impedance and clearing times.

If the parallel lines have different line ratings, the line with the higher MVA rating is tripped.

If the parallel lines have different impedances, the line with the lower impedance is faulted and tripped.

If the parallel lines have difference fault clearing times, the line with the slower clearing time, or longer reclosing time is faulted and tripped.

5.9.2 Transformer Contingencies

Transformer outages must be treated differently than outages to other transmission equipment given the long lead times for repair and/or replacement.

Transformer additions at 138/66 kV, 66/25-12.5 kV terminal stations with one transformer per voltage class shall be planned on the basis of being able to install the Hydro mobile transformer or one of Newfoundland Power's mobile transformers under agreement between the two parties with respect to use of mobile transformer equipment. These transformers are generally located on radial portions of the system.

Transformer additions at all major (≥230 kV) terminal stations (i.e. two or more transformers per voltage class) shall be planned on the basis of being able to withstand the loss of the largest unit (i.e. installed spare transformer capacity) such that all firm loads can be supplied during system peak.

Generally the 230/138 kV and 230/66 kV transformers supply local networks or radial systems. Historically the terminal station design has been that multiple transformers are connected to a common 230 kV bus with no individual 230 kV circuit breakers (a cost vs. reliability decision). For these stations[5] a transformer fault will result in tripping of the 230 kV bus with consequential load loss within the local network or radial system. Following isolation of the faulted transformer, the load is restored utilizing the remaining transformer capacity in the station(s).

New 230/138 kV and 230/66 kV stations shall be designed such that a transformer fault or bus fault does not result in temporary loss of load.

Generally 315 kV and 735 kV transformers are connected to the PTS. As a result, fault of a 315 kV or 735 kV rated transformer shall not result in loss of load or overload of the remaining installed transformer capacity during system peak. In addition, a spare single phase unit is required for three phase banks comprised of single phase units at the 315 kV and 735 kV level. Existing spare 315 kV and 735 kV transformers include:

- $\frac{230}{\sqrt{3}}/\frac{735}{\sqrt{3}}$/13.8 kV, 333 MVA at Churchill Falls
- $\frac{315}{\sqrt{3}}/\frac{735}{\sqrt{3}}$/13.8 kV, 280/333 MVA at Churchill Falls Terminal Station 2
- Installed spare capacity 315/138/25 kV, 75/100/125 MVA at Muskrat Falls

[5] Massey Drive 230/66 kV, Stony Brook 230/138 kV, Bay d'Espoir 230/69 kV, Sunnyside 230/138 kV, Western Avalon 230/138 kV 230/66 kV, Hardwoods 230/66 kV and Oxen Pond 230/66 kV

Similarly, a spare single phase unit is required for three phase shunt reactor banks comprised of single phase units at 315 kV and 735 kV. Existing spare single phase shunt reactors include:

- 735/√3, 55 MVAR at Churchill Falls

Given the time frames for transformer repair and/or replacement generator step up transformer capacity, for PTS, generators shall be planned on the basis that there is a spare generator step-up transformer. Existing spare generator step-up transformers include:

- a spare 230/13.8 kV, 110 MVA generator step-up transformer for hydro-electric generators
- a spare 230/16 kV, 170 MVA generator step-up transformer for Holyrood thermal
- spare 230/13.8 – 6.9 kV transformer capacity at Grand Falls for Exploits generation
- a spare 230/25/15 kV, 200 MVA synchronous condenser step-up transformer for Soldiers Pond Synchronous Condenser plant
- a spare 15/315 kV, 217 MVA generator step-up transformer for Muskrat Falls
- a spare 15/230 kV, 530 MVA generator step-up transformer at Churchill Falls
- a spare converter transformer at each of Muskrat Falls and Soldiers Pond converter stations

5.10 Short Circuit Levels

The planned maximum short circuit levels shall not exceed the interrupting capability of any associated circuit breakers. When short circuit review indicates that the short circuit level will exceed the interrupting rating of a circuit breaker(s), a mitigation plan shall be developed to replace the identified circuit breaker(s) prior to the system addition/modification resulting in the increased short circuit level being placed in service.

5.11 Dynamic Stability

Stability of the Newfoundland and Labrador Interconnected System shall be maintained in normal pre-contingency operation, during a contingency and post-contingency for all applicable contingencies with due regard to single pole and/or three pole reclosing and any automatic control actions.

The proper timing sequences which occur as a result of protection settings and telecommunication propagation times must be modelled for each event.

Stability of the system will be considered acceptable if all oscillations in voltage, current and angle are adequately damped so as not to cause unplanned equipment tripping or equipment damage. Generator pole slipping is unacceptable.

5.12 Performance Requirements

This section provides the performance requirements for the Newfoundland and Labrador Interconnected System.

5.12.1 Steady State and Dynamic Performance

- The System shall remain stable. Cascading and uncontrolled islanding shall not occur.
- Consequential Load Loss as well as generation loss is acceptable as a consequence of any event except pre-contingency normal operation.
- Simulate the removal of all elements that Protection Systems and other controls are expected to automatically disconnect for each event.
- Simulate Normal Clearing.
- Planned System adjustments such as Transmission configuration changes and re-dispatch of generation are allowed if such adjustments are executable within the time duration applicable to the Facility Ratings.
- Analyses shall be performed with one high inertia synchronous condenser at Soldiers Pond out of service.

5.12.2 Steady State Only Performance

- Applicable Facility Ratings shall not be exceeded.
- System steady state voltages and post-Contingency voltage deviations shall be within acceptable limits.
- The response of voltage sensitive Load that is disconnected from the System by end-user equipment associated with an event shall not be used to meet steady state performance requirements.
- There shall be no interruption of firm transmission service, nor shall there be Non-Consequential load loss in the pre-contingency normal operation state.

5.12.3 Dynamics Only Performance

- System response shall be stable and clearly demonstrate positive damping within 30 seconds of the initiating event/contingency following a disturbance.
- Transient voltage response shall be within acceptable limits
- Post fault system frequencies shall be limited as follows:
    - Prior to High-Power Operation of the Labrador – Island HVdc link (LIL), post fault system frequencies shall not drop below 58 Hz and shall not rise above 62 Hz
    - With the LIL bipole in service for High-Power Operation, post fault system frequencies shall not drop below 59 Hz on the Island portion of the system
- Prior to High-Power Operation of the LIL, under frequency load shedding on the Island portion

of the system shall be permitted, but controlled, for:
    - loss of generation
    - loss of an ML pole
    - loss of the ML bipole
    - loss of the a LIL pole
    - loss of the LIL bipole
- With the LIL bipole in service for High-Power Operation, under frequency load shedding on the Island portion of the system shall be limited as follows:
    - shall not occur when both HVdc links are in service. Load loss shall be scheduled and controlled if the HVdc links are out of service
    - shall not occur for permanent loss of an HVdc pole
    - shall not occur for a temporary HVdc bipole outage
    - shall be controlled for a permanent HVdc bipole outage
- There shall be no commutation failures of an HVdc link during post fault recovery.
- To ensure reliable operation of Holyrood units, HVdc exports shall be limited such that the post-contingency generating output of each unit is within 15 MW of the pre-contingency output within 20 seconds
- There shall be no interruption of firm transmission service or Non-Consequential load loss for a three phase fault on either of the following PTS elements:
    - Generator
    - Transmission line
    - Transformer
    - Shunt reactor, capacitor, harmonic filter, FATCS device
    - Synchronous condenser
- With the LIL bipole in service for High-Power Operation, a single pole fault on the Labrador-Island HVdc Link shall not result in Non-Consequential load loss. Runback/curtailment of the Nova Scotia Block on the Maritime Link is acceptable for loss of a LIL pole under agreement between Emera and Nalcor.
- Opening of a NL BES transmission line without a fault shall not result in the interruption of firm transmission service or Non-Consequential load loss.
- A single line to ground fault on a PTS bus section:
    - Shall not result in interruption of firm transmission service or Non-Consequential load loss for EHV buses
    - May result in interruption of firm transmission service or Non-Consequential load loss for HV buses
- A single line to ground internal circuit breaker fault on a PTS circuit breaker may result in interruption of firm transmission service or Non-Consequential load loss.
- A single line to ground fault on a PTS element followed by a stuck breaker (breaker failure) may result in interruption of firm transmission service or Non-Consequential load loss.

6 Reference Documents

1. TP-S-001 NLSO Standard – Transmission Facilities Rating Guide