Interconnection Guideline

Customer Generation Capacity Not Exceeding 100 kW

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VERSION HISTORY

DATE	REV.	DESCRIPTION
Apr. 27, 2018	1.8	Added Appendix B – Advanced Inverter Requirements
Nov. 27, 2019	1.9	Removed Advanced Inverter Requirements exemption for <10 kW inverter based generators

CONTENTS

1. Purpose

This document establishes the minimum requirements for safe and effective operation of small-scale (i.e. not exceeding 100 kW) generation facilities interconnected with the Nova Scotia Power Inc. (NS Power) Distribution System. This guide describes NS Power's interconnection requirements, as well as the minimum design standards the Customer- generator must satisfy, and a range of normal and emergency system conditions the generating facility could encounter while connected to the Distribution System.

Customer-generators should discuss project plans with NS Power before purchasing or installing equipment, as requirements will vary depending on capacity, type, location and the existing NS Power facilities in place.

Implementing the requirements of this guideline will help ensure that the Customer- generator's equipment does not operate in a manner that would compromise the safe operation, reliability or power quality of the Distribution System. The Customer- generator is required to install, operate and maintain its generating and interconnection facilities in accordance with manufacturer's recommendations to ensure good working order and fitness for service at all times.

This guideline is based on the following assumptions and principles:

(a) The addition of the Customer-generator's equipment to the Distribution System will not appreciably change the Distribution System and its characteristics.

(b) The installation meets the installation requirements of the Canadian Electrical Code (CE Code) Part 1 and the equipment is certified to the relevant CE Code Part 2 product standard. Other local and provincial construction and installation regulations may apply.

(c) The safety of NS Power personnel, the public and equipment is of primary concern in the design of the interconnection systems.

1.1. Interconnecting Generation to the Distribution System.

A Customer-generator may be permitted to operate 60 Hertz, three phase generators up to 100 kW or single phase generators up to 30 kW, in parallel with the Distribution System, provided the Customer-generator and their facilities meet or exceed the requirements of these interconnection guidelines and supporting interconnection agreements and documents.

The Customer-generator is required to install, operate and maintain its facilities in good order and repair at all times (in conformity with good electrical practice) to ensure safe and reliable parallel operation with the Distribution System. In all cases, agreement to and execution of the "Class 1 Interconnection Agreement"[1] between the Customer-generator and NS Power is required before the Generating Facility can be interconnected to the Distribution System.

1.2. Limitations

The criteria and requirements of this document are applicable to all generation technologies, with aggregate capacity up to 100 kW (three phase generators) and 30 kW (single-phase generators) which are interconnected to the Distribution System. Based on this size limitation, it is anticipated that the generation systems will be interconnected with radial Distribution Systems at typical primary voltages (rated less than 26,400 V phase to phase) or secondary voltages (less than 750 volts phase to phase).

For generators with capacity greater than 100 kW refer to the document "Nova Scotia Power – Interconnection Guideline (Applicable to Generating Facilities > 100 kW - Connected to Distribution Systems Rated ≤ 26,400 V)"

The requirements of this document do not apply to emergency back-up generators utilizing automatic or manual transfer schemes in which load is transferred between a generator and the Distribution System in a momentary "break-before-make" operation.

The requirements in this guideline are not intended to provide protection of the Customer-generator's facilities. The Customer-generator is fully responsible for protecting their facilities in such a manner that faults or other disturbances on the NS Power system do not cause damage to their equipment, and NS Power shall not be liable for any such fault, damage or disturbance.

This document is not intended or provided as a design specification or as an instruction manual for the Customer-generator or their agents. Persons using information included in the document do so at their own risk and at no risk to NS Power, and they rely solely upon themselves to ensure that their use of all or part of this document is appropriate in the particular circumstances.

The Customer-generator or their agents recognize that they are, at all times, solely responsible for the Customer-generator's facilities design, construction, and operation. NS Power, its servants or agents shall not be or become an agent of the Customer-generator in any manner howsoever arising.

The advice of NS Power, its servants or agents, that the Customer-generator facilities design or equipment meets certain limited requirements of NS Power does not mean, expressly or by implication, that all or any of the requirements of the law or other Good Utility Practices have been met by the Customer-generator in their facilities.

The use of this document does not supersede or exclude any requirements for interconnection described by the document "Nova Scotia Power Rates, Regulations and Procedures", or orders of the Nova Scotia Utility and Review Board.

Agreement to and execution of the "Class 1 Interconnection Agreement" between the Customer-generator and NS Power is required before the Generating Facility can be interconnected to the Distribution System

All technical requirements mandated by the latest revisions of this document, system assessments or studies, or any associated documents must be complied with. NS Power reserves the right to amend any of these requirements at any time.

2. Definitions

Advanced Inverter: A Generating Facility's Inverter that performs functions that, when activated, can autonomously contribute to grid support during excursions from normal system operating voltage and frequency conditions by providing: dynamic reactive/real power support, voltage and frequency ride though, ramp rate controls, and other functions.

Applicable Laws and Regulations: All duly promulgated applicable federal, provincial and local laws, regulations, rules, ordinances, codes, decrees, judgments, directives, or judicial or administrative orders, permits and other duly authorized actions of any Governmental Authority.

Cease to Energize: In response to an abnormal excursion, the inverter-based Generating Facility shall, without intentional delay, cease to provide real and reactive current. Note: Cease to Energize does not necessitate physical isolation or a trip of the Generating Facility.

Class 1 Interconnection Agreement: A document which defines the responsibilities of the Customer-generator and NS Power identifies key contacts, electrical characteristics of the Customer-generator's equipment and requirements for the safe and orderly operation and of the Customer-generator's facilities with the Distribution System.

CSA: Canadian Standards Association, an accredited standards development organization within Canada.

Customer-generator: The owner/operator of the interconnected Generating Facility.

Distribution System: NS Power's facilities nominally rated at 26,400 V or less, which are used to distribute electric power between substations and customer loads.

Generating Facility: The Customer-generator's electricity production device to be interconnected with the Distribution System.

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 reliability, safety, environmental protection, economy and expedition as applied and practiced in the utility industry with respect to power generation, delivery, purchase and sale.

Hertz (Hz): A measure of the number of times or cycles that a periodic signal repeats in a second, also denoted as cycles per second.

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

Interconnection: The addition of a Generating Facility to the Distribution System.

Inverter: An electronic device that converts direct current (DC) to alternating current (AC).The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by a DC source, such as photovoltaic panels.

Islanding: A condition in which a portion of the Distribution System is energized solely by a Generating Facility.

Isolation: Physically disconnected or separated from all sources of dynamic energy by approved devices or procedures.

Metering Equipment: All metering equipment installed or to be installed at the Generating Facility pursuant to the Class 1 Interconnection Agreement at the metering points, including but not limited to instrument transformers, MWh-meters, data acquisition equipment, transducers, remote terminal unit, communications equipment, phone lines, cellular modems and fiber optics.

Parallel (-ed, -ing): A condition in which the Customer-generator's Generating Facility is connected a point common with the Distribution System, with the intent to transfer power between the two systems.

Point of Interconnection: The point where the interconnection facilities are connected to The Distribution System.

Stabilized: A condition where the Distribution System has returned to normal voltage (110% ≥ Voltage ≥ 88%) and frequency (60.7 Hz ≥ f ≥ 59 Hz) for 5 minutes or an alternate time determined by NS Power, following a system disturbance which has resulted in a disconnection of the Generating Facility.

Standard Protection Code: NS Power's set of safe work practices for work on the Distribution System designed to ensure the safety of workers and security of the Distribution System.

3. Getting Connected – The Interconnection Process

The first step in getting connected is to have the project assessed. This is initiated by completing and submitting the applicable "Interconnection Request and Equipment Information Form"[2].

The basic steps in the process are as follows:

- The NS Power Coordinator will acknowledge receipt of the Interconnection Request and will then initiate a review of the Interconnection Request and NS Power's field conditions (e.g.. is the transformer large enough, is there three phase at site, does the metering have to be changed, etc.) This review will identify any new NS Power equipment or upgrades to the existing Distribution System that are required to enable the connection of the generator. This review takes into account the size, type, ratings and location of the proposed generation equipment.
- NS Power will develop specific interconnection requirements and cost estimates for required system additions/upgrades (If required), including changes to the NS Power revenue Metering Equipment.
- The cost estimates for the required system additions or changes will be provided to the Customer-generator for review.
- Once the Customer-generator accepts the requirements and pays the identified costs, the required construction work can be scheduled to commence.
- The "Class 1 Interconnection Agreement" between the Customer-generator and NS Power is executed.
- As part of the electrical and generating equipment installation, the Customer-generator's electrician must obtain a Wiring Permit and arrange to have all required electrical inspections performed and passed.
- After the wiring inspections are performed and passed, and the Interconnection Agreement is signed, NS Power will advise the Customer-generator that interconnection of the generator with the NS Power system can proceed.
- At this stage, NS Power may require and/or witness the commissioning and testing of the generation equipment.

Final reconciliation of NS Power's costs will determine the actual costs (or refunds) to be paid by (to) the Customer-generator.

The Customer-generator Generating Facility is now operational.

4. Safety Requirements

4.1. NS Power Safety Requirements - Standard Protection Code[3]

Safe work procedures described in NS Power's Standard Protection Code will be followed by NS Power in providing isolation for work on any part of the interconnected Distribution System, including providing Isolation.

4.2. Electrical Inspection Act[4] *and the Canadian Electrical Code Parts I& II*[5]

The Customer-generator's installation must meet all applicable national, provincial and municipal electrical construction and safety codes, including, without limitation, the Electrical Installation and Inspection Act and Code Regulations. Except as expressly permitted by law, all electrical equipment must be approved by a recognized certification agency e.g. CSA, or equivalent.

Information Bulletins regarding NS Power Electrical Permits (B-B1-002), and Customer Owned High Voltage Equipment (B-36-000), along with other bulletins can be found at: www.nspower.ca under "For My Home" and "For Your Business", "Electrical Inspections".

4.3. Permission to Operate

Under no circumstances shall the Customer-generator begin interconnected operation of the generator until final written approval in the form of a signed "Class 1 Interconnection Agreement" has been given by NS Power.

4.4. Islanded Operation

Under no circumstances shall a Generating Facility be permitted to operate in an islanded condition (i.e., the portion of distribution line to which the generator is connected becomes isolated from the Distribution System).

5. Interconnected Systems – Characteristics and Requirements

An interconnected system is defined as one in which the Customer-generator's generation is connected at a point common with the Distribution System, resulting in a transfer of power between the two systems. As a result of this interconnection, the generator system becomes an integral part of the Distribution System and must be considered in the electrical protection and operation of the Distribution System.

Section 5.1 lists the typical Distribution System operating and power quality conditions within which the Customer-generator's equipment must operate. It lists representative values of parameters that the Distribution System normally maintains and some abnormal conditions that the Generating Facility needs to be designed to withstand. It is the Customer- generator's responsibility to ensure that the Generating Facility operates correctly in this environment.

Sections 5 & 6 list typical conditions and responses to abnormal conditions that the Customer-generator's system must meet as well as the interconnection protective function requirements.

5.1. NS Power Distribution System

5.1.1. Distribution System Configuration

NS Power's primary Distribution System is a 3-phase, 4-wire multi-grounded common neutral system ("effectively grounded-wye") operated at three typical voltage levels:

- 4,160 Volts line to line; 2,400 Volts line to ground (4 kV)
- 12,470 Volts line to line; 7,200 Volts line to ground (12 kV)
- 24,940 Volts line to line; 14,400 Volts line to ground (25 kV)

Distribution transformers, which step the primary voltage down to utilization voltages, are mainly single-phase units with primaries connected phase to ground. Three phase distribution transformers are normally configured grounded wye - grounded wye. This generally provides a single intentional ground path for short-circuit currents (one zero-sequence path) and has been utilized in the design of short-circuit protection applied to distribution feeder systems. NS Power's standard secondary voltages are:

- 120/240 Volts 1-Phase
- 120/208 Volts Solidly Grounded Wye 3-Phase,
- 4-Wire 347/600 Volts Solidly Grounded Wye 3-Phase, 4-Wire

5.1.2. System Grounding

Distribution Systems are typically three-phase 4-wire multi-grounded systems incorporating single-phase distribution taps. They are typically operated as effectively (solidly) grounded.

Following the addition of any Generating Facility, the Distribution System must remain effectively grounded at all locations, in all sustained, temporary, and transient conditions.

5.1.3. Phasing

Phasing is not standardized across Distribution Systems. For three phase generation, the phase sequence and the direction of rotation must be coordinated with the Distribution System.

5.1.4. System Frequency

The power system in Nova Scotia is connected to the North American grid. As a result of this tie, the Nova Scotia system has tight frequency control which rarely varies more than 0.2 Hz from its 60 Hz nominal value.

5.1.5. System Voltage

NS Power's Regulation 2.7[6] provides general guidance as to appropriate Distribution System steady state service voltage levels, in accordance with "CSA CAN-3-C235-1983 (R2015) Preferred Voltage Levels for AC Systems, 0 to 50,000 Volts, Electric Power Transmission and Distribution"[7].

5.1.6. Voltage and Current Distortion

NS Power has adopted Standard IEEE-519-2014 IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems[8] which establishes harmonic distortion limits for the Distribution System. It provides the harmonic voltage distortion levels that can be expected on Distribution Systems and the current distortion limits that the Generating Facility must operate within.

5.1.7. Voltage Flicker, Dips and Unbalance

NS Power has established guidelines for the power system regarding voltage dips and voltage flicker. These are provided in Section 6.10.

The voltage unbalance on the Distribution System under normal operating conditions is typically under 3% but may reach 5% due to the unbalanced loading and single-phase voltage regulation. Voltage unbalance is calculated using RMS voltage levels measured phase to phase at the Point of Interconnection under no load conditions:

Voltage unbalance (%) = 100 x [(max. deviation from average) / (average)]

The addition of any Generating Facility should not increase the voltage unbalance to more than 3% at any point on the Distribution System. If the generator is unable to tolerate this inherent voltage unbalance, the Customer-generator may request that NS Power make system modifications to lower voltage unbalance (to the extent that is achievable by NS Power) at the Customer-generator's expense.

5.1.8. Fault Levels, Fault Clearing and Restoration

NS Power's power lines are subject to a variety of natural and man-made hazards. The resulting electric problems are principally short circuits, grounded conductors, and broken conductors. These fault conditions require that the damaged equipment be de-energized as soon as possible because of the potential hazards they pose to the public and the operation of the Distribution System.

Short-circuits on distribution feeders are detected and cleared by the operation of protective devices such as reclosers and circuit breakers. These protective devices detect and interrupt the fault current and then reclose the circuit to restore service. If the short circuit remains (permanent fault) then the protective device again interrupts the circuit and again recloses. Reclosing is a common utility practice. This cycle may be repeated multiple times before the protective device opens and must be manually reclosed.

Short-circuit clearing times (fault initiation to interruption) typical of The Distribution Systems are less than 1.0 second, although in some instances clearing times can be longer.

Single phase "Type T" cutout fuses are also utilized on the distribution system to operate under downline fault conditions.

The maximum design fault level of the 12.5 kV system is 9000 A. The maximum design fault level of the 25 kV system is 8000 A. Actual fault levels will vary from substation to substation and will decrease with distance from the substation

Fault levels on down-stream distribution circuits will vary depending on circuit characteristics and configuration. NS Power will provide information on available fault levels at a given site upon request by the Customer-generator.

5.2. Generator Types

5.2.1. Synchronous Generators

Synchronous generators are generally capable of contributing current for faults occurring on the Distribution System. Synchronous generators require synchronizing equipment to ensure proper synchronizing of the Customer-generator's equipment to the Distribution System.

NS Power utilizes automatic reclosing as part of its Distribution System protection scheme. This reclosing function must be taken into account in the design of a synchronous Generating Facility's

protection scheme to avoid damage to the generator due to high torques that could result during non-synchronous paralleling.

Following the disconnection of the generator from the NS Power system due to a protection operation, sufficient time must be allowed to ensure the NS Power system has Stabilized.

5.2.2. Power Electronic Converter (Inverter) Systems

Inverters convert direct current (dc) power to alternating current (ac) power by means of electronic switching devices. Switching can be controlled by the ac voltage waveform of the NS Power's supply system (grid-dependent) or by internal electronic circuitry (grid-independent). Inverters are generally not capable of supplying sustained fault current. Grid-independent inverters are capable of supplying load current independently of the NS Power supply system.

Advanced (Smart) Inverters have the capability to provide a range of grid-support functions. All inverter-based Generating Facilities having a valid interconnection request on or after the effective date of this document shall comply with the Advanced Inverter Requirements set forth in Appendix B of this document.

5.2.3. Induction Generators

Induction generators are basically induction motors that are mechanically driven above synchronous speed to produce electric power. Reactive power supply for induction generators may pose design problems, depending on the generator size. Special considerations for induction generators are:

- Capacitors may be necessary to limit the adverse effects of reactive power flow on NS Power's system voltage regulation.
- Self-excitation of the induction generator due to installed capacitors can produce abnormal high magnitude, distorted voltages.
- Voltage flicker resulting from induction generators starting, particularly on remote portions of the Distribution Systems may be unacceptable to NS Power.

6. Generating Facilities - Requirements for Interconnection

This section addresses the technical requirements for the interconnection of generation with the Distribution System.

In general, the Generating Facility shall be equipped with protective functions or devices designed to:

a) Prevent isolated operation of the generator (islanding) with any part of the NSPI Distribution System upon loss of the supply to the Distribution System (Anti-Islanding);

b) Prevent connection or parallel operation of the Generating Facility with the Distribution System unless the voltage and frequency are of normal magnitude and;

c) Interrupt the maximum available fault current at the point of connection with the Distribution System and promptly cease to energize the Distribution System for over-current fault conditions.

In addition to the requirements of Section 6, all Inverter-based Generating Facilities with a valid interconnection request on or after the effective date of this document shall also comply with the Advanced Inverter Requirements set forth in Appendix B of this document.

6.1. Adverse Effects on Other Customers

The Generating Facility must not adversely affect the Distribution System or service to any other connected customers or facilities.

To limit the potential for adverse effects on other customers, NS Power requires that Generating Facilities with capacity greater than 10 kW interconnect with the Distribution System via dedicated step-up transformer(s).

6.2. Isolation – Disconnect Switch

A manual disconnecting device for isolation purposes must be provided. The form of this switch will vary with the service voltage and capacity but in all cases must be:

- accessible to NS Power,
- capable of providing a visible break, breaking load, opening all phases simultaneously (Gang-operated), and
- being locked in the open position.

The location and form of the device is subject to approval by NS Power. This isolating device is owned by the Customer-generator and is therefore subject to the requirements of the Canadian Electrical Code.

Additional disconnection devices may be required for Generating Facilities with more than one generator.

6.3. Grounding Requirements

The Customer-generator's equipment must be grounded as per manufacturer's recommendations, the Canadian Electrical Code Part I, and in accordance with the normal practices of NS Power.

Following the addition of any Generating Facility to the Distribution System, the system must remain effectively grounded at all locations, in all sustained, temporary, and transient conditions. Operating temporarily ungrounded at any time is unacceptable.

Interconnection of three phase transformers and transformer grounding systems on three phase Distribution Systems shall be coordinated with NS Power and shall not cause voltage disturbances nor disrupt coordination of The Distribution System ground fault protection. The interconnection transformer configuration and the grounding methods chosen by the Customer-generator are subject to review and acceptance by NS Power.

6.4. Synchronizing

Generating systems that can generate an ac voltage waveform independent of the Distribution System shall be connected in parallel with NS Power only in combination with synchronizing capabilities. The generator shall synchronize to the Distribution System while meeting the flicker requirements of Section 6.10 and without causing voltage variation at the Point of Interconnection of greater than 5%. The generating system may synchronize to the Distribution System only if the Distribution System is Stabilized.

6.5. Voltage Regulation and Power Factor Control

The Customer-generator's equipment shall not cause the voltage level of the Distribution System to be sustained outside the limits of CSA CAN3-C235-83, Normal Operating Conditions Range[7] (Table in NS Power Regulation 2.7[6]), measured at the Point of Interconnection.

The generator is not required to be capable of adjusting the power factor, but each generating unit shall be capable of operating within a range of 0.95 power factor lag to 0.95 power factor lead.

Refer to Appendix B for additional voltage regulation and power factor control requirements specific to the interconnection of smart/advanced inverter-based generation.

6.6. Response to Abnormal Frequencies

Every Generating Facility requires under/over frequency protection to detect abnormal frequencies and to disconnect the generator from the system.

When a system frequency is in a range given in Table 1 below, the Customer-generator's equipment shall automatically cease to energize the Distribution System. Adjustable under-frequency settings shall be coordinated with the Distribution System representative.

Table 1: Response to Abnormal Frequencies

Utility Voltage Condition	*Frequency Condition*	*Maximum number of Seconds to disconnect**
Normal Voltage	>60.7	0.16
Normal Voltage	<59	0.16

Note: Refer to Appendix B for frequency protection and frequency ride-through requirements applicable to the interconnection of an Inverter-based Generating Facility.

6.7. Response to Abnormal Voltage Levels

Every Generating Facility requires under/over voltage protection to detect abnormal voltages and to disconnect the generator from the system.

Three-phase generator systems shall automatically cease to energize when any individual phase-to-neutral voltage on a grounded-wye system or any individual phase-to-phase voltage on an ungrounded-wye or delta system goes outside the range of Table 2. Single-phase inverter systems shall detect the phase-to-neutral voltage if connected to neutral. Single-phase equipment connected line-to-line but not to the neutral conductor shall detect the line-to-line voltage.

When any voltage is in an abnormal range of Table 2 below, the Customer-generator's equipment shall cease to energize the Distribution System in the timeframes listed.

Note: Refer to Appendix B for voltage protection and voltage ride-through requirements applicable to Inverter-based Generating Facilities.

Table 2 -Response to Abnormal Voltages - Default Settings

Voltage Range	*Maximum Clearing Time**	
% Of Base Voltage	**Default Setting (seconds)**	**Adjustable up to and including (seconds)**
V < 45%	0.16	0.16
45% ≤ V < 60%	1	11
60% ≤ V < 88%	2	21
88% ≦ V ≦ 110%	**Normal Operation**	
110% < V < 120%	1	13
V ≧ 120%	0.16	0.16

From IEEE P1547a[8]

6.8. Islanding

Islanding is not permitted, i.e. a Generating Facility shall not energize the Distribution System when the Distribution System is not being energized from the NS Power source. The Generating Facility shall not remain energized after the portion of the Distribution System to which it is connected has become electrically separated from the rest of the Distribution System.

The Customer-generator's equipment shall be equipped with an approved non-islanding protection function design to prevent the generator from being connected to a circuit that is not energized by the utility supply. Within 2 seconds of island formation, the islanding condition must be detected and the Generating Facility must cease to energize the Distribution System.

All inverters shall be "non-islanding type" as defined by CSA C22.2 No. 107.1-01 Standard[9].

6.9. Thermal Limits

Thermal limits of NS Power equipment shall not be exceeded as the result of the addition of the Generating Facility.

6.10. Flicker

The Customer-generator's facility shall not create objectionable flicker for other customers served from the Distribution System. It is recognized that flicker is a site dependent condition.

The Customer-generator is to ensure that the operation of the Generating Facility does not cause voltage variations on the Distribution System that result in objectionable lamp flicker to other connected customers.

The voltage variations will be measured at the Point of Interconnection (POI). These variations can be caused by the start-up and shut-down sequences of the generator (capacitor switching, inrush, resister by-pass etc.), referred to as "voltage dips", or may be caused by the quasi-continuous variation of the prime mover (typically wind) which is referred to as "flicker".

The acceptable limits of flicker emissions from any generation facility on The Distribution System, measured at the designated Point of interconnection in accordance with the IEC Standard IEC 61000-4-15 Ed. 1.1 b:2003[10] are:

Pst99% ≤ 0.35
Plt99% ≤ 0.35

In computing the flicker emission levels, only periods in which the Generating Facility is in operation shall be included. These limits apply to all consecutive periods.

6.11. Voltage and Current Distortion

The harmonic current injection from the Generating facility to the Distribution System measured at the Point of Interconnection shall not cause the limits established by IEEE 519-2014[6] to be exceeded.

The Generating Facility must be tolerant of harmonic voltage distortion levels that are indicated in IEEE 519-2014[6] for Distribution Systems. These distortion levels may be present in the absence of any harmonics generated by the Interconnecting Customer's facility

6.12. Over-current Protection

The Customer-generator's interconnection equipment must detect and promptly cease to energize for over-current fault conditions.

6.13. Protection of Equipment & Fault Detection

The proper detection and isolation of all types of faults whether they occur on the Distribution System, or within the Customer-generator's facilities, are essential ensure safe operation and limit damage to equipment. The Customer-generator must ensure that their protection devices detect abnormal system conditions and isolate their facilities from the Distribution System. The Generating Facility shall be equipped with the protection set out in Table 3: Protection Requirements Summary.

6.14. Protection Requirements Summary

Table 3: Protection Requirements Summary

Guide Section	Device Category	Up to 10 kW	Greater than 10 kW up to 100 kW
6.1	**Dedicated Transformer**	NO	YES
6.2	**Interconnection Disconnect Device (Lockable, Accessible, Visible, Gang Operated)**	YES	YES
6.4	**Synchronizing/Synch Check**	YES	YES
6.6	**Over/Under Frequency Trip**	YES*	YES*
6.7	**Over/Under Voltage Trip**	YES*	YES*
6.8	**Anti-Islanding**	YES	YES
6.9	**Overcurrent Trip/Shutdown**	YES	YES

*See Appendix B for protection and advanced inverter functional requirements applicable to the interconnection of Inverter-based Generating Facility.

6.15. Automatic Start/Restart of Generation Facilities

The Customer-generator may reconnect only when the utility Distribution System voltage and frequency return to normal range (Table 2 & 3) and has Stabilized for a period of at least five (5) minutes.

7. Metering

Revenue-class Metering Equipment will be supplied, installed and maintained in accordance with Section 4.1 of the Class 1 Interconnection Agreement.

Power flows to and from the Generating 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 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 Generating Facility and shall own, operate, test and maintain such Metering Equipment.

The Customer-generator shall be responsible for all costs associated with the purchase, installation, operation, testing and maintenance of the Metering Equipment.

All revenue Metering Equipment installations shall at all times meet the requirements of Good Utility Practice and all Applicable Laws and Regulations.

7.1. Customer-generator Requirements

The Customer-generator must provide and install at Customer-generator's expense, and in accordance with NS Power Metering Standards[11], meter sockets and metering cabinets in a suitable location to permit access to Metering Equipment by NS Power.

8. Operating Requirements

8.1. General Operating Requirements

NS Power may require operational control over interconnection equipment, as necessary, to ensure safety, reliability or serviceability of the Distribution System.

8.2. Interconnection Agreement

Prior to the interconnected operation of the Generating Facility, a Class 1 Interconnection Agreement shall be executed between the Customer-generator and NS Power to identify key contacts, desired electrical operating characteristics, and other relevant operating responsibilities considerations.

8.3. Testing

All protective devices or functions supplied to satisfy the requirements in Section 6 and Appendix B shall be routinely tested by qualified personnel at the Customer-generator's expense. Reports and findings of this routine testing shall include the "as left" settings. Test reports will be made available to NS Power.

Special tests may also be requested by NS Power to investigate apparent mis-operations that have had an adverse effect on the NS Power system. The Customer-generator shall conduct, or allow NS Power to conduct such tests and the costs of such tests will be at Customer-generator's expense.

9. Responsibility for Costs

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

Where upgrades and/or revisions are required to existing NS Power systems to accommodate the generation addition, the Customer-generator shall pay the actual cost of the installation/changes. The Customer-generator shall pay a capital contribution for any required line extensions necessary

to extend the NS Power system to the Generating Facility. If this line is dedicated to serve the Customer-generator, all maintenance, repair and replacement costs are the responsibility of the Customer-generator. NS Power will perform and manage the maintenance of these facilities.

10. Provision for Future Changes

NS Power reserves the right to amend any of these requirements at any time.

The Customer-generator is responsible for making required changes to the Customer-generator's equipment and facilities to meet new or revised standards and documents judged applicable by NS Power. The generation owner shall make all required changes in a timely manner. The Customer-generator is responsible for all costs associated with such changes.

11. Appendices

Appendix A - Interconnection Request and Equipment Information Form

Appendix B - Specific Technical Requirements – Inverter-Based Systems Appendix C – References

Appendix A: Interconnection Request And Equipment Information Form

The current version of the NS Power Interconnection Request and Equipment Information Form is found at www.nspower.ca, by follwing the these links from the NS Power Home Page:

Your Home>> Save Money and Energy>> Make You Own Energy>> Enhanced Net Metering>> How to Apply

Or

Your Business>> Save Money and Energy>> Make Your Own Energy>> Enhanced Net Metering>> How to Apply

Interconnection Request and Equipment Information Form

Appendix B - Advanced Inverter Functions and Operating Requirements

In addition to the requirements listed in Section 6 of this Guideline, the Advanced Inverter Functions and Operating Requirements of this Appendix B shall apply for interconnection of all inverter-based Generating Facilities having a valid interconnection request on or after the effective date of this document.

All such inverter equipment shall be CSA certified and meet the functional requirements of UL-1741 Supplement A (SA): "Standard for Grid Support Utility Interactive Inverters and Converters" or the equivalent CSA standard in place at the time of the Interconnection Application.

Advanced Inverter Protection Functions Required:

(a) Over and under voltage trip functions which i) cause the inverter to cease to energize the Distribution System whenever the Distribution System voltage at the Point of Interconnection deviates from the normal voltage limits and timeframes set out in Table B1 - Advanced Inverter Voltage Ride-Through Function Settings and ii) prevent the Advanced Inverter from restarting and re-energizing the Distribution System unless the system voltage has Stabilized; and

(b) Over and under frequency trip functions which i) cause the inverter to cease to energize the Distribution System whenever the Distribution System frequency at the Point of Interconnection deviates from the nominal 60 Hz frequency and timeframes set out in Table B2 - Advanced Inverter Frequency Ride-Through Function Settings and ii) prevent the Advanced Inverter from restarting and re-energizing the Distribution System unless the frequency has Stabilized.

(c) Anti-Islanding protection to prevent the inverter from being connected to any portion of the Distribution System that is not energized by the utility supply, in accordance with Section 6.8 of the guideline.

1. Response to Abnormal Voltage Conditions - Voltage Trip and Ride Through Settings

Table B1 defines the voltage ranges and protective trip limits. Generating Facilities shall cease to energize the Distribution System within the prescribed trip time whenever the voltage at the Point of Interconnection deviates from the allowable voltage operating range. Unless provided alternate settings by NS Power, all inverter-based Generating Facilities must comply with the standard voltage ride-through and trip settings specified in Table B1.

Whenever the Distribution System voltage at the Point of Interconnection is outside Normal Voltage Range for the parameters set forth in Table B1, the Advanced Inverter's protective functions shall cause the Advanced Inverter(s) to cease to energize the Distribution System, as follows:

(a) The Advanced Inverter shall stay connected to the Distribution System while the system remains within the "Ride-Through Duration" voltage-time range and must function in the corresponding "Operating Mode" for each Voltage Condition listed in Table B1.

(b) In the Normal Voltage – High (NVH) region, the Advanced Inverter may be required to reduce power output as a function of voltage (per 3.1 Volt-Watt mode). The activation state and settings of this mode will be determined by NS Power.

c) If the Distribution System voltage recovers to normal prior to the expiration of the Ride-Through time, the Advanced Inverter shall restore continuous operation within 2 sec.

d) If the Distribution System voltage does not exit the ride-through region and returns from the

Under Voltage UV3 region to the UV2 or UV1 region, the Advanced Inverter shall restore available current within 2 sec.

e) Post Ride-Through Start/Restart Conditions: Before restarting the inverter output after a ride through event, the system voltage shall be Stabilized (i.e. between 110% to 88% of nominal system voltage for 5 minutes or another time as established by NS Power in the Interconnection Agreement).

f) Different settings than specified and operating modes than those in Table B1 may be specified by NS Power.

Voltage Condition	Voltage at POI (% of Nominal)	Ride-Through Duration Default Setting (Sec)	Inverter Operating Mode[1]	Clearing time: Adjustable up to and including (sec)	Post Ride-Through Start/Restart Conditions	
					Voltage Criteria (V) (% of Nominal)	Time Delay (min)[2]
Level 2 Over Voltage (OV2)	V ≥120%	No Ride Through	Cease to Energize	0.16	110% ≥ V ≥ 88%	5 - 60
Level 1 Over Voltage (OV1)	110% < V < 120%	1	Mandatory Operation	13	110% ≥ V ≥ 88%	5 - 60
Normal Voltage Range - High (NVH)	100% < V ≤ 110%	Indefinite	Continuous Operation (Permissive Volt-Watt)[3]	Not Applicable Within Normal Voltage Range		
Normal Voltage Range - Low (NVL)	88% ≤ V < 100%	Indefinite	Continuous Operation			
Level 1 Under Voltage (UV1)	60% ≤ V < 88%	20	Mandatory Operation	21	110% ≥ V ≥ 88%	5 - 60
Level 2 Under Voltage (UV2)	45% ≤ V < 60%	10	Mandatory Operation	11	110% ≥ V ≥ 88%	5 - 60
Level 3 Under Voltage (UV3)	V < 45%	No Ride Through	Cease to Energize	0.16	110% ≥ V ≥ 88%	5 - 60

Table B1 - Advanced Inverter Voltage Ride-Through Function Settings

Table B1 Notes:

1 Operating modes:
Mandatory Operation: the inverter continues to output power during the Ride-Through Duration time and then starts the shutdown process.
Cease to Energize: the inverter reduces its output power to zero and then starts the shutdown process.
"Continuous Operation": the inverter continues to output power as available.

2, 3 Actual settings will be specified by NS Power.

2. Response to Abnormal Frequency Conditions - Frequency Trip and Ride Through Settings

Table B2 defines the frequency ranges and protective trip limits. Generating Facilities shall cease to energize the Distribution System within the prescribed trip time whenever the frequency at the Point of Interconnection deviates from the allowable frequency operating range. Unless provided alternate settings by NS Power all inverter-based Generating Facilities must comply with the standard frequency ride-through and trip settings specified in Table B2.

Whenever the Distribution System frequency at the Point of Interconnection is outside Nominal Operation Range for the parameters set forth in Table B2, the Advanced Inverter's protective

functions shall cause the Advanced Inverter(s) to cease to energize the Distribution System, as follows:

a) The Advanced Inverter shall stay connected to the Distribution System while the system remains within the "Ride-Through Duration" frequency-time range and must function in the corresponding "Operating Mode" for each Frequency Condition listed in Table B2.

c) In the OF1 region, the Advanced Inverter shall have the capability to reduce power output as a function of frequency (per 3.2 Frequency-Watt mode). The activation state and settings of this mode will be determined by NS Power.

d) If the Distribution System frequency recovers to a normal range before to the expiration of the Ride-Through time, the Advanced Inverter shall restore continuous operation within 2 sec.

e) If the Distribution System voltage does not exit the ride-through region and returns from either Level 2 (Over/Under) region to the corresponding Level 1 (Over/Under) region, the Advanced Inverter shall restore available current within 2 sec.

f) Post Ride-Through Start/Restart Conditions: Before restarting inverter output after a ride through event, the system voltage shall be Stabilized (i.e. between 110% and 88% of nominal system voltage for 5 minutes or another time as established by NS Power). When the system voltage is in range of 60.7 Hz and 59 Hz, the Advanced Inverter can operate according to its available power output and is not required to increase or decrease power as a function of system frequency.

g) Different settings than specified and operating modes than those in Table B2 may be specified by NS Power.

Frequency Condition	Distribution System Frequency	Ride-Through Duration	Inverter Operating Mode[1]	Clearing time: adjustable up to and including (sec)[2]
Level 2 Over Frequency (OF2)	f > 62	No Ride Through	Cease to Energize	0.16
Level 1 Over Frequency (OF1)	62 ≥ f > 60.7	299	Mandatory Operation (f-W)[3]	300
Normal Frequency Range	60.7 ≥ f ≥ 59	Normal Range	Continuous Operation	Not Applicable
Level 1 Under Frequency (UF1)	59 > f ≥ 57	299	Mandatory Operation	300
Level 2 Under Frequency (UF2)	f < 57	No Ride Through	Cease to Energize	0.16

Table B2 - Advanced Inverter Frequency Ride-Through Function Settings

Table B2 Notes:

1 Operating modes:
Mandatory Operation: the inverter continues to output power during the Ride-Through Duration time and then starts the shutdown process.
Cease to Energize: the inverter reduces its output power to zero and then starts the shutdown process.
"Continuous Operation": the inverter continues to output power as available.

2, 3 The actual settings will be specified by NS Power.

3. Additional Advanced Inverter Operational Functions Required

3.1. Volt-Watt Mode

The Advanced Inverter shall be capable of altering its actual real power output when the system voltage at the Point of Interconnection exceeds the defined "volt-watt start set point (%V_{nom})". The real power output of the inverter shall be reduced according to the "gradient setting (%P_{nom}/%V_{nom})".

Volt-Watt Default Settings		
V-W Setting Parameter	**Default setting**	**Range**
Start Voltage (% of V_{nom})	106	105 to 120
Gradient (%P_{nom}/%V_{nom})	0	0 to 100%

a) When the system voltage reaches or exceeds 106% of nominal, the active power output produced by the Advanced Inverter shall be reduced by X% of real power nameplate rating per %Vnom.
b) The voltage default dead-band shall be +10%/+6% (132 V to 127 V).
c) Start Voltage and Gradient Settings to be provided by NS Power.

3.2. Frequency-Watt Mode

The Advanced Inverter shall be capable of altering its actual real power output whenever the system frequency at the Point of Interconnection exceeds the defined "frequency-watt start set point (Hz)". The real power output of the inverter shall be reduced according to the "gradient setting (%P_{nom}/Hz)".

Frequency-Watt Default Settings		
f-W Setting Parameter	**Default setting**	**Range**
Start Frequency (Hz)	60.7	60.1 to 65
Gradient (%Pnom/Hz)	0	0 to 100%

a) When the system frequency exceeds 60.7 Hz, the active power output produced by the Advanced Inverter shall be reduced by X% of real power nameplate rating per hertz.
b) Start Frequency and Gradient Settings to be provided by NS Power.
c) The frequency default dead-band shall be +0.7/-1.0 Hz (60.7 Hz to 59 Hz). When the system frequency is in range of 60.7 Hz and 59 Hz, the Advanced Inverter can operate according to its available power output and is not required to increase or decrease power as a function of system frequency.

3.3. Power Factor Control

Advanced inverters must be capable of controlling voltage and operating at a fixed, preset power factor. The controller's voltage set-point shall be adjustable throughout the range of 95-105% of rated terminal voltage. The generator must have the capability of operating with a range of 95% lagging to 95% leading power factor when generating its real power rated capability. The actual settings will be specified by NS Power.

3.4. Dynamic Volt/VAr Operations

Advanced Inverters shall be capable of providing dynamic reactive power compensation (dynamic Volt/Var operation) within the following constraints:

a) The Advanced Inverter shall be able to consume reactive power in response to an increase in line voltage, and produce reactive power in response to a decrease in line voltage.
b) The reactive power provided shall be based on available reactive power, but the maximum reactive power provided to the system shall be as directed by NS Power.
c) The voltage thresholds and reactive power set points are provided by NS Power.
d) This Volt/VAR capability shall be able to be activated or deactivated in accordance with NS Power requirements.

3.5. Ramp Rate Requirements

The Advanced Inverter shall have the following ramp capabilities. Ramp rates are reliant on sufficient energy being available from the Advanced Inverter.

a) Continuous Operation ramp rate: For power output level changes during normal operation. The default value is 100% of maximum rated current output per second with a range of adjustment from 1% to 100%, with specific setting as provided by NS Power.

b) Connect/Reconnect ramp rate: Upon starting to inject power on start up or a disconnection, the inverter shall be able to control its rate of increase of power from 1 to 100% maximum current per second. The default value is 2% of maximum current output per second with specific settings as provided by NS Power.

3.6. Summary:

Default Advanced Inverter Functions	**Default Activation State**
a) Anti-Islanding	Activated
b) Voltage Ride Through	Activated
c) Frequency Ride Through	Activated
d) Volt-Watt Mode	Not Activated unless specified by NS Power
e) Frequency-Watt Mode	Not Activated unless specified by NS Power
f) Fixed Power Factor	Not Activated unless specified by NS Power
g) Dynamic Volt-VAr Mode	Not Activated unless specified by NS Power
h) Ramp Rate – Normal Operation	Activated
i) Ramp Rate – Reconnect Operation	Activated

Appendix C - References

[1] Nova Scotia Power ***"Class 1 Interconnection Agreement"*** Current version: Class 1 Interconnection Agreement

[2] Nova Scotia Power ***"Class 1 Interconnection Request And Equipment Information Form"*** Current Version: Interconnection request - 100 kW or less

[3] Nova Scotia Power Inc. ***"Standard Protection Code"*** - Current version

[4] Province of Nova Scotia ***"Electrical Installation and Inspection Act" R.S.N.S. 1989, c. 141***

[5] ***CSA Canadian Electrical Code Part 1, C22.1-02, Safety Standards for Electrical Installations (CE Code)***

[6] NS Power Regulation 2.7 ***"Electric Service Availability and Standard Voltages"***

[7] CSA Standard CAN3 C235-83 – ***"Preferred Voltage Levels for AC Systems 0 to 50,000V"***

[8] IEEE 519 – 2014: ***Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems***

[9] CSA C22.2 No.107.1-01 Standard ***"General Use Power Supplies"***

[10] IEC Standard IEC 61000-4-15 Ed. 1.1 b:2003 ***"Electromagnetic compatibility (EMC) – Testing and measurement techniques – Section 15: Flickermeter"***

[11] Nova Scotia Power Inc. ***"Metering Standards"*** Current version