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# NLSO Standard

## Technical Requirements for Connection to the NL Transmission System
## DRAFT

**Date: June 20, 2017**
**Transmission Planning - NLSO**

newfoundland labrador hydro
a nalcor energy company

| NLSO Standard<br>Technical Requirements for Connection to the NL Transmission System | | | |
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| NLSO Standard<br>Technical Requirements for Connection to the NL Transmission System Reviewed | |
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| ______________________________<br>**Manager Transmission Planning** | ____________<br>**Date** |
| ______________________________<br>**Manager** | ____________ |

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# Table of Contents

# List of Figures



# List of Tables

## 1.0 INTRODUCTION

The transmission system within the province of Newfoundland and Labrador (NL) consists of nominal voltage levels including 46 kV, 66 kV, 69 kV, 138 kV, 230 kV and 315 kV. The voltages available for a party wishing to interconnect to the transmission system will vary depending upon geography. In addition to the ac system voltage levels, the Island portion of the province is connected to Labrador via a ±350 kV, 900 MW HVdc Link and to Nova Scotia via a ±200 kV, 500 MW HVdc Link.

## 2.0 PURPOSE

The purpose of this standard is to set out the Newfoundland Labrador System Operator's (NLSO) minimum technical requirements for connection to the NL transmission system. A power plant or generator may be connected directly to the NL transmission system or through facilities owned by a separate transmission owner within the NLSO footprint. Generally a network customer, including industrial customers will connect to the NL transmission system. The requirements included in this document apply to both new power plants and existing power plants that undergo modifications as well as network customers.

The requirements in this standard apply to:

- wind power plants (i.e. wind farms);
- a new power plant connecting directly the NLSO transmission system;
- a new power plant connecting through facilities of an industrial customer;
- a new power plant connecting to customer owned transmission; and
- modifications to an existing power plant already connected directly or indirectly to the NLSO transmission system;
- network customers connection to the NL transmission system including industrial customers

The Appendices to this document are an integral part of the technical requirements for the connection of power plants to the NL transmission system.

This document is not intended as a design specification or as an instruction manual or guide for the power producer and this document shall not be used for those purposes.

## 3.0 DEFINITIONS

**Asynchronous Generator –** An asynchronous machine operating to generate electricity. The machine is an alternating current machine in which the rotor does not turn at synchronous speed. It may be connected to the grid either directly or through a converter.

**Circuit Breaker –** a device used to open and close a circuit by non-automatic means thereby breaking, or interrupting load current. The device will automatically open the circuit on a predetermined overload of current without damage to the device when properly applied.

**Disconnect Switch** - A switch that is intended to open a circuit only after the load current has been interrupted by another means, such as a circuit breaker. An ***Isolation Disconnect Switch*** is the first visible disconnection point in the power producer facilities closest to the Point of Interconnection.

**Disturbances** - a departure from normal operation conditions of a power system caused by events such as faults or loss of generation or load.

**Facilities Study** - A study conducted by the NLSO or its third party consultant to determine a list of facilities, the cost of those facilities, and the time required to interconnect with the NL transmission system.

**Flicker** – an increase or decrease in voltage over a short-period of time, often associated with motor starting or fluctuating load.

**Generating Unit** – a device that produces electricity. It is usually comprised of an asynchronous turbine-generator combination, or a synchronous turbine-generator combination.

**Harmonics** – A sinusoidal component of a periodic wave or quantity having a frequency that is an integral multiple of the fundamental frequency.

**Industrial Customer** – a network service customer of Newfoundland and Labrador Hydro connected to the NL transmission system at a voltage of 66 kV or greater.

**Islanded** – means the power producer and customer load has been isolated from the main grid.

**Interconnection Party** – any entity that has entered into an Interconnection Agreement with the NLSO. It will include but not limited to, power producers and network customers.

**Network Service Customer** – an entity connected to the NL transmission system that supplies electric power and energy to residential and commercial customers within the Province of Newfoundland and Labrador. In general, Newfoundland and Labrador Hydro is the Network Service customer.

**NLSO** – Newfoundland Labrador System Operator

**NL transmission system** – for the purposes of this document the NL transmission system means the transmission system within the Province of Newfoundland and Labrador with nominal operating voltages between 46 kV and 315 kV.

**Point of Interconnection (POI)** - The point of interconnection is defined as the boundary point between the NL transmission system and the electrical equipment of the power producer or generator owner.

**Power Plant** - a power plant is any site where electricity is produced.

**Power Producer** - A Power Producer is any person or entity carrying on electric power generation activities.

**Power Producer Facilities -** Power Producer Facilities include, but are not limited to, electric power lines required to connect the generation to the NL transmission system, equipment such as generating units, transformers, synchronous or static condensers, substations, metering equipment, special protection systems, and communication, protection and control facilities,

**Single Element Contingency** – the failure, malfunction or accidental operation of any system element, device or component that is part of the Power Producer Facilities.

**Station** – a fenced area containing electrical equipment such as circuit breakers, disconnect switches, transformers and control buildings.

- **Terminal Station** is an electrical station which contains transmission system equipment at a rated voltage of 46 kV or greater.
- **Substation** is an electrical station which contains distribution system equipment where the rated equipment voltage does not exceed 34.5 kV (Newfoundland and Labrador Hydro). In addition the term substation is used to refer to high voltage electrical stations owned by non-Newfoundland and Labrador Hydro transmission owners on the Island portion of the province.
- **Switchyard** is an electrical station containing transmission system circuit breakers, disconnect switches, line terminations and control buildings, generally a term used in Labrador.

**Synchronous Generator** – A synchronous alternating current machine that transformers mechanical power into electric power. The synchronous machine average speed at normal operation is proportional to the connected system frequency.

**System Impact Study (SIS)** - An engineering study conducted by the NLSO or its third party consultant that evaluates the impact of the proposed interconnection on the safety and reliability of the NL transmission system and neighboring transmission systems. The study shall identify and detail the system impacts that would result if the facility were interconnected without project modifications or system modifications, focusing on the adverse system impacts.

**Tripping** – the change in state of a circuit breaker (i.e. opening) brought about by a special or conventional protection system.

## 4.0 CONNECTION

The NLSO will determine the appropriate solution for connecting the proposed power plant or customer to the transmission system including the network upgrades required to complete the connection through power system studies. The final solution will be based upon technical and economic criteria while being safe and environmentally acceptable.

### 4.1 Point of Interconnection

The physical Point of Interconnection (POI) is determined after agreement between the NLSO and the Power Producer or Network Service Customer. It is the physical location in the transmission system of the line ownership between the NLSO and the power producer/customer. Typical location is the NLSO side of the NLSO service termination on the power producer disconnect switch and is specified in the Generator Interconnection Agreement. For industrial customers the typical location is the low voltage bus and is specified in the Asset Interconnection Agreement.

The power producer or network service customer facilities are required to have a visible disconnection point so that the facilities can be disconnected from the NL transmission system for grid operational purposes. The visible disconnection point is achieved using a disconnect switch. The disconnect switch(es) must be accessible at all times so that the NLSO can lock it (them) out.

The power producer or network service customer facilities are required to have one or more circuit breakers in the ac station to protect the power producer's equipment and avoid unnecessary surges on the transmission network. The number of circuit breakers will depend upon the number of transmission tie lines and/or step up transformers at the point of interconnection.

Figures 1 to 3 provide examples of the equipment requirements for power producer facilities at potential points of interconnection.

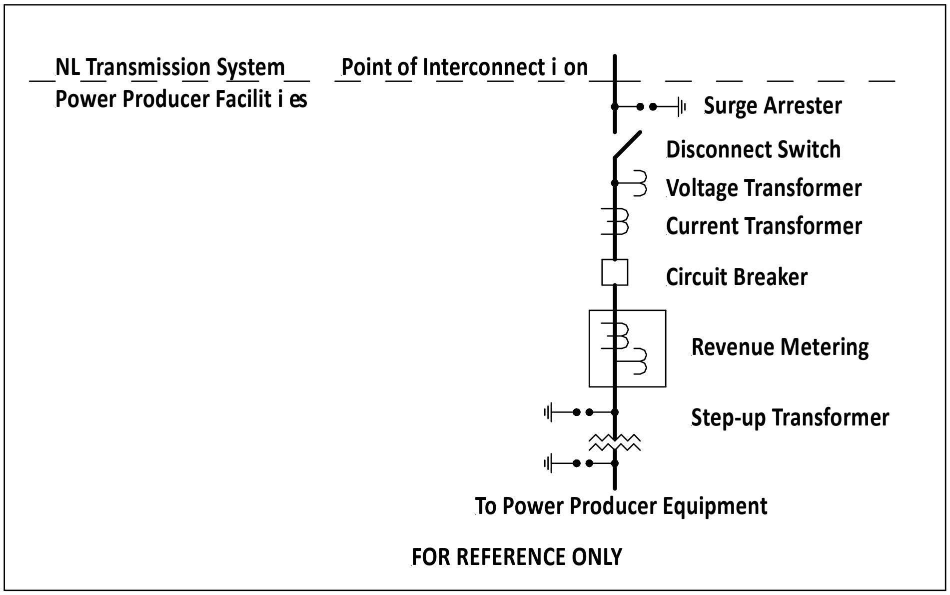


Figure 1 – Power Plant Connected to Transmission System

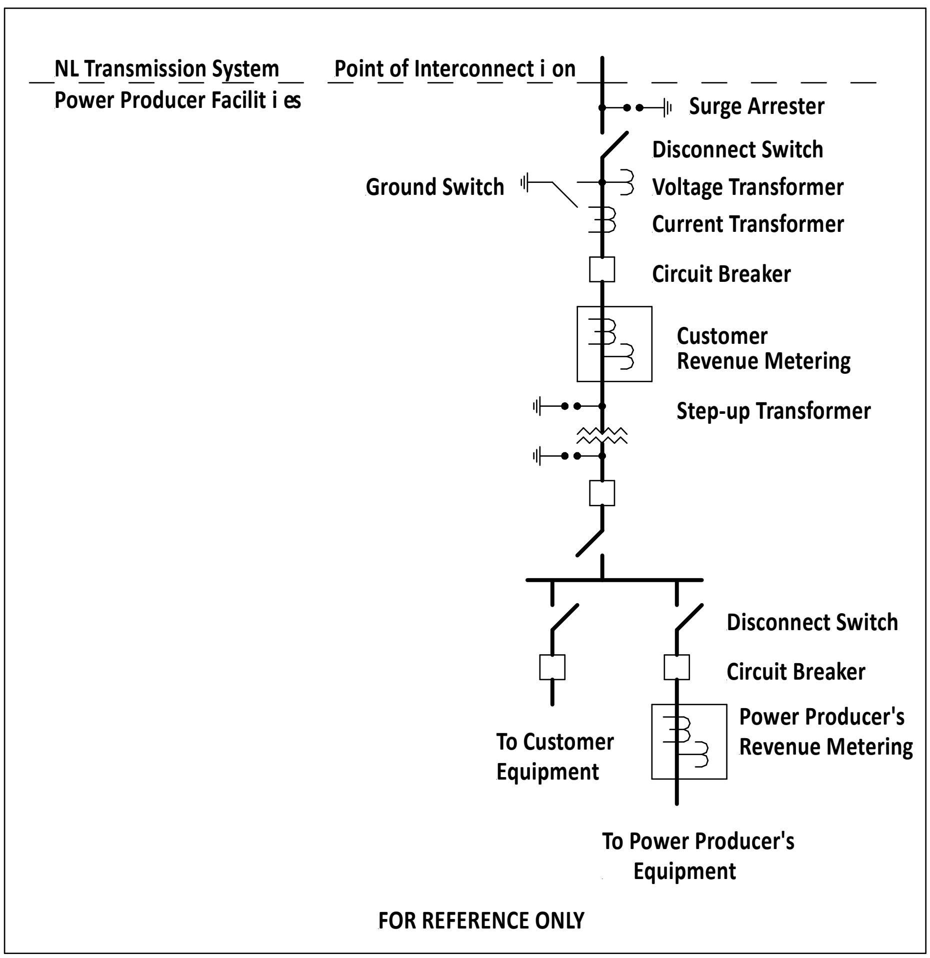


Figure 2 – Power Plant Connected to Customer/Industrial Equipment

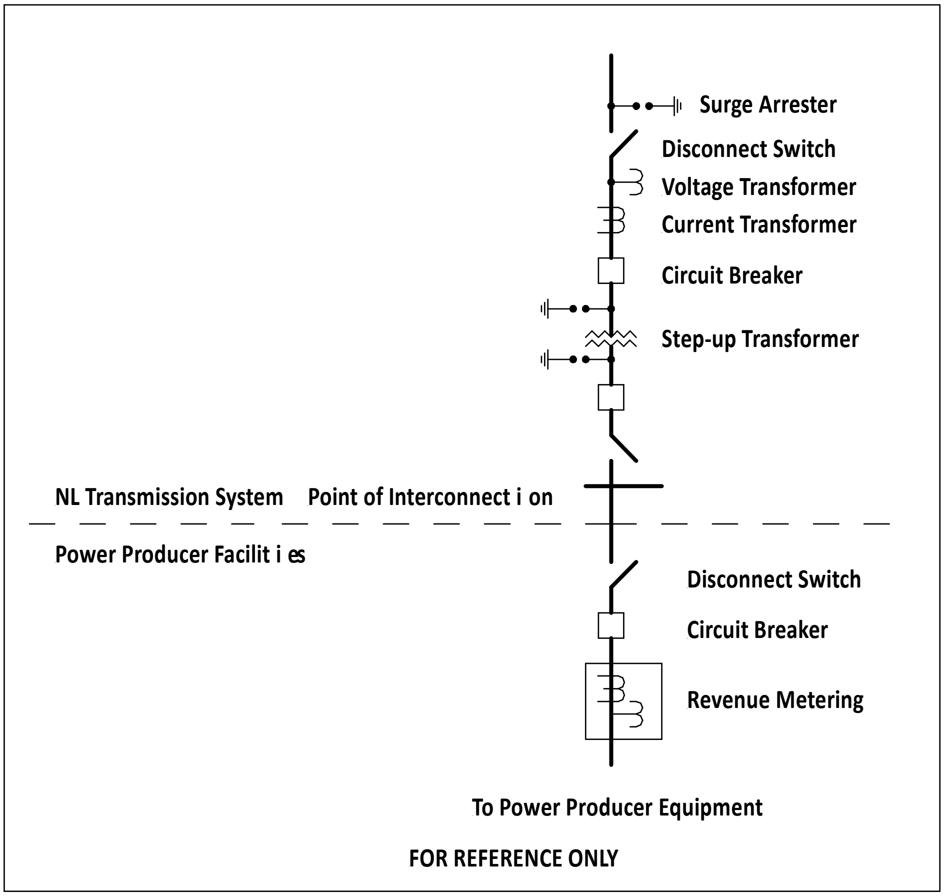


Figure 3 – Power Plant Connected to Low Voltage of Step-Up Transformer

## 5.0 GENERAL REQUIREMENTS

This section covers the general requirements for a power producer's or network customer facilities within the NL transmission system. The requirements in this document are intended to ensure safe, reliable, efficient operation of the NL transmission system. The following factors are of significance in any interconnection:

- Safety of NLSO employees and the public
- Reliability of the NL transmission system
- Stability of the transmission system and connected power plants
- Protection of NL transmission system equipment
- To this end, those connecting to the NL transmission system must conform to the Canadian Electrical Code where applicable and shall operate within the applicable guidelines of this document and any other specific requirements stated in the Interconnection Agreement.

The NLSO will carry out a System Impact Study (SIS) for every interconnection request to determine what network upgrades are required for connection. The NLSO will then, pending agreement of the power producer to proceed, conduct a Facility Study to provide an estimate of the scope, cost and duration of any required upgrades or modification to the NL transmission system required for connection. The results of these studies may alter, or add to, these general requirements.

## 6.0 EQUIPMENT REQUIREMENTS

It is recognized that the power producer or customer must complete engineering studies following industry standards and best practice for its equipment. The following requirements are the minimum requirements from the transmission system perspective only.

### 6.1 Transmission System Grounding Connection Requirement

The NL transmission system is, in most cases, effectively grounded under normal operating conditions. The power producer is responsible for the appropriate safety grounding of their equipment. The ac station must have an effectively grounded neutral point connection as seen from the high voltage side of the station.

In order to meet this requirement, the neutral on the high-voltage windings of the step-up transformer(s) used to connect the power plant must be grounded. The impedance values for the transformer(s) and winding connections must meet the following criteria for effective grounding:

$$0 \le X_0/X_1 \le 3 \text{ and } 0 \le R_0/X_1 \le 3$$

Where:

$X_1$ = positive sequence reactance of the power plant seen from the HV side of the station
$X_0$= zero sequence reactance of the power plant seen from the HV side of the station
$R_0$= zero sequence resistance of the power plant seen from the HV side of the station

The preferred connection on the generator step-up transformer(s) is WYE-GND on the high-voltage side and DELTA on the low-voltage side. In general terms, the generator neutral is grounded through a distribution transformer with a resistor in the secondary winding.

Unless otherwise stipulated in the results and recommendations of the SIS, the transmission system transformers rated 230/138 kV, 315/230 kV and 315/138 kV will be autotransformers with a DELTA Tertiary winding.

Transmission system transformers rated 230/46 kV, 138/66 kV, 230/66 kV require a thirty degree phase shift between high and low voltage. Therefore, unless otherwise stipulated in the results and recommendations of the SIS, the transmission system transformers rated 230/46 kV, 138/66 kV, 230/66 kV will have a high voltage WYE-GND winding and a low voltage DELTA winding, or a high voltage WYE-GND winding and a low voltage ZIG-ZAG-GND winding configuration. The low voltage system grounding for these installations will be provided by the application of specific grounding transformers or through application of a reactor in the neutral of the low voltage ZIG-ZAG-GND winding.
Network Service transformers for local distribution system supply are rated 46/25:12.5 kV, 66/25:12.5 kV, 69/25:12.5 kV, 138/25:12.5 kV and, unless otherwise stipulated in the results and recommendations of the SIS, will have a high voltage DELTA winding and a low voltage WYE-GND winding, except 138/25 kV network service transformers in eastern Labrador which have a high voltage WYE-GND winding, a low voltage WYE-GND winding and a DELTA tertiary winding. If power producer facilities are connected to the low voltage side of the network service transformer, the winding configuration must be changed such that there is system grounding on the high voltage winding side.

Industrial customer connections to the transmission system are supplied from network service transformers with high side winding voltages of 66 kV, 69 kV, 138 kV, 230 kV or 315 kV and low side winding voltages of 6.6 kV, 6.9 kV, 4.16 kV or 13.8 kV. Typically when there is no power producer facility such as a co-generation facility on the customer side of the point of interconnection the high voltage winding will be DELTA and the low voltage winding will be WYE-GND. Generally the neutral of the low voltage winding will be grounded through a neutral resistor to limit the ground fault current on the low voltage system to meet the requirements of the industrial customer. For Industrial customer connections to the transmission system where there are power producer facilities on the customer side of the point of interconnection, the network service transformer high voltage winding will be WYE-GND and the low voltage winding will be DELTA. The system grounding on the low voltage side of the network service transformer will be controlled via dedicated grounding transformers with appropriately sized neutral resistors to meet the ground fault current requirements of the industrial customer.

### 6.2 General Electrical Characteristics of Equipment

Table 1 provides the general electrical characteristics of facilities connected to the NL transmission system. The table provides the standard insulation levels and short circuit levels for each voltage class. In designing its facilities, it is recommended that the interconnection party check with the NLSO to confirm the electrical characteristics that apply to the portion of the transmission system where the facilities will be connected.

An interconnection party installing equipment with an interrupting capacity below the standard short circuit levels set by the NLSO will have to pay to replace its equipment if the interrupting capacity becomes too low as the transmission system evolves.

**Table 1~~5~~ - Standard Insulation and Short Circuit Levels NL Transmission System**

| Standard Insulation and Short Circuit Levels NL Transmission System | | | | |
|---|---|---|---|---|
| Nominal System Voltage (kV L-L rms) | Rated Voltage of Equipment (kV L-L rms) | BIL (kV p-p) | Current Rating A | Standards short-circuit current (kA sym) |
| 46 | 52/72.5 | 250/350 | 1200/2000 | 31.5/40 |
| 66/69 | 72.5 | 350 | 1200/2000 | 31.5 |
| 138 | 152 | 550 - 650 | 2000 | 20 |
| 230 | 253 | 900 - 1050 | 1200/2000 | 31.5 |
| 315 | 362 | 1175 - 1300 | 3150 | 40 |

### 6.3 Disconnect Switch Requirements

The disconnect switches are required to provide a visible isolation point. In the event that a disconnect switch is included in a compact Gas-insulated-Substation (GIS) then the GIS must be equipped with viewing ports or sight glasses such that transmission operator personnel can see the visible air gap when the disconnect switch is open.

It must be possible to lock the disconnect switch on the open position. For blades that open upwards, the blades must form an angle greater than 90° when in the open position to avoid accidental closure of the blades.

All disconnect switches applied at 138 kV and above must be equipped with a motor operator such that the switch can be controlled remotely. For motorized disconnect switches it is required that the motor drive control mechanism can be disabled and locked out of service.

### 6.4 Ground Switch Requirements

All ground switches used for the discharge of energy and isolation of transmission system elements must be manually operated devices. Ground switches must be located in the following locations as a minimum:

- at each transmission line termination on the line side of the isolation disconnect switch
- on the high voltage terminals of transformer windings rated 315 kV and above
- on the line terminals of shunt reactors rated 230 kV and above
- on both the line and neutral sides of a shunt capacitor bank

Where the disconnect switch is coupled with a ground switch there must be an interlock to prevent the ground switch from closing if the disconnect switch is closed. In no instance may a disconnect switch, on the transmission system, be coupled to a grounding switch that grounds automatically when the disconnect switch opens.

### 6.5 Surge Arrester Requirements

Surge arresters must be of the zinc oxide type with no spark gap and appropriately rated for the constraints of the transmission system and the facilities to which they are connected.

Surge arresters are required on both the high and low voltage windings of transformers, the high voltage windings of shunt reactors and the line side of shunt capacitor banks. In addition for voltages 230 kV and above, each transmission line termination in a system will be equipped with surge arresters. The line termination arresters shall be on the line side of any isolation disconnect switch.

### 6.6 Circuit Breaker Requirements

Circuit breakers must have adequate insulation to withstand and interrupting capacity to interrupt any type of fault on the power producer's facilities or on any part of the NL transmission system to which the power producer facility is connected. All circuit breakers applied at 230 kV or high voltage must have two sets of trip coils with separate cores, each designed for both automatic trip circuits per protection. For lower voltage levels the NLSO may also require two sets of trip coils with separate cores if the need for system protection so warrants.

### 6.7 Transformer Requirements

The winding connections of transformers must meet the Transmission System Grounding Connection Requirement as noted above in section 6.1.

Following the SIS, the NLSO may specify transformer impedance limits (maximum and minimum) to meet the Transmission System Grounding Connection Requirements as applicable.

Unless stipulated in the results and recommendations of the SIS, generator/synchronous condenser step-up transformers shall be equipped with de-energized taps located on the high voltage winding to adjust the transformer tap ratio based upon the voltage conditions of the transmission system at the point of interconnection. The de-energized taps shall be of the range ±5% in 2.5% steps unless otherwise specified. There shall be no current derating of the transformer windings for off-nominal tap position. Table 2 provides the tap positions and winding voltages for generator step-up transformers.

**Table 2 - Standard Generator Step-up Transformer Tap Ratios and Winding Voltages**

| Generator Step-up Transformer Tap Ratios and High Side Winding Voltages | | | | | | | |
|---|---|---|---|---|---|---|---|
| Tap Position | Tap Ratio | High Side Winding Voltage - V | | | | | |
| | | 46 kV | 66 kV | 69 kV | 138 kV | 230 kV | 315 kV |
| 1 | 105% | 48,300 | 69,300 | 72,450 | 144,900 | 241,500 | 330,750 |
| 2 | 102.5% | 47,150 | 67,650 | 70,725 | 141,450 | 235,750 | 322,875 |
| 3 | 100% | 46,000 | 66,000 | 69,000 | 138,000 | 230,000 | 315,000 |
| 4 | 97.5% | 44,850 | 64,350 | 67,275 | 134,550 | 224,250 | 307,125 |
| 5 | 95% | 43,700 | 62,700 | 65,550 | 131,100 | 218,500 | 299,250 |

For transmission system transformers rated 230/138 kV, 315/230 kV, 315/138 kV, 138/66 kV and 230/66 kV the units shall be equipped with on load tap changers (OLTCs) located on the high voltage winding to adjust transformer ratio based upon voltage conditions of the transmission system at the point of interconnection. Unless stipulated in the results and recommendations of the SIS, the on load tap changer range shall be +5%/-15% in 1.25% steps (total of 17 positions). There shall be no current derating of the transformer windings for off-nominal tap position. Table 3 provides the tap positions and winding voltages for transmission system transformers.

Table 3 - Standard Transmission System Transformer On Load Tap Changer Tap Ratios and Winding Voltages

| Transmission System Transformer OLTC Tap Ratios and High Side Winding Voltages | | | | | | | |
|---|---|---|---|---|---|---|---|
| Tap Position | Tap Ratio | High Side Winding Voltage - V | | | | | |
| | | 46 kV | 66 kV | 69 kV | 138 kV | 230 kV | 315 kV |
| 1 | 105% | 48,300 | 69,300 | 72,450 | 144,900 | 241,500 | 330,750 |
| 2 | 103.75% | 47,725 | 68,475 | 71,587.5 | 143,175 | 238,625 | 326,812.5 |
| 3 | 102.5% | 47,150 | 67,650 | 70,725 | 141,450 | 235,750 | 322,875 |
| 4 | 101.25% | 46,575 | 66,825 | 69,862.5 | 139,725 | 232,875 | 318,937.5 |
| 5 | 100% | 46,000 | 66,000 | 69,000 | 138,000 | 230,000 | 315,000 |
| 6 | 98.75% | 45,425 | 65,175 | 68,137.5 | 136,275 | 227,125 | 311,062.5 |
| 7 | 97.5% | 44,850 | 64,350 | 67,275 | 134,550 | 224,250 | 307,125 |
| 8 | 96.25% | 44,275 | 63,525 | 66,412.5 | 132,825 | 221,375 | 303,187.5 |
| 9 | 95% | 43,700 | 62,700 | 65,550 | 131,100 | 218,500 | 299,250 |
| 10 | 93.75% | 43,125 | 61,875 | 64,687.5 | 129,375 | 215,625 | 295,312.5 |
| 11 | 92.5% | 42,550 | 61,050 | 63,825 | 127,650 | 212,750 | 291,375 |
| 12 | 91.25% | 41,975 | 60,225 | 62,962.5 | 125,925 | 209,875 | 287,437.5 |
| 13 | 90% | 41,400 | 59,400 | 62,100 | 124,200 | 207,000 | 283,500 |
| 14 | 88.75% | 40,825 | 58,575 | 61,237.5 | 122,475 | 204,125 | 279,562.5 |
| 15 | 87.5% | 40,250 | 57,750 | 60,375 | 120,750 | 201,250 | 275,625 |
| 16 | 86.25% | 39,675 | 56,925 | 59,512.5 | 119,025 | 198,375 | 271,687.5 |
| 17 | 85% | 39,100 | 56,100 | 58,650 | 117,300 | 195,500 | 267,750 |

For Network Service transformers connected to the transmission system and supplying local distribution systems, transformers rated up to 10/13.3/16.7 MVA will be equipped with a de-energized tap changer located on the high voltage winding. The de-energized taps shall be of the range ±5% in 2.5% steps unless otherwise specified in the results and recommendations of the SIS. There shall be no current derating of the transformer windings for off-nominal tap position. Distribution class voltage regulators of appropriate size will be connected in series with the network service transformer to regulate the 12.5 kV or 25 kV distribution bus voltage to within acceptable limits. Table 4 provides the tap positions and winding voltages for Network Service transformers rated up to 10/13.3/16.7 MVA.

Table 4 - Standard Network Service Transformer Rated up to 10/13.3/16.7 MVA Tap Ratios and Winding Voltages

| Network Service Transformer Rated up to 10/13.3/16.7 MVA Tap Ratios and High Side Winding Voltages | | | | | | | |
|---|---|---|---|---|---|---|---|
| Tap Position | Tap Ratio | High Side Winding Voltage - V | | | | | |
| | | 46 kV | 66 kV | 69 kV | 138 kV | 230 kV | 315 kV |
| 1 | 105% | 48,300 | 69,300 | 72,450 | 144,900 | 241,500 | 330,750 |
| 2 | 102.5% | 47,150 | 67,650 | 70,725 | 141,450 | 235,750 | 322,875 |
| 3 | 100% | 46,000 | 66,000 | 69,000 | 138,000 | 230,000 | 315,000 |
| 4 | 97.5% | 44,850 | 64,350 | 67,275 | 134,550 | 224,250 | 307,125 |
| 5 | 95% | 43,700 | 62,700 | 65,550 | 131,100 | 218,500 | 299,250 |

For Network Service transformers connected to the transmission system and supplying local distribution systems, transformers rated 15/20/25 MVA and greater will be equipped with an on load tap changer (OLTC) located on the high voltage winding regulating the low voltage bus. The OLTC taps shall be of the range +5%/-15% in 0.625% steps (total of 33 positions) unless otherwise specified in the results and recommendations of the SIS. There shall be no current derating of the transformer windings for off-nominal tap position. Table 5 provides the tap positions and winding voltages for Network Service transformers rated 15/20/25 MVA and beyond.

**Table 5 - Standard Network Service Transformer Rated 15/20/15 MVA and Beyond On Load Tap Changer Tap Ratios and Winding Voltages**

| Network Service Transformer Rated 15/20/25 MVA and Beyond OLTC Tap Ratios and High Side Winding Voltages | | | | | | | |
|---|---|---|---|---|---|---|---|
| Tap Position | Tap Ratio | High Side Winding Voltage - V | | | | | |
| | | 46 kV | 66 kV | 69 kV | 138 kV | 230 kV | 315 kV |
| 1 | 105% | 48,300 | 69,300 | 72,450 | 144,900 | 241,500 | 330,750 |
| 3 | 103.75% | 47,725 | 68,475 | 71,587.5 | 143,175 | 238,625 | 326,812.5 |
| 5 | 102.5% | 47,150 | 67,650 | 70,725 | 141,450 | 235,750 | 322,875 |
| 7 | 101.25% | 46,575 | 66,825 | 69,862.5 | 139,725 | 232,875 | 318,937.5 |
| 9 | 100% | 46,000 | 66,000 | 69,000 | 138,000 | 230,000 | 315,000 |
| 11 | 98.75% | 45,425 | 65,175 | 68,137.5 | 136,275 | 227,125 | 311,062.5 |
| 13 | 97.5% | 44,850 | 64,350 | 67,275 | 134,550 | 224,250 | 307,125 |
| 15 | 96.25% | 44,275 | 63,525 | 66,412.5 | 132,825 | 221,375 | 303,187.5 |
| 17 | 95% | 43,700 | 62,700 | 65,550 | 131,100 | 218,500 | 299,250 |
| 19 | 93.75% | 43,125 | 61,875 | 64,687.5 | 129,375 | 215,625 | 295,312.5 |
| 21 | 92.5% | 42,550 | 61,050 | 63,825 | 127,650 | 212,750 | 291,375 |
| 23 | 91.25% | 41,975 | 60,225 | 62,962.5 | 125,925 | 209,875 | 287,437.5 |
| 25 | 90% | 41,400 | 59,400 | 62,100 | 124,200 | 207,000 | 283,500 |
| 27 | 88.75% | 40,825 | 58,575 | 61,237.5 | 122,475 | 204,125 | 279,562.5 |
| 29 | 87.5% | 40,250 | 57,750 | 60,375 | 120,750 | 201,250 | 275,625 |
| 31 | 86.25% | 39,675 | 56,925 | 59,512.5 | 119,025 | 198,375 | 271,687.5 |
| 33 | 85% | 39,100 | 56,100 | 58,650 | 117,300 | 195,500 | 267,750 |

For network service transformers connected to the transmission system and supplying an industrial customer, two winding transformers will be equipped with an OLTC located on the high voltage winding regulating the low voltage bus. Unless stipulated in the results and recommendations of the SIS, the on load tap changer range shall be +5%/-15% in 1.25% steps (total of 17 positions). There shall be no current derating of the transformer windings for off-nominal tap position. Table 6 provides the tap positions and winding voltages for Network Service transformers supplying industrial customers.

**Table 6 - Standard Network Service Transformer Supplying Industrial Customer On Load Tap Changer Tap Ratios and Winding Voltages**

| Network Service Transformer Supplying Industrial Customer OLTC Tap Ratios and High Side Winding Voltages | | | | | | | |
|---|---|---|---|---|---|---|---|
| Tap Position | Tap Ratio | High Side Winding Voltage - V | | | | | |
| | | 46 kV | 66 kV | 69 kV | 138 kV | 230 kV | 315 kV |
| 1 | 105% | 48,300 | 69,300 | 72,450 | 144,900 | 241,500 | 330,750 |
| 2 | 103.75% | 47,725 | 68,475 | 71,587.5 | 143,175 | 238,625 | 326,812.5 |
| 3 | 102.5% | 47,150 | 67,650 | 70,725 | 141,450 | 235,750 | 322,875 |
| 4 | 101.25% | 46,575 | 66,825 | 69,862.5 | 139,725 | 232,875 | 318,937.5 |
| 5 | 100% | 46,000 | 66,000 | 69,000 | 138,000 | 230,000 | 315,000 |
| 6 | 98.75% | 45,425 | 65,175 | 68,137.5 | 136,275 | 227,125 | 311,062.5 |
| 7 | 97.5% | 44,850 | 64,350 | 67,275 | 134,550 | 224,250 | 307,125 |
| 8 | 96.25% | 44,275 | 63,525 | 66,412.5 | 132,825 | 221,375 | 303,187.5 |
| 9 | 95% | 43,700 | 62,700 | 65,550 | 131,100 | 218,500 | 299,250 |
| 10 | 93.75% | 43,125 | 61,875 | 64,687.5 | 129,375 | 215,625 | 295,312.5 |
| 11 | 92.5% | 42,550 | 61,050 | 63,825 | 127,650 | 212,750 | 291,375 |
| 12 | 91.25% | 41,975 | 60,225 | 62,962.5 | 125,925 | 209,875 | 287,437.5 |
| 13 | 90% | 41,400 | 59,400 | 62,100 | 124,200 | 207,000 | 283,500 |
| 14 | 88.75% | 40,825 | 58,575 | 61,237.5 | 122,475 | 204,125 | 279,562.5 |
| 15 | 87.5% | 40,250 | 57,750 | 60,375 | 120,750 | 201,250 | 275,625 |
| 16 | 86.25% | 39,675 | 56,925 | 59,512.5 | 119,025 | 198,375 | 271,687.5 |
| 17 | 85% | 39,100 | 56,100 | 58,650 | 117,300 | 195,500 | 267,750 |

For three winding transformers supplying an industrial customer where there are two low voltage windings connected to two independent low voltage buses due to transformer size and low voltage equipment ratings, the transformer will be equipped with OLTCs on each of the low voltage windings regulating the low voltage bus voltage. Unless stipulated in the results and recommendations of the SIS, the on load tap changer range shall be +5%/-15% in 1.25% steps (total of 17 positions). There shall be no current derating of the transformer windings for off-nominal tap position.

The preferred transformer sizes for the NL transmission system are as per CAN/CSA-C88-M90 Power transformers and Reactors Table 2.

In order to meet the NLSO planning criteria, redundant transformer capacity will be required for all transformers connected to the NL transmission system.

- For Network Service transformers supplying local distribution systems on the Island portion of the province consideration may be given to the use of a mobile transformer station to provide the redundant transformer capacity.
- For Network Service transformers supplying distribution systems in Labrador there must be installed redundant spare transformer capacity.
- For Network Service transformers supplying industrial customers installed redundant transformer capacity is required unless specifically agreed to with the customer in the Interconnection Agreement.
- For transmission system transformers rated 230/46 kV, 230/66 kV, 230/138 kV, 230/315 kV and 315/138 kV there must be installed redundant transformer capacity.
- For 138/66 kV and 138/69 kV transmission system transformers consideration may be given to the use of a mobile transformer station to provide the redundant transformer capacity on the Island only.
- For power producer generator step-up transformers connecting an installed generating capacity in excess of 50 MW, a spare generator step-up transformer is required
- For synchronous condenser plants generator step-up transformers connecting an installed capacity in excess of 50 MVAR, a spare generator step-up transformer is required
- For HVdc converter stations a spare converter transformer is required at each station (rectifier and inverter)
- For three phase transformer banks comprised of single phase units, in addition to installed redundant transformer capacity, a spare single phase transformer unit is required.

### 6.8 Shunt Capacitor Requirements

Unless stipulated in the results and recommendations of the SIS, shunt capacitor banks connected to the NL transmission system shall be configured as WYE-UNGROUNDED banks. The capacitor bank must be equipped with current inrush/outrush limiting reactors, a line side surge arrester, a ground switch on both the line and neutral side of the capacitor bank for discharge of the bank and maintenance and point on wave controllers for the capacitor bank circuit breakers. Shunt capacitor banks shall not trip or disconnect from the NL transmission system for failure of a single capacitor can on each of the three phases.

The switching of a shunt capacitor 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% on the NL transmission system.

### 6.9 Shunt Reactor Requirements

Each shunt reactor will be equipped with an isolation disconnect switch, a circuit breaker appropriate for shunt reactor switching and line side surge arresters. A ground switch on the line side of the shunt reactor is required for discharge and maintenance on each reactor rated 230 kV and above. There shall be sufficient shunt rector capacity to ensure acceptable system voltages for sudden loss of a shunt reactor. For three phase shunt rector banks comprised of single phase units, a spare single phase unit is required.

The switching of a shunt reactor 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% on the NL transmission system.

### 6.10 Station Layout

The NLSO does not accept the practice of “Tee-Tapping” transmission lines operating at a nominal voltage greater than 69 kV. Where necessary, terminal stations will be established for connection to the NL transmission system. The preferred station configuration at 230 kV and above is the breaker-and-one-half arrangement. For a limited number of elements the ring bus arrangement may be considered pending the results and recommendations of the SIS.

For terminal stations operating at 230 kV and above there must be two independent and redundant sources of station service such that there is no common mode of failure. Acceptable station service supply alternatives include:

- Two station service voltage transformers, or station service transformers connected to opposite buses in the ring bus or breaker-and-one-half arrangement
- Supplies from the DELTA tertiaries of two autotransformers
- supplies from two low voltage buses at an industrial customer location where the low voltage buses are separated by a bus tie circuit breaker

### 6.11 Station Grounding

The interconnection party will ensure adequate grounding within their respective stations to provide for safe step and touch potentials in accordance with safety standards and industry practice.

### 6.12 Creepage Distance Requirements

The NL transmission system, particularly the island portion, is exposed to significant salt contamination due to prevailing winds from the ocean. Table 7 provides the minimum creepage distances for electrical equipment connected to the NL transmission system.

Table 7 - Minimum Creepage Distances for Electrical Equipment Bushings

| Minimum Creepage Distances for Electrical Equipment Bushings | | | |
|---|---|---|---|
| Nominal Voltage (kV L-L) | Maximum Voltage (kV L-L) | IEC 60071-2 Specific Creep mm/kV | Total Creepage Distance (mm) |
| 66/69 | 72.5 | 25 | 1813 |
| 138 | 152 | 25 | 3800 |
| 230 | 253 | 25<br>31 | 6325<br>7843 near coast |
| 315 | 347 | 20<br>25 | 6940 Labrador<br>8675 Island |

### 6.13 Event Recorders

In order to determine the performance of the transmission system and connected generation facilities when system disturbances occur, and to analyze the cause of such disturbances, it is necessary to record relevant information about the system. Consequently, the NLSO may require that the power producer or customer incorporate event recorders, fault recorders or other instruments necessary to study system disturbances, within the power producer's facilities.

## 7.0 POWER PLANT REQUIREMENTS

This section provides the general requirements specific for power plants to connect to the NL transmission system. These general requirements apply equally as well to synchronous condenser plants.

### 7.1 Requirement Regarding Maximum Loss of Generation Following a Single Element Contingency

A single element contingency is defined as the failure, accidental operation or malfunction of any system element, device, or component within the power producer's facilities. A system element includes: generator, transmission line, multi-circuit line, transformer, bus, circuit breaker, capacitor bank, shunt reactor, SVC, STATCOM, etc.

All power producer facilities connecting a power plant with an installed capacity exceeding 1000 MW in Labrador must be designed, built and operated such that no single element contingency in those facilities can result in loss of generation in excess of 1000 MW.

All power producer facilities connecting a power plant with an installed capacity exceeding 155 MW on the Island of Newfoundland must be designed, built and operated such that no single element contingency in those facilities can result in loss of generation in excess of 155 MW.

### 7.2 Requirement Regarding Generation Response to Disturbances

Generating facilities connected to the NL transmission system must remain in service during transmission system disturbances without tripping as long as possible to help maintain system stability and restore both system frequency and voltage following the disturbance. All power producer facilities must remain in service without a generating unit trip for the voltage and frequency excursion provided in Tables 8 to 11.

Table 8- Frequency Variations During Transient Conditions – NLSO Area

| Frequency Variations During Transient Conditions – NLSO Area | |
|---|---|
| Frequency (Hz) | Duration |
| F < 55.5 | 0 seconds |
| 55.5 ≤ F < 56.5 | 0.35 seconds |
| 56.5 ≤ F < 57.0 | 2 seconds |
| 57.0 ≤ F < 57.5 | 10 seconds |
| 57.5 ≤ F < 58.5 | 1.5 minutes |
| 58.5 ≤ F < 59.4 | 11 minutes |
| **59.4 ≤ F < 60.6** | **Steady State** |
| 60.6 ≤ F < 61.5 | 11 minutes |
| 61.5 ≤ F < 63.0 | 1.5 minutes |
| 63.0 ≤ F < 66.0 | 5 seconds |
| F > 66.0 | 0 seconds |
| Power plants must also remain in service when system disturbances occur and the system frequency varies by ±4 Hz/s. | |

Table 9 - Power Frequency Voltage Variations During Transient Conditions – Labrador

| Power Frequency Voltage Variations During Transient Conditions – Labrador | |
|---|---|
| Voltage (p.u.) | Duration |
| V < 0.60 | 0.10 seconds |
| 0.60 ≤ V < 0.75 | 0.25 seconds |
| 0.75 ≤ V < 0.85 | 2 seconds |
| 0.85 ≤ V < 0.90 | 300 seconds |
| **0.90 ≤ V < 1.10** | **Steady State** |
| 1.10 ≤ V < 1.15 | 300 seconds |
| 1.15 ≤ V < 1.20 | 30 seconds |
| 1.20 ≤ V < 1.25 | 2 seconds |

Table 10 - Power Frequency Voltage Variations During Transient Conditions – Island of Newfoundland

| Power Frequency Voltage Variations During Transient Conditions – Island of Newfoundland | |
|---|---|
| Voltage (p.u.) | Duration |
| V = 0.00 | 0.15 seconds |
| 0. 0 ≤ V < 0.80 | 1 second |
| 0.85 ≤ V < 0.90 | 300 seconds |
| **0.90 ≤ V < 1.10** | **Steady State** |
| 1.10 ≤ V < 1.20 | 3 seconds |
| 1.10 ≤ V < 1.30 | 0.5 seconds |
| 1.30 ≤ V < 1.50 | 0.1 seconds |

Table 11 - Power Frequency Over Voltage Range Following a Disturbance Before Unit tripping Ensuring Equipment Integrity - Labrador

| Power Frequency Over Voltage Range Following a Disturbance Before Unit tripping Ensuring Equipment Integrity - Labrador | |
|---|---|
| Over Voltage (p.u.) | Duration |
| 1.00 ≤ V ≤ 1.10 | Continuous |
| 1.10 < V ≤ 1.15 | 300 seconds |
| 1.15 < V ≤ 1.20 | 30 seconds |
| 1.20 < V ≤ 1.25 | 5 seconds |
| 1.25 < V ≤ 1.40 | 2.5 seconds |
| 1.40 < V ≤ 1.50 | 0.1 seconds |
| V > 1.50 | 0.033 seconds |

The low voltage ride through requirements of wind power plants are covered in a separate section.

## 7.3 Requirement for Power Plant Islanding

Unless studies have been completed and arrangements reached, the NLSO's requirement is that power producers connected to the NL transmission system must not supply in islanded mode the loads of customers connected to the NL transmission system. However, the power producer may island on its own load and assume the risk of self-supply in the instance of co-generation facilities. Power Producers should be equipped with protection systems which detect a power island condition and cause the generator to cease to deliver power to the NL transmission system.

## 7.4 Requirement for Blackstart Capability

The NLSO must maintain a strategy for the energization of the transmission system following a blackout. As a result the NLSO must depend upon a number of generating facilities with blackstart capabilities to maintain frequency and voltages within acceptable limits as transmission and generating facilities are returned to service. The NLSO may require a power producer to equip its facilities with blackstart capability following the completion of the interconnection studies.

## 7.5 Requirement for Voltage Regulation

Power plants connected to the NL transmission system must assist in achieving steady-state, dynamic and transient voltage regulation. To this end, synchronous generators synchronized to the transmission system must be equipped with an automatic voltage regulation system (AVR) and be able to supply or absorb reactive power as needed to maintain voltage.

The generating units of the power producer will have a minimum power factor of 0.90 under-excited and 0.90 over-excited. The NLSO, following the completion of the SIS may require, depending upon the interconnection location and local system requirements, request the power producer to modify the generator unit power factor to 0.95 under-excited and 0.95 over-excited.

Synchronous generating units rated greater than 15 MW must be equipped with a static excitation system and a stabilizer. The stabilizer shall be a delta-omega multiband power system stabilizer.

Static excitation systems will have a ceiling voltage value equal to or greater than 12.3 p.u. where the base value is the no load rated voltage value of exciter voltage on the air gap line.

On the Island portion of the NL transmission system, the NLSO may allow lower ceiling voltage values provided the SIS results indicate that the performance of the local and main power system is undiminished. For the modification to generating stations with slow static excitation systems the NLSO may allow an excitation system whose performance matches that of the rotating diode exciter provided the SIS results indicate that the performance of the local and main power system is undiminished.

## 7.6 Requirement for Frequency Control

In order to assist in system frequency control, all generating units with a rated capacity of greater than 10 MW that are synchronized to the NL transmission system must be equipped with a speed governor system having a permanent speed-droop that is adjustable over a range of at least 0% to 5% with a frequency deadband setting down to 0 Hz.

### 7.7 Requirement for Synchronization

The power producer must equip its facilities with a frequency synchronization system for synchronous generators. A speed monitoring system is required for asynchronous generators. The NLSO may require the power producer synchronize the generating units to the transmission system on the high side of the step-up transformer.

### 7.8 Requirement for Inertia

For transmission system stability and to minimize the risk of oscillation between generating stations the inertia constant of generating units in a power producer's facilities connected to the NL transmission system must be compatible with the inertia constants of exiting generating units in the same region. The SIS results will indicate if the proposed inertia constant is acceptable or if there is a requirement to change the generator unit inertia.

### 7.9 Access to Power Producer Facilities and Property Rights

Under the interconnection agreement, the NLSO or its agent, must have access to the power producer's property and facilities to perform tasks such as installing, building, operating, maintaining, repairing, modifying or removing of equipment that belongs to the NLSO. The NLSO must also have access to telecommunications links and equipment used for protection and telemetry.

If it is a matter of personal safety or transmission security, or when transmission system or telecommunications failures occur, the NLSO or its agent must be able to access the power producer facilities at all times.

The power producer must assign the the NLSO real rights on its property so that the NLSO can erect the tie line(s) needed to connect the power plant to the transmission system. The power producer must also conform to the electrical clearances for such line(s) in accordance with the NLSO standards.

## 8.0 PROTECTION REQUIREMENTS

The proper detection of faults and the disconnection of the generating facility from the NL transmission system are critical for safety and the protection of equipment. The power producer is responsible for ensuring that the generating facilities are equipped with protection systems that will detect and isolate the generation facilities from the NL transmission system. The protection systems used by the power producer in its facilities must be compatible and coordinated with the protection systems utilized on the NL transmission system. Protection systems must be quick, reliable and selective in triggering and clearing of any type of faults within the power producer facility.

The protection systems must cover all types of faults including three phase, two phase, two phase to ground, and single phase to ground with and without a fault resistance.

In addition to protection for all types of faults, the protection system will include, but not be limited to:

- Voltage protection – both overvoltage and undervoltage
- Frequency protection – both over and under frequency
- Remote tripping to avoid unwanted islanding or self-excitation
- Breaker failure protection

For connections at the 230 kV level and above there must be:

- two primary protection schemes (Protection A and Protection B)
- each of Protection A and Protection B will be supplied from separate dc battery banks (Bank A and Bank B)
- there will be two independent sources of station service
- there will be independent battery chargers for Bank A and Bank B
- Protection A will utilize Schweitzer relays
- Protection B will utilize a comparable but different relay manufacturer

## 9.0 WIND POWER PLANT REQUIREMENTS

As installations of wind power plants increase and technology evolves wind power can have an impact on the connected transmission system. This section provides the general requirements specific for wind power plants to connect to the NL transmission system.

### 9.1 Requirements of Wind Generation During System Disturbances

Wind power plants must remain in service without tripping when the transmission system operates with the steady state voltage limits of ±10% of nominal and the steady state frequency limits of 59.4 to 60.6 Hz.

It is necessary for generating facilities to remain connected to the NL transmission system without tripping for as long as possible during and following disturbances to assist with maintaining system stability, voltage and frequency. To this end wind power plants must be designed, built and operated for the voltage and frequency variations given in Figures 4 and 5 and Tables 12 and 13.

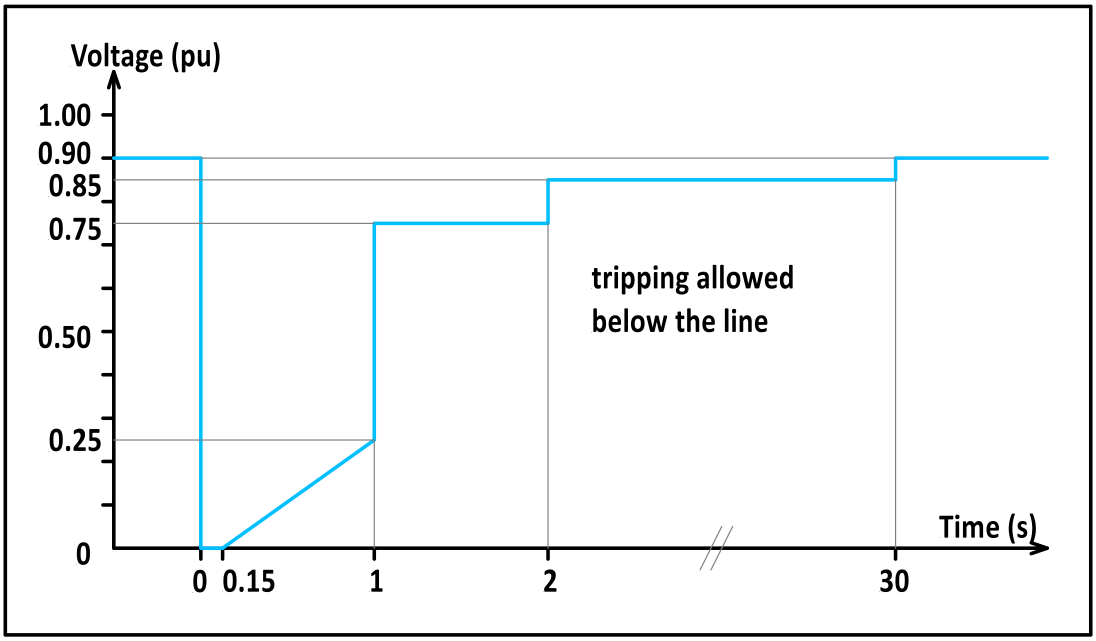


Figure 4 - Wind Power Plant Low Voltage Ride Through – Labrador

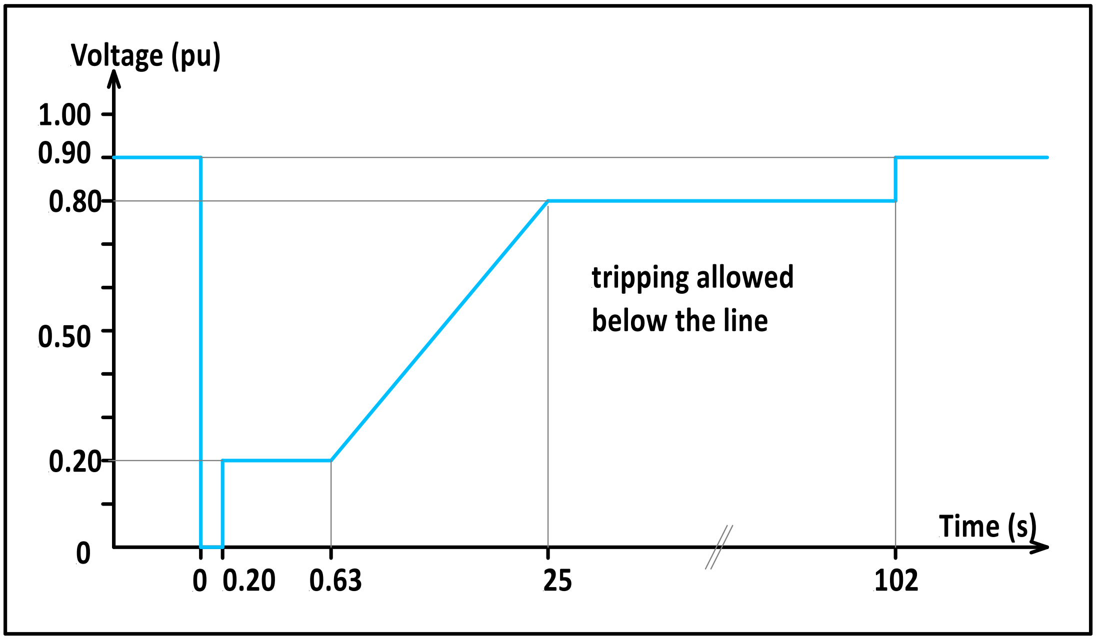


Figure 5 - Wind Power Plant Low Voltage Ride Through – Island

Table 12 - Power Frequency Over Voltage Range Following a Disturbance

| Power Frequency Over Voltage Range Following a Disturbance Before Wind Power Plant Tripping - Labrador | |
|---|---|
| Over Voltage (p.u.) | Duration |
| $1.00 \leq V \leq 1.10$ | Continuous |
| $1.10 < V \leq 1.15$ | 300 seconds |
| $1.15 < V \leq 1.20$ | 30 seconds |
| $1.20 < V \leq 1.25$ | 2 seconds |
| $1.25 < V \leq 1.40$[1] | 0.1 seconds |
| $V > 1.40$[1] | 0.033 seconds |
| 1 – Temporary blocking is permitted for wind facilities using power electronics when the voltage exceeds 1.25 pu. Normal operation of the facility must resume once the voltage falls back below 1.25 pu. | |

Table 13 - Frequency Range vs Minimum Time before Wind Power Plant Tripping

| Frequency Range vs Minimum Time before Wind Power Plant Tripping Following a Disturbance | |
|---|---|
| Frequency (Hz) | Minimum Duration |
| F < 55.5 | Instantaneous trip |
| 55.5 ≤ F < 56.5 | 0.35 seconds |
| 56.5 ≤ F < 57.0 | 2 seconds |
| 57.0 ≤ F < 57.5 | 10 seconds |
| 57.5 ≤ F < 58.5 | 1.5 minutes |
| 58.5 ≤ F < 59.4 | 11 minutes |
| **59.4 ≤ F < 60.6** | **Steady State - Continuous** |
| 60.6 ≤ F < 61.5 | 11 minutes |
| 61.5 ≤ F < 61.7 | 1.5 minutes |
| F ≥ 61.7 | Instantaneous trip |
| Power plants must also remain in service when system disturbances occur and the system frequency varies by ±4 Hz/s.<br>On the Island portion of the NL transmission system, wind power plants with a capacity not exceeding 27 MW may have an over frequency setting of 61.2 Hz for 0.2 seconds and an under frequency setting of 56.4 Hz for 0.2 seconds. | |

## 9.2 Requirement for Voltage Regulation at Wind Power Plants

Power producer facilities are required to have voltage regulation capability in order to maintain transmission system reliability and stability. Wind power plants are required to take part in regulating transmission system voltage. Wind power plants must be equipped with an automatic voltage regulation system that can supply or absorb reactive power corresponding to an overexcited or under excited power factor equal to or less than 0.95 on the high voltage side of the wind power plant step-up transformer. For wind power plants with a rated capacity not exceeding 27 MW on the Island portion of the NL transmission system, the automatic voltage regulation system may have an overexcited power factor of 0.98 at rated output and an underexcited power factor of 0.96 at rated output. Based upon SIS results the transmission provider may require that the voltage regulation system have a permanent droop adjustable between 0% and 10%.

Reactive power must be available from/to the wind power plant over the entire normal operating voltage range (0.90 pu to 1.10 pu). At a voltage of 0.90 pu the wind power plant is required to be able to supply reactive power corresponding to an overexcited power factor of 0.95, but is not required to absorb reactive power corresponding to an underexcited power factor of 0.95. At a voltage of 1.1 pu, the wind power plant is expected to absorb reactive power corresponding to an underexcited power factor of 0.95, but is not required to supply reactive power corresponding to an overexcited power factor of 0.95.

Wind power plants must be designed and built so that they can be equipped with a power system stabilizer. All power plants connected to the transmission system must provide stable behavior so that they can assist in maintaining system stability and restoration of voltage and frequency when disturbances occur. If the power plant does not exhibit stable behavior, the NLSO may require that the power producer facilities be equipped with a stabilizer. For the wind power plant the stabilizer will be jointly agreed with the manufacturer.

### 9.3 Requirement for Frequency Control at Wind Power Plants

Wind power plants with a rated capacity greater than 10 MW must be equipped with a frequency control system that is continuously in service but act only during major frequency deviations. The wind power plant frequency control system will not be used for steady state frequency control. To assist with restoration of system frequency and maintenance of transmission system performance following a major disturbance, the wind power plant must have a inertial response similar to that of a conventional synchronous generator whose inertia constant H equals at least 3.5 MW*sec/MVA.

### 9.4 Requirement for Wind Power Plants to Limit Real Power

The NLSO may require the wind power plant to be equipped with a control system that will respond to commands, including a command to limit real power, given transmission system operating constraints and requirements.

### 9.5 Requirements for Wind Power Plants to Shut Down due to Environmental Conditions

Wind power plants must be designed and built for gradual shut down over a minimum period of 1 to 4 hours when weather forecasts call for cold temperatures or high winds that will entail complete wind generation shut down.

### 9.6 Requirements for Wind Power Plant Ramp Rates

In order to avoid excessive loss of wind generation at times when load is rising and excessive rise of wind generation when load is falling during the daily load cycle, wind power plants must be designed and built to comply with the following output ramp rates:

- Ramp up from 0 MW to maximum power plant output in an adjustable 2 to 60 minutes

- Ramp down from maximum power plant output to 0 MW in an adjustable 2 to 60 minutes.

## 9.7 Requirements for Harmonics and Flicker Emissions of Wind Power Plants

On the Island portion of the transmission system the permitted emissions from wind power plants are as follows:

- Permitted harmonic emissions as per IEEE Std 519 "Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems"
- Permitted flicker emissions as per IEEE Std 1453-2004 "IEEE Recommended Practice for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems"
- The permissible voltage change at the point of interconnection is less than 2%.

In addition to the IEEE standards for harmonic and flicker emissions as listed above, on the Labrador portion of the system the wind power plant may be required to meet the International Electrotechnical Commission standards (IEC 60034 series).

# 10.0 OPERATION AND MAINTENANCE REQUIREMENTS

To ensure transmission system reliability and safety of personnel, the interconnection party must maintain its equipment following existing standards, regulations, manufacturer requirements and industry practices.

Equipment used to connect to the transmission system is required to use the NLSO's equipment nomenclature. The NLSO will provide the interconnection party with the appropriate nomenclature during the design process.

## 10.1 Operating Requirements

Prior to the connection of the interconnection party facilities to the NL transmission system, the power producer and the NLSO must sign common operating instructions that will be prepared by the NLSO. These instructions will cover items such as, but not limited to, communication protocols between the parties, operating conditions for the power producer or network customer (industrial) facilities and access to the interconnection party's facilities for the purposes of meter reading, maintenance and inspection.

## 10.2 Data Requirements

In order to ensure safe, efficient and reliable operation of the transmission system, the NLSO requires real time operating data, in a format compatible with its equipment, from each power plant or network customer. The power plant or network customer owner must equip its facilities with all sensors and telecommunications equipment necessary to transmit the required data to the NLSO. The NLSO must approve the equipment used by the interconnection party to provide the required data. The interconnection party will be required to provide the NLSO with data point lists and addresses based upon the NLSO schedule. The interconnection party will be required to take part in testing of the data transmission system to ensure remote indication, and where deemed necessary remote control, is working properly prior to commissioning of the plant.

Typical real time data will include, as a minimum:

- Total plant generation in MW and MVAR
- Generating unit circuit breaker status
- Generating unit disconnect switch status
- Generating unit MW, MVAR, kV and A
- For transformers with on load tap changers tap changer position
- Transformer MW and MVAR
- Shunt reactor MVAR
- Shunt capacitor MVAR
- High voltage circuit breaker status
- High voltage disconnect switch status
- For high voltage motor operated disconnect switches and circuit breakers at point of interconnection remote control
- At point of interconnection MW, MVAR, kV and A
- For hydro-electric units water levels in the forebay, power canal, tailwater
- Pertinent status and alarm signals for the generation type
- For wind power plants
    - Units on line
    - Wind speed
    - Wind direction
    - Temperature

### 10.3 Maintenance Requirements

The interconnection party has full responsibility for the maintenance of its equipment. The interconnection party must maintain its equipment consistent with appropriate standards, regulations, manufacturer recommendations and industry practice to ensure continued reliability of the interconnection party's facilities. The interconnection party must coordinate its facility maintenance with the NLSO to ensure reliable operation of the entire transmission system during local maintenance.

The Interconnection Party must notify the NLSO of any unusual conditions including, but not limited to the following:

- Partial operating capability due to equipment limitations.
- Scheduled outage periods and return to service expectations. Return to service notification must be updated daily to reflect the recent progress or the lack of progress.

The NLSO reserves the right to inspect and test the equipment given reasonable notice. The Interconnection Party must perform the necessary maintenance requested by the NLSO within a reasonable period. Further, the NLSO maintains the right to review the maintenance, calibration, and operation data of all protective equipment for protecting NLSO facilities, customers, and other producers. The Interconnection Party is responsible for providing the necessary test accessories (such as relay test plugs, instruction manuals, wiring diagrams, etc.) required to test these protective devices. Verification testing may include the tripping of the intertie breaker.

Procedures must be established for visual and operational inspections.

Provisions must be established for equipment maintenance and testing. Equipment included in maintenance and testing should include, but not be limited to:

- Power Transformers
- Circuit Breakers
- Protective Relays
- Station Batteries
- Current and Voltage Sensing Devices
- Disconnect Switches
- Circuit Switchers Shunt
- Capacitor Banks
- Shunt Reactors
- AC Harmonic Filters
- Generators

## 11.0 VERIFICATION BY THE TRANSMISSION PROVIDER

The NLSO shall be authorized to verify that the equipment and systems installed by the power producer meet the NLSO requirements and are working properly. This verification includes the setting for protection systems, speed governors, voltage regulators, stabilizers, data and interconnection transmission facilities.

Requirements include testing to validate the dynamic performance of excitation systems, stabilizers and speed governors. References for these verification requirements are outlined in:

- NERC standards
  - MOD-026-1 Verification of Models and Data for Generator Excitation Control System or Plant Volt/Var Control Functions
  - MOD-027-1 Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions

In addition, it is required that the power producer validate the maximum real and reactive power capabilities of the generating equipment. References for these verification requirements are outlined in:

- NPCC Directories
  - #9 Generator Gross and Net Real Power Capability
  - #10 Generator Gross and Net Reactive Power Capability
- NERC standards
  - MOD-025-2 Verification and Data Reporting of Generator Real and Reactive Power Capability and Synchronous Condenser Reactive Power Capability

### 11.1 Initial Verification
During power plant startup or following modifications to an existing power plant, the power producer must verify that its facilities meet the NLSO requirements and are capable of achieving the required performance level.

### 11.2 Periodic Verification
At intervals specified by the NLSO, the power producer must verify its facilities have maintained their characteristics and performance level.

### 11.3 Validation of Generator (synchronous and asynchronous) Models and Parameters
The generator models and parameters requested by the NLSO in Appendix A of this document are essential for proper simulation of the NL transmission system behavior and to ensure its transmission capability.

### *11.3.1 Initial Validation of Generator Models*

The power producer must perform tests to validate the parameters and models supplied to the NLSO for power system analysis under Appendix A of this document.

The NLSO must agree to the parameter validation method. For synchronous generators the validation method specified in IEEE Standard 115 is recommended. For asynchronous generators the validation method referenced in IEEE Standard 112 is recommended.

The NLSO will accept parameter validation as a type test for one generator of each type or rating within a power plant with the exception of open-circuit and short circuit characteristics which must be performed on each power plant generator. It is recommended that open circuit characteristic tests be completed up to 1.2 p.u. of the rated stator voltage.

### *11.3.2 Periodic Validation of Generator Models*

There are no recommended period validations for generator models. However, the power producer must repeat the open circuit characteristics test following repair to the stator winding, or the rotor circuit.

## 11.4 Validation of Voltage Regulation System Parameters and Models

The settings of the voltage regulation system (i.e. excitation system) have a significant impact on both the power system behavior and the security of the power producer and NLSO equipment. Validation of the voltage regulation system parameters through testing ensures appropriate models are used in NLSO system stability studies.

### *11.4.1 Initial Validation Voltage Regulation System Parameters and Models*

All voltage regulation systems must be verified during the initial startup of the power producer's facilities. The power producer must demonstrate that the requirements of this document are met. The power producer must update the voltage regulator and overall excitation system models and block diagrams submitted to the NLSO as requested by the NLSO under Appendix A of this document during the startup process. The power producer must also demonstrate that it has applied the settings established by the NLSO through its SIS.

Tests are required to model all the functions of the regulation system including the automatic voltage regulator, under and over excitation limiters, V/Hz limiter, reactive current compensation, stabilizer, etc. The NLSO must approve the validation methods. The IEEE standard 412.2 is recognized as a reference guide for validation of parameters for voltage regulation systems.

The following minimum tests must be completed:

- With the generator not synchronized to the transmission system
    - Voltage set point step response tests (minimum one step up and one step down)
- With the generator synchronized to the transmission system
    - Voltage set point step responses to validate excitation gain with and without a stabilizer
    - Step responses to verify positive and negative ceiling voltages of the excitation system and immediate response of the excitation system
    - Step responses with and without stabilizer to validate overexcitation and underexcitation limiters
    - Short-duration step responses with stabilizer

The tests will be completed for each generator unit within the power plant. The following measurement points are required for each test:

- Stator voltages and currents for the three phases
- Field voltage and field current
- Stabilizer output signal

The power producer must ensure that the excitation system has the analog and/or digital inputs and outputs needed to run the step response tests. Further, the excitation system must have the proper analog inputs and outputs to determine and characterize the transfer functions of the block diagrams. Measurement points must be readily accessible.

#### *11.4.2 Periodic Verification Voltage Regulation System Parameters and Models*

As a minimum the short duration step responses must be verifies for all power plant generating units every five years. The results must remain similar to those obtained during the initial verification of the generating units. If the periodic test results are not similar to the initial test results, the power producer must take the necessary corrective action.

### 11.5 Validation of Speed Governor System Parameters and Models

The settings of the speed governor system have a significant impact on both the power system behavior and the security of the power producer and NLSO equipment. Validation of the speed governor system parameters through testing ensures appropriate models are used in NLSO system stability studies. Note, power system frequency behaviour and stability depend upon proper governing of generating unit speed.

### *11.5.1 Initial Verification of Speed Governor System Parameters and Models*

All speed governor systems must be verified. The power producer must demonstrate that the requirements of this document are met. The power producer must update the speed governor models and block diagrams submitted to the NLSO as requested by the NLSO under Appendix A of this document during the startup process. The power producer must also demonstrate that it has applied the settings established by the NLSO through its SIS. Tests are required to characterize all functions of the governor system.

The NLSO must approve the validation method for the speed governor system. For hydroelectric power plants the international standard IEC 60308 is used for reference. For gas and steam turbines the CIGRE Technical Brochure 238 is used for reference.

The following validation of parameters and models must be performed on each generating unit at the power plant.

- Steady state power to gate curves for hydro-electric units including the head pond and tail water level
- Steady state power to valve curves for gas and steam units including fuel flow, steam pressure and temperature as appropriate
- Tests to validate the generating unit inertia constant H
    - For generating units capable of synchronous condenser operation with the prime mover disconnected tests to validate the generating unit inertia constant H in synchronous condenser mode are required
- For generating units in Labrador
    - With the generating unit not synchronized one frequency step response
    - With the generating unit synchronized positive frequency step responses at 10%, 50% and 90% of rated capacity and one negative frequency step response at 90% of rated capacity
- For generating units on the Island
    - With the unit synchronized a load rejection test with the unit at 30% of rated capacity
- Measurement points for each test will include as a minimum:
    - Unit speed or frequency
    - Real power
    - Wicket gate or valve position as appropriate
    - Steam or fuel flow as appropriate
    - Output signals from the main blocks of the speed governor system
    - Circuit breaker status for the Island load reject tests

The power producer must ensure that the speed governor system has the analog and/or digital inputs and outputs needed to run the step response tests. Further, the speed governor system must have the proper analog inputs and outputs to determine and characterize the transfer functions of the block diagrams. Measurement points must be readily accessible.

#### *11.5.2 Periodic Verification of Speed Governor System Parameters and Models*

As a minimum the positive frequency step response at 90% of rated capacity for all generating units in Labrador must be tested every five years. On the Island, the 30% of rated capacity load rejection test for all generating units must be completed every five years. If the periodic test results are not similar to those obtained during the initial verification, the power producer must take the necessary corrective action.

### 11.6 Maximum Real and Reactive Power Capability

Tests are required to measure the maximum real and reactive power capability of the generators connected to the NL transmission system such that the NLSO can assess the quantity of reserves available at any time for loss of a generator, and to ensure that the on line generators have sufficient reactive power capability to support the transmission system voltage during contingencies such as transmission line tripping.

The verification test is completed in two steps. Step one requires the power producer to evaluate the each generating unit's maximum real and reactive power capability while remaining within system operating voltage limits and transmission line thermal constraints. The second step requires the power producer to evaluate the entire power plant's maximum real and reactive power capability while remaining within system constraints. This test applies equally to determination of reactive power capability of synchronous condensers and synchronous condenser plants.

Given the potential impacts on the NL transmission system during such verification tests the power producer is required to schedule maximum real and reactive power testing well in advance with the NLSO. It must be noted that based upon system load, verification tests for maximum real and reactive power capability may have to be completed during the winter months.

#### *11.6.1 Initial Verification of Maximum Real and Reactive Power Capability*

All generating units and power plants must demonstrate maximum real and reactive power capability at the time of connection to the NL transmission system. Generating units and power plants will demonstrate maximum real and reactive power during test as follows:

- Generating units or power plants must maintain maximum power output continuously for a one hour period while maintaining transmission system voltages within normal operating limits and without violating thermal limits

- At the end of the one hour period, generating unit or power plant will adjust its reactive power output from the overexcited limit to the underexctied limit of the unit or plant capability curve while maintaining transmission system voltages within normal operating limits and without violating thermal limits. This portion of the test will occur over a 15 to 30 minute period as deemed appropriate by the NLSO at the time of test

#### *11.6.2 Periodic Verification of Maximum Real and Reactive Power Capability*

All generating units and power plants must demonstrate maximum real and reactive power capability periodically. Generating units and power plants will periodically demonstrate maximum real and reactive power as follows:

- Generating unit testing will be conducted every five years or as soon as changes are made that affect the generating unit's real or reactive power capability
- Power plant facilities testing will be conducted every three years
- Power plant owners will prepare a unit testing and generating plant testing schedules five and three years respectively and deliver the schedules annually to the NLSO no later than October 31st each year.
- Periodic testing will be completed on all generator units rated 15 MW and greater on the Island, 50 MVA in Labrador
- Periodic testing will be completed on all power plants rated 25 MW and greater on the Island, 50 MVA in Labrador

### 11.7 Validation of Transformer Data

Where the Interconnection Party provides a transformer as part of its interconnection, the Interconnection Party must submit to the NLSO the results of the factory tests and routine tests performed on the transformer(s). In addition, the Interconnection party must submit a copy of the transformer nameplate drawing and description of any voltage regulation performed by on-load tap changers including regulating method, set points and band width.

### 11.8 Validation of Transmission Line Data

Where the Interconnection party builds a transmission line(s) as part of its interconnection, the Interconnection Party must submit the following data to the NLSO:

- Structure outline drawings depicting phase spacing, overhead shield wire locations, attachment heights
- Average structure height
- Total length of transmission line

- Transmission line phase conductor type(s) and size(s)
- Overhead shield wire type(s) and size(s)

## 11.9 Wind Generation

The power producer is responsible for conducting tests to verify the compliance with the requirements of this document and to validate simulation models. The purpose of the tests is to validate and verify:

- Voltage control
- Under voltage response and Low Voltage Ride Through capability
- Inertia
- Secondary control systems
- Power factor
- Ramp rates

Periodic verification tests will be specified by the NLSO for the particular wind farm once every five years as required.

## 12.0 TEST REPORTS FOR POWER PRODUCER EQUIPMENT

Field-testing of all electrical equipment must be completed prior to energization. This includes physical testing of equipment such as transformers, circuit breakers, disconnect switches and ground switches. Testing of all SCADA points will be completed including remote indication and control. This testing also includes setting and testing of relays and control systems, as well as verifying coordinated relay settings. Demonstration tests must be employed to ensure that each of the required protection systems and protective devices operate correctly.

Prior to completion of the power plant, the power producer must submit test and verification reports to the NLSO to demonstrate that the facilities comply with the requirements.

For each power transformer the power producer will provide a copy of the manufacturer test report including:

- Rated power and voltage
- The power at each transformer tap position
- Number of taps and range
- Impedance (resistance and reactance) at each tap
    - Typically max, min and nominal tap
    - Include zero sequence impedance tests
- Excitation current (80%, 90%, 100%and 110% of rated voltage)
- Winding configuration
- Transformer nameplate

For each generator unit

- Validation tests to demonstrate the generator capacity and characteristics
    - Open circuit saturation curve
    - Short circuit saturation curve
    - De-acceleration test
    - Impedance tests
    - Steady state load vs wicket gate/valve position/wind speed
    - Exciter step tests
    - Governor step tests
    - Load rejection tests
    - PSS®E model parameters ‘as left” by manufacturer

## 13.0 MODIFICATION TO EXISTING FACILITIES

The power producer must not make modifications to its facilities prior to the NLSO having assessed the impact on the transmission system. To enable system study and power plant modification, the power producer must submit to the NLSO all relevant information regarding to intended modification(s). The modifications of a power producer facility must be coordinated with any resultant modification on the transmission system. Modifications of existing power producer facilities include, but are not limited to, the following:

- Capacity increase of generating unit(s) or plant
- Replacement of existing generator controls including
    - Excitation system
    - Power system stabilizer
    - Speed governor system
    - Protection systems
- Replacement of existing generator step-up transformers
- Replacement or modification to station service supply

# Appendix A – Technical Information Required by the NLSO for its SIS

The NLSO requires information to complete a System Impact Study (SIS) for the power producer. The power producer is required to provide the information contained within this Appendix. The power producer is responsible for the validity of the information (data, models and parameters) that it, or its supplier, submits to the NLSO. If the power producer facilities do not behave according to the models and parameters submitted, the NLSO, may, where necessary, develop a new cost estimate for the connection of the power plant to the transmission system. The NLSO may be required to share the information provided in this Appendix with its counterparts in neighbouring jurisdictions to ensure power system reliability within the region.

1. **Scheduled commissioning date of the New Generating Station**

2. **Location diagram for the New Generating Station and Transmission System**

3. **General information regarding the New Generating Station**:
    a. Installed capacity, anticipated capacity at annual peak load and projected ultimate capacity
    b. Number of units

4. **Characteristics of generator equipment in the New Generating Station** (data in p.u. based on equipment rating in MVA)
    a. **Synchronous generators:**
        i. Type (smooth pole/salient pole)
        ii. Damper windings (connection method)
        *iii.* Design ambient temperature °C
        *iv.* Temperature rise at rated power °C
        *v.* Coolant temperature °C
        *vi.* Rated power and voltage
        *vii.* Rated power factor in over-excited and under-excited modes
        *viii.* Unsaturated direct-axis synchronous reactance ($X_{di}$)
        *ix.* Unsaturated quadrature-axis synchronous reactance ($X_{qi}$)
        *x.* direct-axis transient reactance unsaturated ($X'_{di}$) and saturated ($X'_{dv}$)
        *xi.* quadrature-axis transient reactance unsaturated ($X'_{qi}$) and saturated ($X'_{qv}$)
        *xii.* direct-axis sub-transient reactance unsaturated ($X''_{di}$) and saturated ($X''_{dv}$)
        *xiii.* quadrature-axis sub-btransient reactance unsaturated ($X''_{qi}$) and saturated ($X''_{qv}$)

*xiv.* Positive sequence leakage reactance ($X_l$)
*xv.* Negative sequence reactance ($X_2$)
*xvi.* Time constants $T'_{do}$ (and corresponding temperature in °C), $T'_{qo}$, $T''_{do}$, and $T''_{qo}$
xvii. Armature resistance, by phase ($R_a$) and corresponding temperature in °C
*xviii.* Stator forward resistance ($R_1$) at 60 Hz and corresponding temperature °C
*xix.* Saturation curve of generators
*xx.* Saturation coefficients $S_{(1.0)}$ and $S_{(1.2)}$
*xxi.* Inertia constant H *(for each generating unit, with and without turbine)*

*b.* ***Asynchronous Generators:***

*i.* Design ambient temperature in °C
*ii.* Temperature rise at rated capacity
*iii.* Coolant temperature *(where applicable)*
*iv.* Rated capacity and voltage
*v.* Power factor at 100%, 75% and 50% of rated capacity
*vi.* Stator leakage reactance ($X_S$)
*vii.* Stator resistance ($R_S$)
*viii.* Rotor leakage reactance ($X_r$)
*ix.* Rotor resistance ($R_r$)
*x.* Magnetizing reactance ($X_m$)
*xi.* Locked rotor reactance ($X_{lr}$)
*xii.* Open-circuit reactance ($X_o$)
*xiii.* Time constant $T'_{do}$
*xiv.* Inertia constant H (*for each generating unit)*
*xv.* Torque-slip curve
*xvi.* Slip at rated capacity

5. **Voltage Regulator, excitation system and stabilizer**
    a. Detailed model and parameters based on a standard IEEE model (IEEE 421.5 IEEE Recommended Practice for Excitation System Models for Power System Stability Studies), or
    b. A model with associated parameters that can be used by the NLSO in its dynamic simulation studies with the Siemens PTI PSS®E (Power System Simulator) software package

6. **Turbine and Speed Governor**
    a. Detailed model and parameters based on a standard IEE model
        i. "Dynamic Models for Combines Cycles Plants in Power System Studies" IEEE 94 WM 185-9 PWRS, Working Group on Prime Mover and Energy Supply Models for System Dynamic Performance Studies
        ii. Dynamic Models for Steam and Hydro Turbines in Power System Studies", IEEE Transaction on Power Apparatus and System, Vol.PAS-92, pp. 1904-1915, 1973
        iii. "Hydraulic Turbine and Turbine Control Models for System Dynamic Studies", IEEE Transactions on Power Systems, Vol. 7, No. 1, pp. 167-179, Feb 1992, or
        iv. A model with associated parameters that can be used by the NLSO in its dynamic simulation studies with the Siemens PTI PSS®E (Power System Simulator) software package

## 7. Wind Power Plants

a. Detailed model of the wind power plant based upon IEEE models including relevant generator and converter parameters. The models must be compatible with the Siemens PTI PSS®E (Power System Simulator) software package.

b. A IEEE model is not available, the generation owner must

    i. Provide a manufacturer written/black-box model including

        1. Relevant technical information/documentation
        2. Block diagrams
        3. Data
        4. Parameters

    ii. The model must

        1. allow all wind generators to be represented as a single generator and must function across the entire range of real and reactive power.
        2. Be compatible with the Siemens PTI PSS®E (Power System Simulator) software package.
        3. Be able to work with a time step exceeding ___ms.

    iii. If voltage regulation of the wind power plant is achieved using additional compensation equipment in the ac station, the generator owner must provide detailed models and associated parameters of that equipment based upon standard IEEE models compatible with the Siemens PTI PSS®E (Power System Simulator) software package.

    iv. If the generator owner provides a black-box model and the actual wind generator behaviour does not conform with the black-box model, the generator owner must pay any additional expense that may be incurred to connect the wind power plant to the transmission system.

8. **Generator Step-up transformers (*as provided by generation owner*)**
    *a.* Number
    *b.* Rated power and voltage
    *c.* Power with corresponding cooling method
    *d.* Positive and zero sequence impedances
    *e.* Winding resistance
    *f.* Winding connection
        *i. H.V. winding*
        *ii. L.V. winding*
        *iii. T.V. winding*
    *g.* Number of taps, regulating range and location
    *h.* Exciting current (at 80% - 115% of rated voltage)
    *i.* Saturation curve of transformers

9. **Station Transformers**
    *a.* Number
    *b.* Rated power and voltage
    *c.* Power with corresponding cooling method
    *d.* Positive and zero sequence impedances
    *e.* Winding resistance
    *f.* Winding connection
        *i. H.V. winding*
        *ii. L.V. winding*
        *iii. T.V. winding*
    *g.* Number of taps, regulating range and location
    *h.* Exciting current (at 80% - 115% of rated voltage)
    i. Saturation curve of transformers

## *10.* Circuit Breakers and Disconnects

| | | |
|---|---|---|
| *Project name:* | | |
| *Operating Voltage* | | |
| *Circuit Breakers* | | |
| *Rated voltage* | | |
| *BIL* | | |
| *SIL* | | |
| *Rated Current* | | |
| *Rated Short circuit current* | | |
| *Make/model* | | |
| *Disconnect Switches* | | |
| *Rated voltage* | | |
| *BIL* | | |
| *SIL* | | |
| *Rated Current* | | |
| *Make/model* | | |

## *11.* Shunt Capacitor Bank or Filters

*a.* Location
*a.* Power
*b.* Voltage
*c.* Inrush/outrush reactor rating
*d.* Harmonics filters and layout of RLC components
*e.* Operating strategy

## *12.* Surge Arresters

*a.* Type
*b.* Ratings
*c.* Protection characteristics

**13. Characteristics of HVdc converter unit and related equipment**

a. Number, type, topology and operating modes
b. Rated active power, reactive power and voltage
c. Power with corresponding cooling method
d. Positive and zero sequence impedances of converter transfomers

| *Converter Transformer Data* | | | |
|---|---|---|---|
| *Parameter* | *Rectifier* | *Inverter* | *Unit* |
| *Winding Arrangement* | | | |
| *Vector Group* | | | |
| *Rated Power (6-pulse, 3 phase)* | | | *MVA* |
| *Maximum continuous power (6-pulse, 3 phase)* | | | *MVA* |
| *Rated Line Voltage* | | | $kV_{RMS}$ |
| *Rated valve winding voltage* | | | $kV_{RMS}$ |
| *Maximum valve winding voltage* | | | $kV_{pk}$ |
| *Extreme negative tap* | | | *%* |
| *Extreme positive tap* | | | *%* |
| *Tap step* | | | *%* |
| *Transformer impedance*<br>• *Impedance ($V_{star}$ or $V_{delta}$ leg)*<br>• *Base MVA*<br>• *Base Voltage* | | | <br>*%*<br>*MVA*<br>$kV_{RMS}$ |

e. Planned runback and automatic controls
f. Characteristics of shunt reactive compensation and filtering equipment (if applicable)
g. Characteristics of the DC Link
    i. *Overhead line*
    ii. *Submarine Cable*
    iii. *Electrode Lines*
    iv. *Electrode sites*
    v. *Total resistance values used for modeling:*
        1. *Bipole mode*
        2. *Monopole mode Ground Return*
        3. *Monopole mode Metallic Return*

*h.* Characteristics of protection systems (AC and DC fault clearing time, under- and over- voltage protection, under frequency protection, etc.)
   *i. Three Phase AC fault clearing time in cycles*
   *ii. AC LG fault clearing in cycles and for Single Pole Reclosing*
      *1. Near end breaker open time in cycles*
      *2. Far end breaker open time in cycles*
      *3. Delay time in cycles and location of breaker that is used to test line*
         *a. Time to trip all breakers if fault remains in cycles 3 cycles*
         *b. Time to close open breaker in cycles and location If fault is cleared*
   *iii. DC fault clearing time*
   *iv. curtailment of DC power for power frequency over-voltages of _____ pu for a maximum duration of _____ msec.*

*i.* Characteristics of special control functions (AC voltage regulation, active/reactive power control, frequency control, load frequency control system, power limiter system, black start control and other special functions, etc.)

*j.* Control system disturbance under disturbance conditions (time to restore after a 100% drop in commutation bus voltage, OVRT, LVRT, etc)

***14.*** **Planned transmission lines (*including collector system for wind power plants*)**

*a.* number, type and length
*b.* Voltage
*c.* power with corresponding cooling method
d. ampacity
e. characteristics of conductors and overhead ground wires (if applicable), physical arrangement of overhead conductors (typical span) and soil resistivity;
    *i. conductors and overhead ground wires*
        *1. Phase Conductor:*
        *2. Ground Wire: it*
    *ii. Conductor arrangements*
        *1. Phase conductors*
            *a. configuration*
            *b. phase spacing*
            *c. Maximum attachment height*
            *d. Minimum attachment height*
            *e. Minimum ground clearance*
        *2. Overhead ground wires*
            *a. attachment height,*
            *b. OPGW/OHGW to OPGW/OHGW separation protection angle 30$^o$*
    *iii. centre line separation distance*
    *iv. Typical span*
    *v. Soil resistivity*
*f.* Characteristics of cables including
    *i.* Voltage
    *ii.* Type
    *iii.* Length
    *iv.* Size
    *v.* ampacity
*g.* Protections, remote protections (type and setting parameters)
h. Any SPS integrated to generating/transmission stations (type and setting parameters)

**15. Single-line diagram of the New Generating Station and/or Transmission System**

a. Schematic diagram showing power transformers, the position of switchgear and its operating mode (NO/NC), and the position of instrument transformers, surge arresters and breakers.
b. A preliminary control and protection schematic must also be included.

**16. Operating strategy and annual generation profile planned for the New Generating Station**

a. intended operating strategy (power flow)
b. Description of operating modes under normal, degraded and emergency conditions
c. Description of the operation of special protection systems planned
d. Capacity factor of the New Generating Station and mean monthly value of energy (GWh) and power for a typical year
    i. *Capacity Factor*
    ii. *Typical Mean Monthly Values:*

| *Typical Annual Production* | | | |
|---|---|---|---|
| | *Avg on peak MW* | *Avg off Peak MW* | *Gwh* |
| *Jan* | | | |
| *Feb* | | | |
| *Mar* | | | |
| *Apr* | | | |
| *May* | | | |
| *Jun* | | | |
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