Transmission System

Interconnection Requirements

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VERSION HISTORY

DATE	REV.	DESCRIPTION
December 23, 2020	1.0	Initial Issue.
February 25, 2021	1.1	Added footnote to Table 8 clarifying the classification of transmission lines as BPS elements.
November 25, 2024	1.2	Updating to reflect the changing generation mix and evolving industry criteria to accommodate high penetration of renewables
February 21, 2025	1.3	Correction to Section 7.6.11 (corrected typo in final paragraph to replace “over” with “under”) and minor formatting fixes.

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1.0 PURPOSE

1.1. Transmission System Interconnections

These Transmission System Interconnection requirements identify the minimum technical requirements for interconnection of Generating Facilities, BESS Facilities and/or Transmission Customer Load Facilities to the Nova Scotia Power Inc (NS Power) Transmission System.

The requirements in this document identify the minimum requirements to help ensure the reliability and stability of the Nova Scotia Power Transmission System as well as the safety of Nova Scotia Power employees and the general public.

All Generating Facilities that have an impact on the reliability and stability of the NS Power Transmission System shall be required to adhere to these technical requirements unless otherwise stated in the System Impact Study.

1.2. Limitations

This document is not to be interpreted as the sole source of technical specifications and requirements for the safe and reliable design of the *Interconnection Customer Facilities*. All *Interconnection Customers* must also comply with all applicable codes, standards, and conform with *Good Utility Practice*.

1.3. Disclaimer

This document is not intended as a final design specification or as an instruction manual for *Interconnection Customer Facilities*.

Interconnection Customers using this document are solely responsible to ensure all or any part of this document is appropriate to their particular requirements.
Nova Scotia Power's review of the specifications and detailed plans shall not be construed as confirming or endorsing the design or as warranting the safety, durability, or reliability of the *Customer Interconnection Facilities.*

The information contained in this document is subject to change and may be revised at any time. Nova Scotia Power should be consulted in case of doubt on the current applicability of any item.

2.0 DEFINITIONS

Adverse System Impacts: The negative effects due to exceeding technical or operational limits on conductors or equipment that may compromise the safety and reliability of the electric system.

Asynchronous Generator: A machine that generates electricity and is not directly coupled to the ac grid.

Battery Energy Storage System (BESS): is a term used to describe the entire system, which includes the battery energy storage device along with a power electronic interface, control electronics, and packaging. For the purpose of this document BESS, including when in grid forming mode, is considering an asynchronous facility.

BESS Facility: The *Interconnection Customer's* device for the storage and later injection of electricity to the *Transmission System* at voltages 69kV and above, as identified in the *Generator Interconnection Request*, but shall not include the *Interconnection Customer's* Interconnection Facilities.

Black Start: The ability of a generating unit or station to go from a shutdown condition to an operating condition and start delivering power without assistance from the electric system to which it is interconnected.

Bulk Electric System (BES): see North American Reliability Corporation (NERC) Glossary of TERMS for full definition. Transmission elements operated at 100 kV or higher and active power and reactive power resources connected to 100 kV or higher (adjusted for the Inclusions and Exclusions identified in the *NERC BES* Definition and in the NS BES Exception Procedures), but excluding facilities used in the local distribution of electric energy.

Bulk Power System (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 of the local area. (local areas being defined by NPCC members).

Canadian Standards Association (CSA): An accredited standards development organization within Canada.

Distribution System: Electrical equipment operating at voltages less than 69kV.

Facility Study: A study conducted by NS Power or a third party consultant on behalf of NS Power for the *Interconnection Customer* to determine a list of facilities (including interconnection facilities and *Network Upgrades* as identified in the *System Impact Study*), the estimated cost of those facilities, and the time required to interconnect the *Interconnection Customer Facilities*.

Feasibility Study: A preliminary evaluation of the system impact and cost of interconnecting the *Interconnection Customer Facility* to the *Transmission System*.

Generating Facility: The *Interconnection Customer's* device for the production of electricity for interconnection to the *Transmission System* at voltages 69kV and above, as identified in the

Generator Interconnection Request, but shall not include the *Interconnection Customer's* Interconnection Facilities.

Generating Unit: A unit that produces electricity, usually compromised of a synchronous turbine-generator combination or an asynchronous turbine-generator combination.

Generator Interconnection Request: An *Interconnection Customer's* request, in the form of Appendix 1 to the *Standard Generator Interconnection Procedures*, in accordance with the Tariff[24], to interconnect a new *Generating Facility*.

Good Utility Practice: Those practices, methods or acts (including but not limited to the practices, methods and acts engaged in or approved by a significant portion of the electric utility industry in North America) that at a particular time, in the exercise of reasonable judgment, would have been expected to accomplish the desired result in a manner consistent with regulations, safety, environmental protection, economy and expedition as applied and practiced in the utility industry with respect to power generation, delivery, purchase and sale.

IEEE: The Institute of Electrical and Electronics Engineers, Inc., an organization that develops voluntary standards relating to electrical safety and product performance.

Interconnection Customer: The owner/operator of the *Interconnection Customer Facilities* connected to the *Transmission System*.

Interconnection Customer Facilities: All facilities and equipment located on the load or generator side of the *Point of Change of Ownership* of an interconnection to NS Power's *Transmission System,* including any modification, addition, or upgrades to such facilities and equipment necessary to physically and electrically interconnect.

Inverter-Based Resource (IBR): A plant/facility consisting of individual devices that are capable of exporting active power through a power electronic interface(s) such as an inverter or converter.

Islanded Operation: Condition when a portion of the *Transmission System* consisting of load and generation becomes isolated from the remaining electrical system due to the tripping of *Transmission System* elements.

Load (End User) Interconnection Request: An *Interconnection Customer's* request, in accordance with the Bulk Power Facilities Connection Guide to interconnect a new Load (End User) Facility to the NS *Transmission System.*

Network Upgrades: The additions, modifications, and upgrades to the *Transmission System* required at or beyond the *Point of Interconnection* to accommodate the interconnection of the *Interconnection Customer* Facility to the *Transmission System.*

North American Electric Reliability Corporation (NERC): A self-regulated organization, subject to oversight by U.S. Federal Energy Regulatory Commission (FERC) and governmental authorities in Canada whose mission is to ensure the reliability of the *Bulk Electric System* in North America.

Northeast Power Coordinating Council (NPCC): A NERC regional reliability council working in northeastern North America and comprised of member utilities and independent system operators representing five regions; New York State, New England, Ontario, Quebec, and the Maritime Provinces.

Open Access Same Time Information Service (OASIS): An electronic medium information system, which provides Open Access Transmission Customers with relevant information regarding available transmission capacity, prices, and other matters to enable them to obtain open access non-discriminatory transmission services from the *Transmission Provider*.

Point of Interconnection (POI): The point where the Interconnection Facilities are connected to NS Power's *Transmission System*.

Point of Change of Ownership (PCO): The point where the *Interconnection Customer* owned interconnection facilities connect to the NS Power interconnection facilities.

Remedial Action Scheme (RAS): a scheme designed to detect predetermined system conditions and automatically take corrective actions that may include, but are not limited to, adjusting or tripping generation, tripping load, or reconfiguring the system to accomplish acceptable system performance. Also commonly referred to as *Special Protection Systems* (SPS).

Standard Generator Interconnection and Operating Agreement (GIA): The form of interconnection agreement applicable to an *Interconnection Request* pertaining to a *Generating Facility*, that is included in the *Transmission Provider's* Tariff[24].

Standard Generator Interconnection Procedures (GIP): The interconnection procedures applicable to an *Interconnection Request* pertaining to a *Generating Facility* that are included in the *Transmission Provider's* Tariff[24].

Standard Protection Code: NS Power's set of lock out/tag out practices for work on the high voltage electrical system designed to ensure the safety of workers and the security of the electrical system.

Special Protection System (SPS): see definition for *Remedial Action Scheme*.

Synchronous Condenser: A machine that contains an excitation system but does not have a mechanical input power system (i.e. prime mover, boiler, etc.).

Synchronous Generator: A machine that generates electricity at a constant frequency and draws its excitation from a power source external to, or independent of, the load or transmission network it is connected to.

System Impact Study (SIS): An engineering study that evaluates the impact of the proposed interconnection on the safety and reliability on the *Transmission System.* The study identifies and details the system impacts that would result if the interconnecting facility was interconnected without project or system modifications.

System Operator: The entity that operates the Nova Scotia *Transmission System*.

Transmission System: Electrical equipment operating at voltages of 69kV and above.

Transmission Provider: Shall mean Nova Scotia Power Inc.

Under Frequency Load Shedding (UFLS): A common technique to maintain power system stability by automatically disconnecting load in defined parts of the electrical system.

Wind Energy Conversion System (WECS): a system for the conversion of wind energy to electrical energy by way of generator sets, transformers, control equipment, and other associated equipment.

3.0 INTERCONNECTION PROCEDURES

3.1. Interconnection Process

All *Generator* I*nterconnection Requests* to the NS Power *Transmission System* shall follow the *Standard Generator Interconnection Procedures (GIP)* [22] that can be obtained from NS Power's *OASIS* website.

All *Load Interconnection Requests* to the NSPI *Transmission System* shall follow the bulk power Facilities Connection Guide that can be obtained from NS Power's *OASIS* website.

The initial primary point of contact for all customer *Load Interconnection Requests* is NS Power Customer Care Centre.

For technical connection information and assistance, the *Interconnection Customer's* information will be forwarded to the appropriate Regional Engineer for assessment. The Regional Engineer will assess the load to confirm if the *Interconnection Customer* will require a *Distribution System* or *Transmission System* connection. If the Regional Engineer determines that a *Distribution System* level connection is required, the project will be managed at the Regional level with any *Distribution System* studies completed as required. If a *Transmission System* level connection is required, the *Interconnection Customer* information will be directed to the appropriate Transmission Planning Engineer. Typically, customer loads under 1 MW will be handled by the Regional Engineer with support from System Planning as required.

3.2. System Interconnection Studies

3.2.1. Feasibility Study

The *Feasibility Study* for all transmission generation *Interconnection Requests* will follow the process outlined in Section 6 of the *GIP*[22].

For all customer transmission *Load Interconnection Requests*, NS Power will conduct an initial review, determined by the scope of the project. The preliminary review may consist of a scope meeting with the *Interconnection Customer* and a decision to move directly to a detailed *System Impact Study*. If a more detailed initial assessment is required to determine the viability of the project, a preliminary review (referred to as a *Feasibility Study* in the *GIP*[22]) with a report of the expected technical requirements and high-level cost estimates can be provided.

A deposit to cover the costs of the Feasibility Study will be required. The actual study costs shall be the responsibility of the *Interconnection Customer*, with any surpluses refunded and any additional costs recovered.

3.2.2. System Impact Study

For load, generator and BESS *Interconnection Customers*, the interconnection *System Impact Study* will consist of power flow, short circuit, stability, and electromagnetic transients (EMT) analysis. The *System Impact Study* will state the assumptions upon which it is based; state the results of the analyses; and provide the requirements or potential impediments to providing the requested connection service, including a preliminary indication of the cost and length of time that would be necessary to correct any problems identified in those analyses. The *System Impact Study* will provide a list of facilities that are required as a result of the *Interconnection Request* and a non- binding estimate of cost responsibility and a non-binding estimated time to construct.

Connection facilities that have the potential for impact on neighbouring power systems (adjacent to the NS Power service territory) may require coordinated joint studies with the affected parties.

These studies provide the framework for the assessments, estimates, and design determinations to be completed in the *Facility Study*.

A deposit to cover the costs of the *System Impact Study* will be required. The actual study costs shall be the responsibility of the *Interconnection Customer*, with any surpluses refunded and any additional costs recovered.

3.2.3. Facility Study

The *Facility Study* for both the load and generation *Interconnection Customers* shall specify and estimate the cost of the equipment, engineering, procurement, and construction work needed to implement the conclusions of the *System Impact Study* to interconnect with NS Power's *Transmission System*. The *Facility Study* shall identify the electrical switching configuration of the connection equipment, including, without limitation: the transformer, switchgear, meters, and other station equipment; the nature and estimated cost of any *Transmission Provider's* Interconnection Facilities and *Network Upgrades* necessary to accomplish the connection; and an estimate of the time required to complete the construction and installation of such facilities. The *Facility Study* will provide the design specifications for the physical plant to be constructed in order to connect the facility.

A deposit to cover the costs of the *Facility Study* will be required. The actual study costs shall be the responsibility of the *Interconnection Customer*, with any surpluses refunded and any additional costs recovered.

3.3. Information and Modelling Data Requirements

Information requirements for all generation *Interconnection Requests* are outlined in Appendix A.

The *Interconnection Customer* shall provide preliminary facility models for steady state feasibility studies, followed by detailed dynamics and EMT models for use in the *SIS*. The model data requirements can be obtained from NS Power's *OASIS* website.

The *Interconnection Customer* is responsible for providing future updated versions of the PSS®E and PSCAD™ models at the request of NS Power and provide control system parameters as set in the field.

4.0 SAFETY AND ENVIRONMENTAL REQUIREMENTS

4.1. NS Power's Safety Policy

The occupational health and safety of people is more important than any business interest. For this reason, occupational health and safety is our number one priority.

4.2. Standard Protection Code

Safe work procedures described in NS Power's *Standard Protection Code*[20] document will be followed when NS Power is performing any applicable work on the interconnected power system, including providing isolation and temporary grounding. *Interconnection Customers* are responsible to follow applicable Nova Scotia Department of Labour and Department of Advanced Education Regulations for carrying out work on their system.

4.3. Electrical Inspection Act[5] and Canadian Electrical Code Parts I, II, & III (CEC)[4]

The *Interconnection Customer's* installation must meet all applicable national, provincial and municipal electrical construction and safety codes, including, without limitation, the Electrical Installation and Inspection Act. Except as expressly permitted by law, all electrical equipment must have *Canadian Standard Association (CSA)* or equivalent approval.

Information Bulletins regarding Nova Scotia Power Electrical Permits (B-B1-002), and Customer Owned High Voltage Equipment (B-36-000), along with other bulletins can be found at: https://www.nspower.ca/your-home/building-renovating/electrical-inspections/bulletins.

4.4. Environmental Requirements

NS Power designs, constructs and operates its facilities in a manner which is protective of the environment. It is expected that any interconnected facility complies with all relevant *Federal, Provincial and Municipal laws, bylaws, ordinances and regulations* with regard to preservation of the environment and that the *Interconnection Customer* shall abide by any conditions or stipulations contained in approvals issued to cover the interconnected facility.

4.5. Permission to Operate

Under no circumstances shall the *Interconnection Customer* begin parallel operation of a *Generating Facility* until final written approval in the form of a signed operating agreement has been provided by NS Power.

Load Interconnection Customers must adhere to *System Operator* handing over of equipment requirements before any transmission interconnections shall be energized.

5.0 COMPLIANCE WITH STANDARDS

5.1. Reliability Standards

All *Interconnection Customer Facilities* must comply with all applicable *North American Electric Reliability Corporation (NERC)* and *Northeast Power Coordinating Council (NPCC)* reliability standards as endorsed and administered in Nova Scotia by the Nova Scotia Utility and Review Board. It is the responsibility of the interconnecting customer to ensure full awareness and compliance to applicable Reliability Standards.

5.2. Industry Standards

All *Interconnection Customer Facilities* must comply with all applicable industry standards pertaining to the safe and reliable operation of electrical facilities. It the responsibility of the *Interconnection Customer* to ensure full awareness and compliance to applicable Industry Standards.

6.0 NOVA SCOTIA POWER SYSTEM INFORMATION AND DESIGN PRACTICES

6.1. System Overview

NS Power is an active member of the *Northeast Power Coordinating Council (NPCC)* and is interconnected to the Eastern North American *Transmission System*. Nova Scotia Power is required to follow and adhere to transmission reliability rules as established by the *North American Electricity Reliability Corporation (NERC)* and *NPCC* and as overseen by the Nova Scotia Utility and Review Board.

The Nova Scotia *Transmission System* consists of over 5000km of transmission lines with AC interconnections with New Brunswick and a DC interconnection with Newfoundland and Labrador. NS Power nominal *Transmission System* voltages include 345kV, 230kV, 138kV and 69kV.
The Major Facilities map (2024) for Nova Scotia is shown in Figure 1.

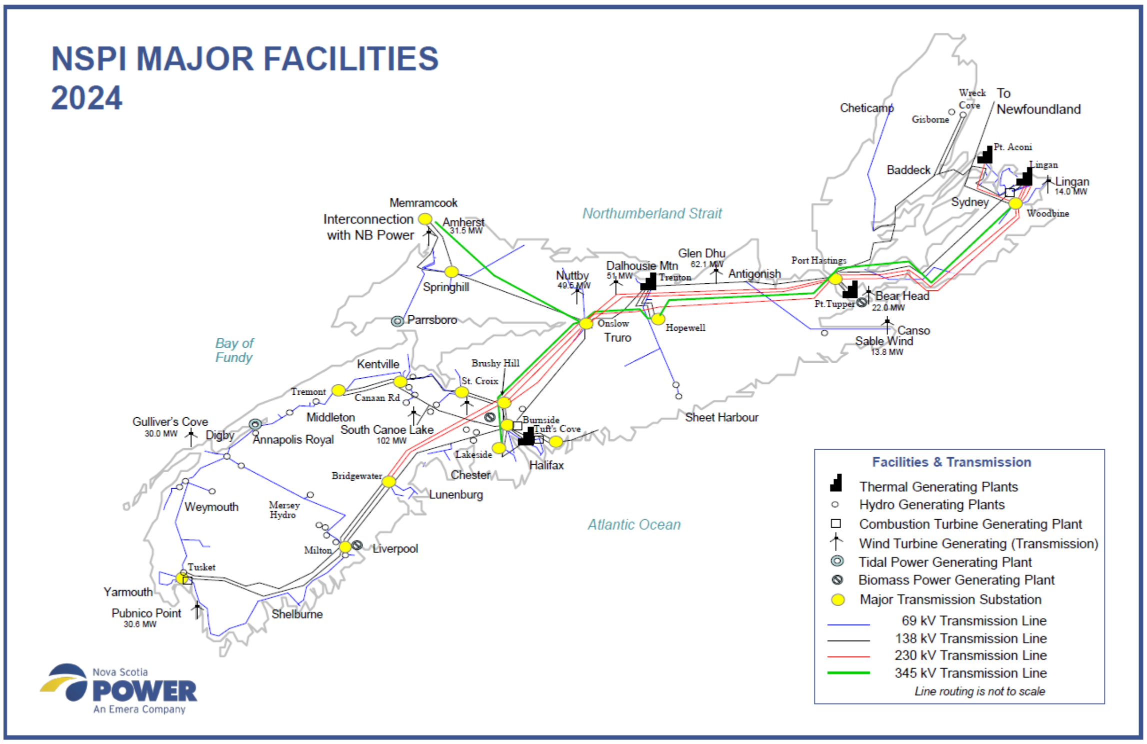

Figure 1: MAJOR FACILITIES MAP FOR NOVA SCOTIA - 2024

6.2. System Design Criteria

NS Power's planning and development criteria shall be applied to all new additions to NS Power's *Transmission System*, however the NS Power criteria are superseded by the *NPCC* criteria with respect to the *Bulk Electric System.*

NS Power's system design criteria combine protection performance specifications with system dynamics and steady state performance requirements. When system expansions are undertaken, facilities are to be designed and constructed such that the criteria are met. The specified speed of protection systems must be achieved unless faster speeds are specified, or slower speeds are accepted based on system studies. System studies to determine adequacy and investment requirements must be conducted using the actual characteristics (setting and operating time) of the existing protection systems.

Details on the NS Power System Design Criteria, and the requirements for each transmission classification, are provided in NS Power's System Design Criteria document NSPI-TPR-003 which can be obtained from NS Power's *OASIS* web site.

6.3. Design Ratings

6.3.1. Basic Design Parameters

6.3.1.1. Ambient Temperature

Ambient temperature for outdoor equipment shall be -35°C to +40°C.
Ambient temperature for indoor equipment shall be -5°C to +40°C.

6.3.1.2. Relative Humidity

Relative humidity range for indoor equipment shall be from 10% to 90% non-condensing.

6.3.1.3. Wind and Ice Loading

Wind and ice loading for the substation bus work shall be assumed to be as follows:

- Wind velocity of 100 km/h (60 mph), together with a gust factor 1.2 plus a coating of 12.5 mm thick ice.
- Wind velocity of 145 km/h (90 mph) gust factor 1.2 and no ice.

Wind and ice loading for the substation structures including dead-ends shall be as follows:

- Wind pressure of 0.8 kPa on the projected surfaces with appropriate factors as required by the National Building Code of Canada and CSA Std S16.19 "Design of Steel Structures[1]".
- 25 mm thick coating of ice with no other load combination.
- 13 mm thick coating of ice, alone or with other load combinations including a wind pressure of 0.4 kPa.
  For the purpose of design all loads shall be combined and considered as acting simultaneously in a manner such as to produce the worst conditions of stresses in the structure with a load factor of 1.5 for all live loads in combination.
- Seismic loading shall be considered as required by the National Building Code of Canada and IEEE 693 - Recommended Practice for Seismic Design of Substations.

6.3.1.4. Conductor Operating Temperature

Maximum operating temperature of conductors terminated on the equipment terminals such as transformer bushings, circuit breaker terminals, etc. should be limited to 70°C.

For general bus work both aluminum and copper conductors may be operated at 90°C.

For short term emergency loading the bus conductors may be operated at 100°C.

6.3.1.5. *Voltage and Insulation Levels*

Voltage and insulation level of all equipment except bus work and power transformers shall be selected from the following tabulation:

Nominal Voltage	Maximum Voltage	BIL	SIWL
13.8 kV	15.5 kV	95 kV	--
25 kV	27.5 kV	125 kV	--
69 kV	72.5 kV	350 kV	--
138 kV	145 kV	650 kV	--
230 kV	245 kV	950 kV	850 kV
345 kV	362 kV	1175 kV	950 kV

Voltage and insulation level for the station post insulators shall be selected from the following table:

Voltage	BIL
15.5 kV	150 kV
27.5 kV	150 kV
72.5 kV	350 kV
145 kV	650 kV
245 kV	900 kV
362 kV	1300 kV

6.3.1.6. *Fault Levels*

The ultimate three phase rms symmetrical design fault levels are as follows:

Nominal Voltage	Fault Level
13.8 kV	250 MVA, 10 kA
25 kV	350 MVA, 8 kA
34.5	900 MVA, 8kA
69 kV	3,500 MVA, 29 kA
138 kV	5,000 MVA, 21 kA
230 kV	10,000 MVA, 25 kA
345 kV	15,000 MVA. 25 kA

All substations shall be designed for the above fault levels unless specified otherwise. Minimum fault levels at the *Point of Interconnection* will be determined by the *System Impact Study*.

6.3.2. Equipment Ratings

NS Power Equipment Ratings, in effect at the time of publication of this document, are included here for reference.

6.3.2.1. *Rating Criteria*

When sizing equipment and other hardware for a substation it shall be ensured that no component of a substation shall limit the maximum output of a power transformer.

The maximum output of a power transformer is considered to be a continuous load at an ambient of 0°C without exceeding winding temperature limit of 95°C and average hot spot temperature of 110°C. For air cooled transformers the maximum output will be 118.75% of the maximum nameplate rating.

Short time emergency loading for power transformers connected to a distribution bus (34.5 kV and below) shall be assumed to be 133% of the maximum nameplate rating. The duration of short time emergency loading will generally be two to three hours per day at an ambient temperature of - 5°C or lower.

6.3.2.2. *Design Ampacity*

When the rating of power transformer(s) to be installed in the substation is known, the rating of the equipment should be based upon the maximum output of the power transformer but should not be less than the minimum rating recommended in this guide.

To determine the minimum ampacity requirement for equipment and bus work in a substation with no power transformer it shall be assumed that power transformers having maximum ratings as per Table 1 may be installed in the substation.

TABLE 1: EQUIPMENT MINIMUM AMPACITY

Voltage	Transformer MVA	Ampacit
345 kV	375/500/625 MVA	1046 A
230 kV	375/500/625 MVA	1569 A
138 kV	270/360/450 MVA	1833 A
69 kV	60/80/100 MVA	837 A
26.4 kV	25/33.3/41.7 MVA	912 A
13.2 kV	15/20/25 MVA	1093 A

These ampacity values are for transformer loading at an ambient temperature of 40°C and should be further adjusted for ring bus, breaker and a half or any other applicable station layouts.

6.3.2.3. *Power Circuit Breakers*

Maximum voltage, short circuit capability and the basic impulse level (BIL) shall be as required by the design parameters.

Short circuit interrupting time for circuit breakers interconnected with NS Power’s system shall be as per Table *2* and the standard ratings as per Table 3.

Table 2: CIRCUIT BREAKER INTERRUPTING TIME

Voltage	Interrupting Tim
345 kV	*2* cycles
230 kV	2 cycles
138 kV	3 cycles
69 kV	5 cycles
25 kV	8 cycles

Table 3: CIRCUIT BREAKERS – NS POWER STANDARD RATINGS

Max. Voltage	Current	Interrupting	Application
15.5 kV	1200 A	12.5 kA	All Locations
25.8 kV	1200 A	12.5 kA	All Locations
72.5 kV	1200 A	31.5 kA	All Locations
145 kV	1200 A	20 kA	Single Bus, Lines
	2000 A	25 kA	Bus Tie, Ring Bus
245 kV	2000 A	31.5 kA	All Locations
362 kV	2000 A	31.5 kA	All Locations

Continuous current rating of a circuit breaker is based on an ambient of 40°C. At lower ambient temperatures the circuit breaker can carry increased load current, generally in the range of 8% to 50% of nameplate rating depending upon ambient. Refer to ANSI 037.010 for additional details.

6.3.2.4. *Reclosers*

The minimum rating of the reclosers interconnected to the NS Power System shall be as per Table 4:

Table 4: RECLOSERS – NS POWER STANDARD RATINGS

Nominal Voltage	Current	Interrupting	BIL
12.47 kV	560 A	10 kA	110 kV
24.9 kV	560 A	8 kA	125 kV

All reclosers shall be installed with electronic controls.

6.3.2.5. *Disconnect Switches*

Recommended ratings and types of disconnect switches interconnected to the NS Power System are as listed in Table 5.

Table 5: DISCONNECTS – NS POWER STANDARD RATINGS

Voltage	IEC Type	Current	Momentary	Application
15.5 kV	N/A*			
25.8 kV	Hook Stick	600 A	40 kA	Recloser Isolation
25.8 kV	A	1200 A	61 kA	
25.8 kV	A	600 A	40 kA	Recloser Bypass
72.5 kV	A	1200 A	61 kA	
145 kV	A,B,G	1200 A	61 kA	Lines, Single Buses
145 kV	A,B	2000 A	100 kA	Ring Buses
245 kV	A	2000 A	100 kA	
362 kV	A	2000 A	100 kA	

* For 15.5 kV substations, disconnects rated for 25.8 kV should be used.

Line disconnects for 145 kV, 245 kV, and 362 kV shall be provided with integral group operated line grounding switches.

Line grounding switches shall be interlocked with the associated line disconnect switches.

Disconnect switches for capacitor banks shall be provided with grounding switches and key interlocks.

All disconnects rated 2000 A or more for 245 kV and 362 kV systems shall be motor

operated. All disconnect switches shall have station post type insulators.

6.3.2.6. *Current Transformers*

Current transformers are generally specified in terms of maximum line to ground voltage, BIL, current ratios, number of windings, and accuracy ratings.

Current transformers shall be capable of carrying system short circuit current for three seconds without exceeding the limiting temperature of 250°C.

Current transformers shall have a continuous current rating factor of 1.33 without exceeding the rated temperature rise and still maintaining rated accuracy.

Design and manufacture of the current transformer shall comply with the requirements of CAN/CSA C61869-1. All current transformer used for revenue metering shall require Industry Canada approval.

6.3.2.7. *Voltage Transformers*

The standard requirement for voltage transformers interconnected to the NS Power System is listed in Table 6.

Table 6: CSA STANDARD VOLTAGE TRANSFORMERS RATIOS (GR.3)

System Voltage	Primary Voltage	Secondary Voltage	Ratio
27.5 kV	13,800 V	115-69 V	120-200/1
72.5 kV	40,250 V	115-67.08 V	350-600/1
145 kV	80,500 V	115-67.08 V	700-1200/1
245 kV	138,000 V	115-69 V	1200-2000/1
362	207,000 V	115-69 kV	1800-2000/1

6.3.2.8. *Surge Arresters*

All arresters used for interconnections to the NS Power *Transmission System* shall be 'Station Class' and with standard ratings as listed in Table 7.

Table 7: SURGE ARRESTERS – NS POWER STANDARD RATINGS

System Voltage	MCOV	Rated Voltage
13.8kV	7.65 kV	12 kV
25 kV	15.3 kV	18 kV
25 kV (Ungrounded)	17.0 kV	21 kV
69 kV	48 kV	60 kV
138 kV	98 kV	120 kV
230 kV	144 kV	180 kV
	152 kV	192 kV
345 kV	220 kV	276 kV
	230 kV	288 kV

7.0 INTERCONNECTION TECHNICAL REQUIREMENTS

This section is organized to provide guidance on requirements for interconnection to the NS Power *Transmission System* based on category of load, generation or BESS equipment:

7.1. General Requirements

All Generating Facilities interconnected to the NS Power *Transmission System* must comply with all applicable standards, codes, and regulations and be designed and operated in compliance with *Good Utility Practice*.

7.2. Steady State Voltage and Frequency Ranges

Under normal operating conditions, transmission voltage can operate continuously in a range of 95% to 105% of nominal.

Under contingency conditions (*NERC*/*NPCC* contingencies), the *Transmission System* voltages can operate continuously in a range of 90% and 110% of nominal voltage for up to 30 minutes.

The nominal frequency range for continuous operation will be as specified by *NERC* and *NPCC* criteria.

7.3. Grounding Requirements

NS Power's *Transmission System* operates as an effectively grounded system. *Interconnection Customer Facilities* shall be designed with $X_0/X_1 \leq 3.0$ and $R_0/X_1 \leq 1.0$.

Substations shall have a ground grid that is solidly connected to all metallic structures and all equipment, and designed to limit ground potential gradients to voltage and current levels such that it will not endanger the safety of people or damage equipment under normal and design fault levels. All ground grids should be designed to applicable CSA and IEEE Standards.

All ground systems that are to be connected to existing NS Power grounding elements must be approved by NS Power.

7.4. Functional and Performance Requirements

Unless otherwise specified in Section 7.5 or 7.6, all generators connected to the NS Power *Transmission System* shall meet these requirements.

7.4.1. Voltage Ride-Through

The *BESS or Generating Facility* shall meet the following voltage ride-through requirements as detailed in *NERC* Standards applicable to the *NPCC BPS* and *NERC BES*. At the time of publication of this document, the applicable standard in Nova Scotia is *NERC* Standard PRC-024-3.

7.4.2. Frequency Variations

The *Generating Facility* shall be capable of operating reliably for frequency variations in accordance with the *NERC* Standard in effect for Nova Scotia.

The *Generating Facility* shall have the capability of riding-through a rate of change of frequency of 4 Hertz per second measured over 500 ms sample time.

7.4.3. Anti-Islanding Protection

Grid following generation will have anti-islanding protection if required by the *System Operator*.

7.4.4. Reactive Power Requirements

All *Generating Facilities* must be capable of delivering reactive power to the *Transmission System* in accordance with Sections 7.5.2, 7.6.2 and 7.6.3.

All *Generation Facilities* connected to the *Transmission System* shall be equipped with the capability for reactive power to be dispatched and controlled by the *System Operator*. The requirement, process, and degree of implementation of this capability shall be determined in the terms of the *GIA*.

All *BESS Facilities* in grid following mode shall be capable of delivering reactive power to the *Transmission System* in accordance with Sections 7.6.2 and 7.6.3.

All *BESS Facilities* in grid forming mode, where applicable, shall be capable of delivering reactive power to the *Transmission System* in accordance with Sections 7.6.2 and 7.6.3.

7.4.5. Dynamic Reactive Power Requirements

The *System Impact Studies* will determine the requirements for dynamic reactive power control ranges to maintain system voltages within acceptable limits during steady state and system disturbance conditions.

7.4.6. Power Quality

The *Interconnection Customer* shall address potential sources and mitigation of power quality degradation in the design of their *Generating Facility* prior to interconnection. Design considerations should include applicable standards including, but not limited to IEEE Standards 142[26], 519[27], 1100[28], 1159[29], ANSI C84.1[30], IEC 61400-21[33], IEC 61000-3-6[31], and IEC 61000-3-7[32].

Typical forms of power quality degradation include, but are not limited to voltage regulation, voltage unbalance, harmonic distortion, flicker, voltage sags/interruptions and transients. The *Generating Facility* shall be equipped with under-voltage, over-voltage, under-frequency, and over-frequency protection to limit the *Adverse System Impacts* due to the *Generating Facility* on the system.

7.4.7. Automatic Generation Control

NS Power reserves the right to require that the *Generating* or *BESS Facility* be capable of Automatic Generation Control (AGC) to assist in balancing load and generation. The *System Impact Study* will determine the need for activation of AGC within the parameters of the facility capability. AGC signals will originate from the NS Power Energy Management System via Supervisory Control and Data Acquisition (SCADA) and will be in the form of +/- changes in real power, or direct power control settings. Alternately, the NS Power EMS may deliver specific real power set-points rather than +/- changes. When required, the active power controls shall react to continuous control signals from the NS Power AGC system to control tie-line fluctuations.

For grid forming generation, the set-point(s) may be a frequency reference rather than active power set-point.

7.4.8. Synchronizing Facilities

Generating Facility synchronous generators shall synchronize to the NS Power *Transmission System* using equipment capable of closing a circuit breaker with minimal transient impact on system voltage and frequency (matching voltage within +/- 0.05 per unit, and phase angle within +/- 15 degrees). The synchronizing system shall meet the IEEE Standard C37.118[7]. Manual synchronizing capability shall be provided as well as automatic facilities.

7.4.9. Black Start Capability

If deemed necessary by the location of the *Point of Interconnection* on the NS Power system, and subject to the capabilities of the technology implemented by the *Generating or BESS Facility*, the ability to *Black Start* the *generating unit* may be required.

7.4.10. Remedial Action Schemes

Remedial Action Schemes (*RAS*), also known as *Special Protection Systems* (*SPS*), are implemented in Nova Scotia to enhance system transfer capability. These schemes will either directly trip or rapidly run-back generated output. System studies will determine if these schemes will be employed at the time of interconnection, or at some time in the future.

7.4.11. Disturbance Monitoring Equipment

Disturbance monitoring equipment shall be provided to analyze the response of the generator to disturbances, or to assist in identifying the cause of disturbances within the *Generating or BESS Facility*. Any generator or BESS connected to the *Bulk Power System* is required to provide disturbance monitoring equipment in accordance with NPCC Directories and *NERC* Standards.

7.4.12. Generation Curtailment

If deemed necessary by the *System Operator* due to system conditions, and subject to the capabilities of the technology implemented by the *Generating or BESS Facility*, all units shall be capable of curtailing output for system security reasons.

7.4.13. Load Shedding

NS Power utilizes *Underfrequency Load Shedding (UFLS)* to help maintain system reliability under extreme contingencies as per *NERC* Underfrequency Load Shedding Program Requirements[16]. NS Power reserves the right to require any customer loads to participate in the *UFLS* program. The *Generating or BESS Facility* shall be coordinated with the *UFLS* program.

7.4.14. Short Circuit Ratio

System short circuit level may decline over time due to changes to transmission configuration and generation mix. The *Generating or BESS Facility* shall be tunable to accommodate these changes to SCR as low as 1.4. In this context, SCR is the ratio of the minimum SCMVA at the *POI* and the MW rating of the facility.

If stable operation at SCR 1.4 cannot be achieved, additional interconnection requirements may be specified in the *SIS*.

7.5. Synchronous Generator Specific Requirements

7.5.1. Transformer Configuration

The generator step-up transformer reactance and tap settings shall be coordinated with NS Power during the *System Impact Study* to optimize the leading and lagging reactive power capability that can be provided to the network. The transformer shall be designed in accordance with IEEE Standard C57.116[6]. The winding configuration is generally grounded-wye on the high side and delta on the low side. Unless otherwise specified, the low voltage winding will be rated at the generator terminal nominal voltage, and the high voltage winding will be rated at 105% of the system voltage. Off-load taps shall be provided to allow the maximum reactive power of the generator to be delivered to the high voltage terminals while maintaining steady-state system voltage and generator terminal voltage within 5% of nominal.

7.5.2. Reactive Power Requirements

Subject to the results of the System Impact Studies, *Synchronous Generators* rated from 10 MW to 75 MW shall have a reactive power at the generator terminals with a range of 0.90 per unit lagging to 0.95 per unit leading. *Synchronous Generators* with a rating greater than 75 MW shall be capable of operating at a power factor or 0.85 per unit lagging to 0.95 per unit leading at the machine terminals. Generators rated below 10MW that are connected to the *Transmission System* shall be capable of delivering reactive power of 0.95 per unit leading and lagging measured at the high voltage terminals of the generator step-up transformer.

7.5.3. Excitation Systems

All *Synchronous Generators* rated 10 MW or greater shall be equipped with a high initial response excitation system in accordance with the guidelines of IEEE Standard 421.4[11]. An electronic (static) excitation shall have a voltage response time of no greater than 100 milliseconds. A rotating exciter may be used providing the response ratio is 2.0 or higher. In either case, the exciter must be capable of positive and negative field voltage and the ceiling voltage shall be 2.0 times full load or greater and the exciter current must be capable of 1.6 times full load, in accordance with the definitions of IEEE Standard 421.1[10]. The suitability of excitation response parameters will be reviewed during the *System Impact Study*. The use of excitation limiters will be coordinated with generation protection requirements in accordance with *NERC* Standards PRC-019-2[17], PRC-024-3[18], and PRC-025-2[19].

7.5.4. Inertia Constant

System stability in Nova Scotia is significantly impacted by the collective inertia of the *generating units* in the province. The impact on system stability of the combined prime mover plus generator unit inertia (H) will be assessed during the *System Impact Studies* and, unless otherwise specified, shall be no less than 2.0 MW*s / MVA. *Interconnection Customers* shall demonstrate, through study and monitored operation, the ability of the generator to maintain synchronization for typical fault clearing times at the *Point of Interconnection*.

7.5.5. Speed Governors

Synchronous Generators connected to the *Transmission System* must be equipped with a speed governor capable of contributing to the control of system frequency, with the following characteristics:

- Speed droop characteristic of 4% (slope of percentage of generator real power output as a function of percentage of system frequency deviations)
- Maximum deadband of +/- 0.06 Hz.
- Capable of controlling generator speed in islanding an interconnected operation.
- Prevent unit trip on overspeed following a full load rejection
- Meet requirements of IEEE Standard 125[8] for hydraulic turbines and IEEE Standard 122[9] for steam turbines.
- Steam turbines shall be equipped with Early Valve Actuation to assist in unit stability by rapidly interrupting steam flow for power unbalance conditions.

7.5.6. Automatic Voltage Regulation

The *Generating Facility* shall be capable of controlling the machine terminal voltage through the use of an Automatic Voltage Regulator (AVR). The AVR shall be equipped with line-droop compensation with an adjustable range up to 60%. The set point of the AVR shall be capable of maintaining steady-state voltage within a deadband of +/- 0.5% (0.005 per unit). Parameters and limits of the AVR will be reviewed in the *System Impact Study* to ensure stable operation of the generator over a wide range of system conditions, including a range of Short Circuit Ratio. The setting of the AVR will be determined by the NS Power *System Operator* in real-time according to system conditions. Joint control of multiple generators at a common *Point of Interconnection* is permitted.

7.5.7. Power System Stabilizer

A *Synchronous Generator* connected to the NS Power *Transmission System* which is equipped with a high initial response excitation system is required to be equipped with a Power System

Stabilizer. The *System Impact Study* will evaluate the performance of PSS parameters as proposed by the *Interconnection Customer*. The PSS, if required, must be capable of being disabled if the generator is operated in islanded conditions.

7.6. Asynchronous Generator Specific Requirements

This section applies to generation facilities that utilize any type of *Asynchronous Generator* technology interconnected with the NS Power *Transmission System*, including *IBR* and hybrid projects. Certain requirements in this section only apply to *Wind Energy Conversion System* (*WECS*), *BESS* or all *IBR* systems as noted.

7.6.1. Transformer Configuration

The facility transformer(s) at the *POI* reactance and tap settings shall be coordinated with NS Power during the *System Impact Study* to optimize the leading and lagging reactive power capability that can be provided to the network. On-load taps are expected to be provided to allow the maximum reactive power of the generator to be delivered to the high voltage terminals while maintaining steady-state voltage at generator terminals.

7.6.2. Fault Current Contribution - IBR

At a minimum, an *IBR* unit shall be capable of the following:

- The *IBR* unit shall be able to prioritize active or reactive current.
  - Shall be capable of injecting negative-sequence reactive current at 50% of its maximum current rating when the inverter terminal negative-sequence voltage is at or above 25% of the nominal voltage.

- For reactive current (Iq) priority, or during voltage ride through, the *IBR*:
  - Shall inject up to its maximum current rating when the inverter terminal voltage falls to less than or equal to 50% of the nominal voltage.

Shall be capable of absorbing reactive current equal to 30% of its maximum current rating when the terminal voltage is at or above 115% of the nominal voltage.

7.6.3. Reactive Power and Voltage Control

The *Asynchronous Generating Facility* shall be capable of delivering reactive power at a net power factor of at least +/- 0.95 of rated capacity to the high side of the facility interconnection transformer over the range shown in Figure 2 below.

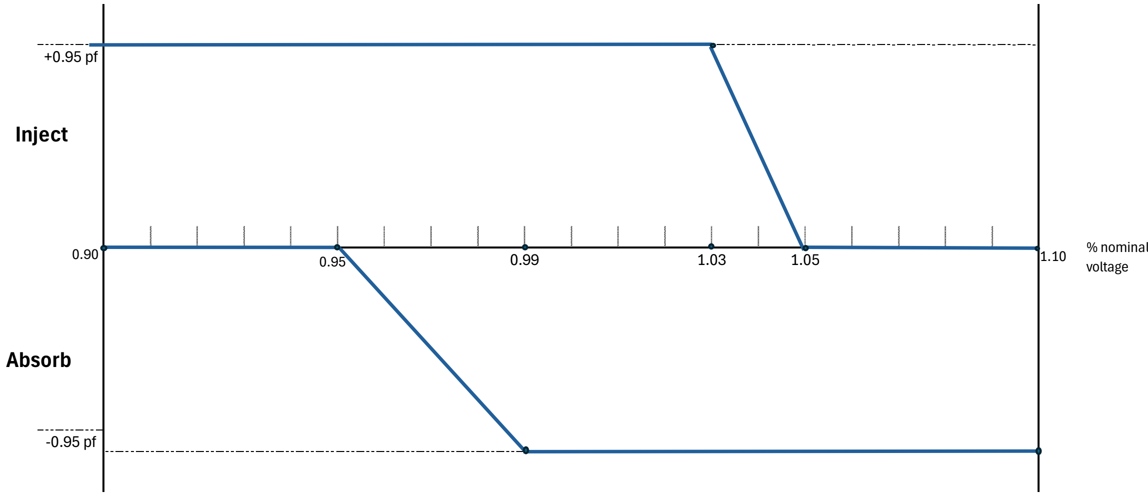

Figure 2: Reactive Power Requirement

Rated reactive power shall be available through the full range of active power output of the *Generating Facility*, from zero to full power.

Unless otherwise determined by the *System Impact Study SIS*, continuously acting voltage regulation shall have a voltage response time of no greater than 100 milliseconds.

The *Asynchronous Generating Facility* shall provide the capabilities of the following mutually exclusive operating modes:

- Voltage control mode with droop: shall be capable of receiving the voltage set point and adjust the reactive power to maintain the system voltage. The voltage droop shall be adjustable in a range specified by NS Power.

- Reactive power control mode: the *IBR* system shall be capable of receiving a reactive power set point (within the acceptable reactive power range) and maintaining the reactive power output as close to the set point as possible.

- Power factor control mode: the *IBR* system shall be capable of receiving a power factor set point and be able to adjust the reactive power output in accordance with the active power output to maintain the power factor as close to the set point as possible.

Grid forming *IBR* will run in Voltage Control Mode with droop unless otherwise specified by NS Power.

7.6.4. Voltage Ride-Through

Further to the requirements of the *Standard Generator Interconnection and Operating Agreement (GIA*[23]), Appendix G, all Generating and BESS Facilities connected to the NS Power *Transmission System* are required to remain connected to the grid during and immediately following a system disturbance.

7.6.5. Active Power Control – WECS and Solar

Asynchronous Generators connected to the *Transmission System* must be capable of controlling active power in response to frequency deviations and control signals from the NSPI *System Operator* to the extent enabled by the technology utilized.

While the *Asynchronous Generating Facility* is curtailed, it shall offer over-frequency and under- frequency control with a deadband of +/- 0.2 Hz and a droop characteristic of 4% or as otherwise directed by NS Power. The active power controls shall also react to continuous control signals from the NS Power Automatic Generation Control (AGC) system to control tie-line fluctuations when required.

While the *Asynchronous Generating Facility* is not curtailed, it shall provide self-regulation for over-frequency conditions in excess of 60.2 Hz at a droop characteristic of 4% or as otherwise specified by NS Power.

The *IBR* system shall be capable of continuous stable operation up to the point when minimum output value is reached, or the maximum available active power is reached.

Furthermore, it shall be possible to set different droop levels for under-frequency and over-frequency conditions. The frequency droop parameters of the *IBR* facility shall be adjustable, at least within the available configuration ranges. This flexibility will allow the *IBR*'s response to be tailored to the specific needs of the NS Power, enhancing its ability to maintain frequency stability and contribute to the security of the power supply.

7.6.6. Active Power and Frequency Response – BESS

BESS shall participate in frequency control by injecting power into (or absorbing power from) the grid in response to changes in frequency during the arresting phase of a frequency excursion event, to improve the frequency nadir and reduce the initial rate of change of frequency.

At a minimum the BESS shall have a Droop Control mode:

- The frequency response controller shall have fixed droop settings and shall offer over-frequency and under-frequency control with a deadband of +/- 0.36 Hz and a droop characteristic of 4% or as otherwise specified by NS Power.

- It should be possible to configure distinct droop levels and deadband for both under-frequency and over-frequency conditions.

It may be determined in the *SIS* that the BESS will require Inertia Control mode for stable operation.

7.6.7. Priority to Active or Reactive Power Contribution

IBR facilities shall be capable of operating in the active or reactive power priority modes as requested by the NS Power operator while meeting continuous operating rating and short-term overload ratings.

7.6.8. Post Fault Active Power Recovery

IBR facility shall restore active power output to at least 90% of its pre-fault power output or available level within 1.0 second of when the voltage at the high-side of the main power transformer returns to the normal contingency range of 0.90 to 1.10 pu.

7.6.9. Power Quality

In addition to the requirements of 7.4.6, the *Interconnection Customer* using *Asynchronous Generators* shall submit the Power Quality Tests Result Report as described in the IEC 61400-21[33] standard. This report includes: general wind turbine data, wind turbine rated data at terminals, voltage fluctuations coefficients (flicker coefficients), current harmonics components, current inter-harmonics components, current high frequency components, response to voltage drops, active power data, reactive power data, grid protection data and reconnection time. The wind turbines shall not exceed the flicker emission limits established by the IEC 61000-3-7[32] standard and the harmonics emission limits of IEC 61000-3-6[31]. Test reports shall be based on 60Hz variants of the *WECS*.

An *IBR* facility shall ensure that its connection to the NS Power *Transmission System* does not result in an unacceptable level of distortion or fluctuation of the supply voltage at the Connection point.

7.6.10. Control Requirements - IBR

The *IBR* system shall be designed with control functionalities so that the *IBR* system shall not degrade system stability and overall performance of the interconnected grid.

- The connection of the *IBR* system shall not negatively impact the operation of other dynamic devices in its close vicinity.
- The connection of the *IBR* system shall not lead to unstable or poorly damped system conditions (commonly referred to as control interactions).
- The connection of the *IBR* system shall not result in transient and temporary over voltages that will impact existing generation, transmission, and distribution equipment.
- The connection of an *IBR* system shall not adversely impact the torsional oscillations (Sub-Synchronous Torsional Oscillations and Interactions (SSTI)).
- The stable operation shall be demonstrated through appropriate RMS (PSS®E) and electromagnetic-transients-type (PSCAD™) simulation tools.

7.6.11. Inertia Equivalent Response – Grid following IBR

An *IBR* Facility shall provide inertia response equivalent to a *synchronous condenser*, with rated MVA as specified in Table 8. The scaling factor for the *synchronous condenser* is dependent on *POI* voltage, given as a percentage of the rated MW of the associated *IBR*. Support can be from a device other than a *synchronous condenser* if equivalent SCMVA support can be demonstrated.

Table 8: Inertia Response Scaling factor

POI voltage	SIR scaling factor
69 kV	0.60
138 kV	0.60
230 kV	0.52
345 kV	0.48

Example: 100MW *WECS* with 138kV *POI* will require, at a minimum, a *synchronous condenser* with an MVA rating of at least 60 MVA.

Facilities adjacent to existing *IBR* facilities that do not have additional inertia support or in extremely weak areas of the grid may require greater inertial support. The *SIS* will determine the total inertial response required to meet performance requirements.

Additionally, *WECS* turbines shall support under frequency deviations with a power boost (virtual inertia response) for at least 10 seconds and, where headroom exists, shall offer over-frequency and under-frequency control with a deadband of +/- 0.2 Hz and a droop characteristic of 4%.

7.6.12. Inertia Equivalent Response - Grid Forming IBR

The grid forming *IBR* shall provide a performance comparable to a grid following *IBR* which meets all the requirements of this document. As grid forming technology is evolving, a grid forming facility will be evaluated during the *SIS* and any requirements for inertia equivalent support or fault contribution will be determined at that time.

If determined by the *SIS*, the grid forming *IBR* may be required to have a control mode which emulates inertia.

As grid forming technologies evolve and requirements are developed, they will be posted to the NS Power *OASIS*.

7.6.13. Anti-icing Mitigation Requirements - WECS

The *Interconnection Customer* shall provide icing models and conduct icing studies for their *WECS Generating Facility*. Icing detection and mitigation systems shall be installed at specified in the *System Impact Study* or *GIA*[23].

7.6.14. Low Ambient Temperature Requirements - Asynchronous

NS Power is a winter-peaking system; therefore, the *Asynchronous Generating Facility* shall be capable of operating at ambient temperatures as low as -30°C.

7.6.15. Operational Wind Data Requirements - WECS

Near real time wind speed measurement shall be provided to the NS Power *System Operator* by the *WECS Generating Facility* to represent wind speeds at the site. One or more data collection locations may be required at each site to provide a reasonable representation of the wind exposure.

All measuring equipment shall meet the technical requirements specified in CAN/CSA-C61400-12- 1-07 (R2012)[2].

7.6.16. High Speed Cut-Out - WECS

It is recognized that wind speeds in excess of safe limits require *WECS* generators to be protected against damage. However, the abrupt loss of generation through the use of high-speed cut-out schemes will adversely impact system reliability and shall be avoided. A high-speed control scheme responding to high wind conditions shall reduce and restore output of a *WECS Generating Facility* at a ramp rate no greater than 20 MW per minute. This requirement is limited to *WECS Generating Facilities* rated at 30 MW or greater.

7.7. Protection System Requirements

The *Generating Facility* shall be responsible to protect its facilities from disturbances and faults initiating in its facilities or on the *Transmission System*. The protection system shall be designed in accordance with *NPCC* and *NERC* Directories and Standards and meet *Good Utility Practice*.

All protection systems shall be coordinated with the existing transmission protection systems. Protection systems at the *Point of Interconnection* and any modifications to the existing transmission protection system required to coordinate with the *Generating Facility* shall be identified in the Facility *Study*. NS Power reserves the right to perform a full set of acceptance testing prior to interconnecting the *Generating Facility*.

The generator protection system shall not result in generator unit tripping within the steady state voltage and frequency ranges as specified in Section 7.4. The generator unit protection shall also be designed to avoid inadvertent tripping for frequency and voltage variations as defined in Sections 7.4.1 and 7.4.2.

BESS and Hybrid facilities shall meet protection requirements as a generator or load as applicable to its Interconnection agreement, operating conditions, and control mode.

7.8. Transmission Load Customers

The Transmission Load Customer shall be responsible for protecting the customer load facilities from all operating conditions and faults on the NS Power *Transmission System.* All protection design shall be accordance with current protection design standards and meet *Good Utility Practice*. All protection systems shall be coordinated with the existing transmission protection systems. NS Power reserves the right to review and accept protection design at the *Point of Interconnection* and perform a full set of acceptance testing prior to interconnecting the transmission load.

Transmission Load Customer's shall provide data as outlined in **Appendix A**.

NS Power reserves the right to require any customer loads to participate in the NS Power *UFLS* program.

7.9. Bulk Power System

All generation and customer load facilities interconnected to the *Bulk Power System* shall meet the additional protection requirements as specified in NPCC Directory 4, *Bulk Power System* Protection Criteria[14], be designed and operated as specified in NPCC Directory 1, Design and Operation of the *Bulk Power System*[12]*,* and comply with maintenance criteria requirements as defined in NPCC Directory 3, Maintenance Criteria for the *Bulk Power System*[13].

7.10. Transmission Tie Line Requirements

Transmission line designs shall meet or exceed the latest version of CSA Standard CAN/CSA-22.3 No. 60826 Design Criteria of Overhead Transmission Lines and CSC 22.3 No.1 Overhead Systems[3] and comply with NS Power's standards for overhead lines and structures.

Interconnection configurations shall comply with Section 8.0.

7.11. Control and Telecommunication Requirements

Control and telecommunication facilities will be required by the *Generating Facility* and/or Transmission Customer for the safe and efficient operation of the power system. NS Power owns and operates a variety of communication mediums and all interfaces require NS Power approval to ensure that all applicable standards are met including cyber security requirements. All communication protocols must be compatible with existing Supervisory Control and Data Acquisition (SCADA) equipment and any other existing monitoring systems.

Facility Studies associated with each transmission interconnected facility will define the communication, control, and tele-protection requirements.

8.0 SYSTEM RELIABILITY AND INTERCONNECTION FACILITY CONFIGURATION

8.1. Reliability Principles

All facilities involved in the generation, transmission, and use of electricity must be properly connected to the interconnected power systems to avoid degrading the reliability of the electric systems to which they are connected.

8.2. Adverse System Effects

The generation, BESS, transmission owners and electricity end-users must meet facility connection and performance requirements, as specified by the *System Operator* in order to avoid any *Adverse System Impacts*.

8.3. Point of Interconnection Requirements

Nova Scotia Power Tariffs[24] and Regulations require that all *Interconnection Customers* make all necessary arrangements to ensure that the interconnection does not unduly deteriorate the reliability and integrity of the power system. The *System Impact Study* will specify the technical requirements for each specific project.

Table 9 provides a guideline that will be applied for transmission interconnections. More stringent requirements may be necessary if specified in the *System Impact Study*.

Table 9: INTERCONNECTION CONFIGURATION REQUIREMENTS

Interconnection Point	**Required Tap Point Configuration**	
Connected to *Bulk Power System* Lines at 345kV, 230kV, or 138kV	Three breaker ring bus, with protection and fully compliant with *NPCC/NERC* criteria and standards	
Connected to non-*Bulk Power System* lines at 138kV or 69kV with existing generation or transfer limits/constraints	Three breaker ring bus with protection	
Connected to non-*Bulk Power System* network lines at 138kV or 69kV	If new line length is <10% of length of main line being tapped to a maximum length of 5km	Single breaker line tap with protection
	If new line length is ≥ 10% of main line being tapped	Three breaker ring bus with protection
Connected to non-*Bulk Power* System radial lines at 138kV or 69kV	If new line length is ≤2% of length of main line being tapped to a maximum length of 1km	Direct line tap with Transfer Trip protection (if generation)
	If new line length is >1km	Single breaker line tap with protection

9.0 OPERATION AND MAINTENANCE REQUIREMENTS

9.1. Operating Agreements

A *Standard Generator Interconnection Agreement (GIA)* [23] shall be executed between the Generation *Interconnection Customer* and the *Transmission Provider* to identify responsibilities, key contacts, desired operating characteristics, and other relevant operating considerations prior to the interconnected operation of the *Generating Facility*.

Nova Scotia Power reserves the right to require a similar form of operating agreement for all transmission interconnected load customers.

9.2. Maintenance Requirements

To ensure continued grid reliability and employee safety, the *Interconnection Customer* must maintain its equipment following industry practices, manufacturer requirements, existing standards and regulations, and as stipulated in the interconnection agreement. For *Generation Facilities* the *Interconnection Customer* has full responsibility for the maintenance and maintenance records of its equipment up to the *Point of Interconnection*.

9.3. Testing and Commissioning

NS Power reserves the right to inspect the *Interconnection Facility* prior to connection to the NS Power *Transmission System* to ensure the facility design and construction will not adversely affect the reliability of the *Transmission System*. All *Interconnection Facilities* are subject to NS Power's review and acceptance of all testing and commissioning requirements and results.

Construction, switching, testing, and commissioning schedules that affect the reliable and stable operation of the *Transmission System* shall be coordinated with the NS Power *System Operator*.

9.4. Control and Communication Requirements

Requirements for real time control, communication, and tele-protection will be defined in the *Facility Study*.

9.5. Production and Maintenance Outage Schedules

Generator production scheduling and maintenance outage scheduling shall be conducted in accordance with Nova Scotia Wholesale Electricity Market Rules[25] MP-11 and MP-9 respectively.

10.0 METERING REQUIREMENTS

10.1. Revenue Metering

Power flows to and from the *Interconnecting Customer Facility* shall be measured at, or at NS Power's option, compensated to, the *Point of Interconnection* to ensure that all required billing quantities are recorded as necessary for application of NS Powers' Tariffs[24] or power purchase agreements. Unless otherwise agreed by the Parties, NS Power will install metering equipment at the *Point of Interconnection* prior to any operation of the *Interconnecting Customer Facility* and shall own, operate, test, and maintain such Metering Equipment.

The *Interconnection Customer* shall be responsible for all costs associated with the purchase, installation, operation, testing and maintenance of the metering equipment.

All metering equipment shall comply with Measurement Canada regulations and NS Power Metering Standards[21].

All revenue metering equipment installations shall at all times meet the requirements of *Good Utility Practice* and all Applicable Laws and Regulations.

10.2. Meter Reading and Accessibility

All metering installations and data shall be both remotely and physically accessible to NS Power.

11.0 RESPONSIBILITY FOR COST

The *Interconnection Customer* is responsible for all capital, operating and maintenance costs of all equipment on the generator or load side of the *Point of Interconnection*.

Where upgrades and/or revisions are required to existing NS Power systems to accommodate the generation or customer load addition, the *Interconnection Customer* shall pay the actual cost of the installation/changes.

All operating and maintenance costs associated with the communication systems necessary for the ongoing control and monitoring of the Interconnection Facility shall be the responsibility of the *Interconnection Customer*.

The *Interconnection Customer* shall pay a capital contribution for any new line extensions necessary to extend the NS Power *Transmission System* to the Facility. If this line is dedicated to serve the Generation or Transmission Customer Facility, all maintenance, repair, and replacement costs are the responsibility of the *Interconnection Customer*. NS Power will perform and manage the maintenance of these facilities.

Costs associated with all generation interconnection studies will follow the cost allocation requirements as defined in the *GIP*[22]. Allocation of costs associated with all interconnection studies for transmission loads will be reviewed and determined at the time of the *Interconnection Request*.

For *Generation Facilities*, refunds for amounts advanced for *Network Upgrades* shall be administered as per section 11.4 of the *GIA*. For *Load (End-User) Facilities*, refunds for capital contributions shall be administered as per applicable line rebate regulations.

12.0 REFERENCES

[1] CSA Std S16.19 – Design of Steel Structures
[2] CSA C61400-12-1-07 ((R2012) – Wind Turbines-Part 12-1 Power Performance Measurements of Electricity Producing Wind Turbines
[3] CSA Standard CAN/CSA-22.3 No. 60826 Design Criteria of Overhead Transmission Lines and CSA 22.3 No.1 Overhead Systems

[4] Canadian Electrical Code Parts I, II, & III C22.1-02

[5] Province of Nova Scotia Electrical Installation and Inspection Act

[6] IEEE C57.116 – Guide for Transformers Directly Connected to Generators
[7] IEEE C37.118 – Synchrophasors for Power Systems
[8] IEEE Std 125 – Speed Governing for Hydraulic Turbines
[9] IEEE Std 122 - Speed Governing for Steam Turbines
[10] IEEE Std 421.1 – Excitation Systems for Synchronous Machines
[11] IEEE Std 421.4 – Guide for Excitation System Specifications

[12] NPCC Directory 1 – Design and Operation of the Bulk Power System
[13] NPCC Directory 3 – Maintenance Criteria for Bulk Power System Protection
[14] NPCC Directory 4 – Bulk Power System Protection Criteria
[15] Removed
[16] NPCC Directory 12 – Underfrequency Load Shedding Program Requirements

[17] NERC PRC-019-2 – Coordination of Generating Unit or Plant Capabilities, Voltage Regulating Controls, and Protection
[18] NERC PRC-024-3 – Generator Frequency and Voltage Protective Relay Settings
[19] NERC PRC-025-2 – Generator Relay Loadability

[20] Nova Scotia Power Inc Standard Protection Code – latest version
[21] Nova Scotia Power Inc Metering Standards – latest version
[22] Nova Scotia Power Inc Standard Generator Interconnection Procedures (GIP)
[23] Nova Scotia Power Inc Standard Generator Interconnection and Operating Agreement (GIA)
[24] Nova Scotia Power Inc Open Access Transmission Tariff

[25] Nova Scotia Wholesale Electricity Market Rules

[26] IEEE Std 142-2007 Recommended Practice for Grounding
[27] IEEE Std 519-2014 Recommended Practice and Requirements for Harmonic Control
[28] IEEE Std 1100-1999 Powering and Grounding Sensitive Electronic Equipment
[29] IEEE Std 1159-1995 Recommended Practice on Monitoring Electrical Power Quality

[30] ANSI C84.1-2016 Electric Power Systems and Equipment – Voltage ratings (60Hz)

[31] IEC 61000-3-6 Electromagnetic Compatibility (EMC) Limits Part 3-6
[32] IEC 61000-3-7 Electromagnetic Compatibility (EMC) Limits Part 3-7
[33] IEC 61400-21 Wind Turbines – Measurement and Assessment of Power Quality

APPENDIX A

Technical Information Required from the Load, Generation, or BESS Facility

The following outlines the data that is required by NS Power to study the interconnection request. The *Interconnection Customer* is responsible for the accuracy and validity of the information provided.

NS Power is a member of NPCC and may be required to share information with counterpart members to adequately assess the overall impacts of the interconnection request.

The *Interconnection Customer* shall supply the minimum following information, as applicable to the facility:

1.0 General:

- Name, address, phone number, and e-mail address of the Applicant
- Contact information for technical information (consultant, project engineer, etc.)
- Expected in-service date
- Physical location, land details, site plan or area map of proposed connection to NS Power *Transmission System*
- Type of Interconnection (Generation, BESS, Load or Hybrid)
- Models of the facility as per TPR-015
- General description of connection (new load, expansion of existing facility, new generation)
- Installed Capacity and anticipated capacity factor
- Electrical one-line diagram of facility
- Number of *generating units*
- Schedule and Commissioning Date
- Projected Annual Generation Profile

2.0 Electrical One-Line

- Generator equipment ratings, configurations, transformations, isolating devices, etc.
- Station Service connections and ratings
- Preliminary protection and control schematic
- Collector circuit configuration for multiple *generating units*

3.0 Generator Data

- *Synchronous Generators*
    - Type
    - Rated Capacity, Power Factor, and Voltage
    - Excitation curves
    - Saturation and synchronous impedance curves
    - Number of similar generators
    - Machine Parameters
        - Inertia Constant, H
        - Armature resistance, pu
        - Direct axis unsaturated synchronous reactance, pu
        - Direct axis unsaturated transient reactance, pu
        - Quadrature axis saturated and unsaturated transient reactance, pu

- Direct axis saturated and unsaturated sub-transient reactance, pu
- Stator leakage reactance, pu
- Negative-sequence reactance, pu
- Zero-sequence reactance, pu
- Zero-sequence unit grounding reactance, pu
- Zero-sequence unit grounding resistance, pu
- Direct axis transient open circuit time constant, seconds
- Quadrature axis transient open circuit time constant, seconds
- Direct axis sub-transient open circuit time constant, seconds
- Quadrature axis sub-transient open circuit time constant, seconds
- Saturation factor at rated terminal voltage, A/A
- Saturation factor at 1.2 per unit of rated terminal voltage, A/A

- *Asynchronous Generators* and BESS
  - Type (induction, full-rated converter, double-fed induction)
  - Rated Capacity and Voltage
  - Power Factor at 100%, 75%, and 50% of rated capacity
  - Operating Modes
  - AC/DC Converter devices
    - Number of converters
    - Nominal AC voltage, kV
    - Capability to supply or absorb reactive power, kvar
    - Converter manufacturer, model name, number, version
    - Rated/Limitation on fault current contribution, kA
    - Minimum short circuit ratio
  - Generator Parameters (induction type)
    - Number of Poles
    - Stator Resistance and Leakage Reactance
    - Rotor Resistance and Leakage Reactance
    - Magnetizing Reactance
    - Locked Rotor Reactance
    - Open Circuit Reactance
    - Time Constant
    - Inertia Constant
    - Torque Slip Curve
    - Slip at Rated Capacity
    - Rated terminal voltage, kV line-to-line
    - Rated armature current kA
    - Power factor at rated load
    - Efficiency at rated load
    - Slip at full load

- Excitation System Modelling Information
  - Type (static, brushless, rotating)
  - Full bridge or half bridge rectification
  - Maximum/Minimum DC current
  - Maximum/Minimum DC voltage
  - Nameplate information

  - Block diagram
  - Power System Stabilizer (PSS) type and characteristics

- Turbine and Speed governor information with detailed modeling information for each type of turbine.
  - Turbine type
  - Total capability, MW (available peak operation rating)
  - Number of stages
  - Manufacturer and model
  - Frequency vs. time operational limits
  - Maximum turbine ramping rates, MW/minute, ramp up and ramp down
  - Minimum stable operation, MW
  - PSS/E model that NS Power can use with its dynamic simulation studies

- Wind Turbines
  - Detailed models of the wind power plant as well as any relevant generator and converter parameters that NS Power can use with its dynamic simulation studies

- Solar / Batteries
  - Detailed models of the converter parameters that NS Power can use with its dynamic simulation studies

4.0 Load Data

- Size of load (rated electrical power)
- Rated voltage, rated power factor
- Load pattern (e.g. cyclic, seasonal, ramping, oscillatory)
- Motor starting characteristics (motors over 500 hp)
- Type of load (e.g. *IBR*, DC motor, electrolytic, variable speed drive, hybrid)
- Anticipated load profiles (daily, monthly, annually)

5.0 Transformer Data

- Power Ratings and Voltages
- Positive and zero sequence impedances
- Winding resistance
- Winding configuration
- Tap changer configuration, number of taps and regulation range
- Excitation current (0.8 to 1.15 pu)

6.0 Transmission Tie Line (when applicable)

- Rating (MVA) at 5°C and 25°C Ambient
- Type of Construction (single/double circuit, wood/steel, etc.)
- Phase spacing
- Positive and zero sequence impedances, per unit on 100 MVA
- Conductor size and type, conductor temperature at maximum sag

Additional information may be requested at any time during the review.