

CONDITIONS OF SERVICE

APPENDIX C0

Technical Requirements for Generator Connection

This Appendix transcribes from the Distribution System Code the technical requirements for generator connection to Horizon Utilities' distribution system. Where the requirements of this schedule and the Code differ, the requirements of the Code shall prevail.

For the connection process, refer to Appendix F of the Code titled *Process and Technical Requirements for Connecting Embedded Generation Facilities*.

An embedded generation facility includes any embedded generation facility or load Customer with generation equipment that will, at any time, be electrically connected to or paralleled with Horizon Utilities' distribution system.

This Appendix does not apply to the connection or operation of an emergency backup generation facility.

1. Point of Supply

The Point of Supply (also may be referred to as point of connection or point of common coupling) shall be identified in the design and on the single line diagram. Horizon Utilities will co-ordinate design, construction, maintenance and operation of the facilities on its side of the Point of Supply. The Customer is responsible for the design, construction, maintenance and operation of the embedded generation facility on its side of the Point of Supply, unless described otherwise in this Appendix. On the Customer's side of the Point of Supply, the equipment shall be approved in accordance with rule 2-004 of the Ontario Electrical Safety Code (OESC).

2. Isolation at the Point of Supply

The Customer shall provide a means of isolation that is in compliance with the OESC. Horizon Utilities' practice may require its own additional means of disconnection on Horizon Utilities' side of the Point of Supply.

3. Interconnection Grounding

The embedded generation facility and its associated interconnection systems shall be grounded in accordance with the manufacturer's recommendations and the OESC, as well as the normal practices of Horizon Utilities.

Interconnection of three-phase transformers, and transformer grounding on three-phase distribution systems shall be co-ordinated with Horizon Utilities and shall not cause voltage disturbances or disrupt co-ordination of distribution system ground fault protection.

4. Voltage Regulation, IEEE 1547, CSA Standard CAN3-C235-83

CSA Standard CAN3-C235-83 provides general guidance as to appropriate distribution system steady state service voltage levels. The embedded generation facility shall operate satisfactorily within the extreme voltage level variation limits shown in these standards. Voltage regulation is the responsibility of Horizon Utilities.

4.1. Steady-State Voltage, CSA Standard CAN3-C235

Customers connected to the feeder will be supplied with adequate voltage levels, in accordance with CSA Standard CAN3-C235 for the following situations: with and without the embedded generation facility generating power for minimum and maximum feeder loading conditions.

4.2. Voltage Fluctuation, CSA CAN3-325-83, IMO Requirements for Facilities of Larger than 10 MW

Adequate voltage regulation shall be maintained under a variety of operating conditions. During normal operation, and whenever possible, the embedded generation facility shall be loaded and unloaded gradually to allow adequate time for regulating devices to respond.

4.3. Synchronization, IEEE 1547 and/or IMO Requirements for Facilities of Larger than 10 MW

The embedded generation facility shall parallel with Horizon Utilities' distribution system without causing a voltage fluctuation or flicker greater than those specified by the above standards at the Point of Supply.

Note: OESC rule 84-006 covers the synchronization of parallel generators.

4.4. Voltage Unbalance

Where Horizon Utilities' distribution system supplies single-phase loads, some unbalances are inevitable. The embedded generation facility should be capable of operating under these conditions and shall not cause further deterioration of existing unbalance conditions.

5. Power Factor, IEEE 1547, CSA C107.1

The embedded generation facility's system is not required to be capable of adjusting the power factor but shall operate in the preferred range of 0.90 lag to 0.95 lead. If the embedded generation facility disturbs Horizon Utilities' distribution system voltage levels at the Point of Supply, then the embedded generation facility may be required to operate within a smaller range or take other compensatory measures. Field settable fixed and dynamic power factor correction techniques may be used if consultation with Horizon Utilities reveals no adverse affect on Horizon Utilities' distribution system. For embedded generation facilities that are IMO inactive, the reactive power compensation at the generating units should be sufficient so as not to cause any material increase in the reactive power requirements at the transmission system transformer station due to operation of the units, at any distribution feeder load conditions.

For inverter-based embedded generation facilities, power factor limits will be as given in the MicroPower Connect guidelines.

6. Equipment Ratings and Requirements

The embedded generation facility's interface equipment must be compatible with Horizon Utilities' equipment ratings at the connection voltage (maximum voltage, basic impulse limit, short circuit ratings, capacity, etc.), and the incorporation of the added embedded generation facility must not result in any of Horizon Utilities' distribution system equipment operating beyond Horizon Utilities' distribution system operational rating. Horizon Utilities will review the equipment ratings for the purpose of assessing integration of the embedded generation facility with Horizon Utilities' distribution system. The equipment ratings that shall be reviewed include, but are not limited to, the following:

6.1. Equipment Thermal Loading

All of Horizon Utilities' existing equipment in distribution and transmission stations shall not be overloaded beyond acceptable limits under all operating conditions of the embedded generation facility. This equipment includes feeder conductor, line voltage regulators, regulating stations, reclosers, circuit breakers and transformers.

Assuming that under existing operating conditions there is no overloaded equipment, the study will be conducted for minimum load conditions and maximum generation including all existing embedded generation facilities already existing on the feeder. The load flow study will identify the potential overload of the existing equipment.

6.2. Impact of Embedded Generation Facility Fault Contribution on Equipment Rating

The embedded generation facility will contribute to the total fault current. Horizon Utilities' distribution system interrupting devices will be able to interrupt the maximum fault current that will flow through the devices. All of Horizon Utilities' distribution system electrical equipment has to be able to withstand the fault current passing through it for the required time for the protection to clear the fault.

The fault interrupting rating of the existing interrupting devices and the fault withstanding rating of the electrical equipment shall be higher than maximum fault current possible to flow through the equipment.

Where the embedded generation facility causes these limits to be exceeded, distribution system equipment replacement or fault current limiting devices may be required.

6.3. Voltage Regulating and Metering Devices

Horizon Utilities' distribution system has been designed for unidirectional flow of power, from source (i.e., station) to the customer. Therefore, the voltage regulating and metering devices are designed to correctly operate in these conditions. The connection of embedded generation facilities to Horizon Utilities' distribution system could cause the power to flow in reverse through the power equipment, which will create difficulties to properly regulate the voltage or to measure the energy, respectively.

Where it is possible for power to flow in reverse through the existing voltage regulating devices and/or the metering points, the regulating devices and metering devices shall be suitable for such bi-directional flow.

A study will be conducted for minimum load and maximum generation condition. The direction of the power flow through voltage regulating devices connected between the embedded generation facility and the transformer station shall be verified including line voltage regulators, regulating stations and transformers' under load tap changer, at the distribution station and transformer station. Also all metering devices, either for billing purpose or monitoring reasons, shall be verified.

7. Cease to Energize

Horizon Utilities will review the Customer's design to ensure that the facility will cease to energize automatically from Horizon Utilities' distribution system supply under the conditions identified in this section.

Important considerations in this design review:

Reference to IEEE 1547

To maintain the reliability of Horizon Utilities' distribution system, Horizon Utilities may use automatic re-closing. The Customer needs to be aware of line re-closing when designing the system protection schemes to ensure that it de-energizes Horizon Utilities' distribution system prior to automatic re-close of Horizon Utilities' distribution system breakers or line re-closers. Horizon Utilities shall review to ensure that the Customer's design will de-energize the embedded generation facility prior to auto-reclose operation of feeder tripping devices.

Reference to IEEE 1547 and OESC 84-008(b)

After a disturbance on Horizon Utilities' distribution system, no reconnection shall take place until Horizon Utilities' distribution system voltages and frequency are within the limits specified in CSA CAN3-C235 standard.

The embedded generation facility's interconnection system shall include an adjustable delay (or a fixed delay of five minutes) that may delay reconnection for up to five minutes after Horizon Utilities' distribution system steady state voltage and frequency are restored to the ranges identified above.

7.1. Loss of Horizon Utilities Supply Resulting in the Formation of an Island, IEEE 1547 CSA C22.2 No. 107.1, OESC 84-008 (Loss of Supply Authority Voltage)

7.1.2. Unplanned islanding

The Customer's system shall cease to energize Horizon Utilities' distribution system following the formation of an unintentional island.

7.1.3. Planned islanding

Where planned islanding is allowed, the Customer and Horizon Utilities will jointly agree to all requirements.

7.2. Over-Current Protection Coordination Due to Embedded Generation Facilities Fault Contribution IEEE 1547 and OESC 84-014 (System Protection Devices)

Any element of the interconnection system external to the embedded generation facility, but ahead of the Point of Supply, should be installed in a fail-safe manner with self-checking features or redundant protection functions for large embedded generation facilities.

Equipment and conductors shall be provided with overcurrent protection from each source of supply. The embedded generation facility's protection system shall be capable of automatically isolating the embedded generation facility from Horizon Utilities' distribution system for the following:

- internal faults within the embedded generation facility; and/or
- external faults within Horizon Utilities' distribution system.

The protective device selectivity and sensitivity have to be maintained over the range of minimum to maximum fault currents with in-feed from the embedded generation facility.

Where the primary connection of the embedded generation facility transformer is Wye (Y)-grounded, the sensitivity of the ground fault protections could become deficient, as zero sequence current will

have an additional ground path through the transformer to Horizon Utilities' distribution system. The ground fault occurring within the protected zone has to be "seen" by the ground fault protections with and without the transformer connected.

7.3. System Voltage Changes Beyond the Over or Under Voltage Range, IEEE 1547

Over and under voltage and over and under frequency protection is required at the embedded generation facility's interconnection point.

The set points and clearing times for over or under voltages and over or under frequencies are dependent upon the magnitude of voltage and frequency variations and embedded generation facility size. For details see relevant clauses of IEEE 1547. Embedded generation facility's equipment should be approved to CSA 107.1 or other acceptable standard.

Note: OESC rule 84-014 states that each parallel power embedded generation facility shall be provided with such additional devices that are required for system stability and equipment protection.

8. Revenue Metering

Revenue metering shall comply with Canada's *Electricity and Gas Inspection Act, R.S. 1985, C.E-4*.

9. Feeder Relay Directioning

The existing over-current protections in Horizon Utilities' distribution system are typically designed to clear line and ground faults occurring downstream from their location, as the source feeding the fault is only the transformer station. Connecting an embedded generation facility provides another source supplying the fault, and the fault contribution from the embedded generation facility might cause protection to operate non-selectively for reverse faults, out of the protected zone.

If the maximum reverse fault current through a non-directional, fault-interrupting device exceeds the setting of the device, the fault-interrupting device shall be provided with a directional feature to prevent tripping for reverse fault current flow. The phase protection could be replaced with an impedance relay (21), if required.

The main concern is the in-feed from the embedded generation facility with grounded connection on the high voltage side of the interface transformer for faults on the adjacent feeders. The Customer may consider adding a reactor <5 ohm in the neutral of the embedded generation facility's transformer, within the constraints of the over-voltages.

10. Monitoring, IEEE 1547, OESC and/or IMO & Transmitter Requirements for Facilities of 10 MW and Higher

An embedded generation facility connected to the Point of Supply, rated at greater than 250 kVA, shall have provision for monitoring connection status, real power output, reactive power output, and voltage either at the Point of Supply or aggregate connection, as required by Horizon Utilities. The monitoring equipment shall either be installed, or there shall be adequate provision in the design to allow future installation of such equipment, if not required at time of interconnection. When implementation of data telemetry is required, Horizon Utilities and the Customer will mutually agree upon communication media options.

Note: At the Customer's side of the Point of Supply the equipment shall be approved as per rule 2-022 of the OESC. The installation shall be inspected as per rule 2-004 of the OESC.

11. Power Quality

The embedded generation facility shall not significantly impact the power quality of the system. If there are negative impacts once the embedded generation facility is in service, the Customer will be required to disconnect the embedded generation facility until appropriate measures have been taken by the Customer; to prevent negative impacts to Horizon Utilities' distribution system, and the customers that it serves.

11.1. Flicker, IEEE1547, IEC 61000-3-7

The embedded generation facility shall not cause objectionable flicker on Horizon Utilities' distribution system. It is recognized that flicker is a site-dependent condition. **The Customer may be required to incorporate** loss of synchronism protection, if necessary, to limit flicker.

11.2. Harmonics, IEEE1547, IEC 61000-3-6

Inverter connected embedded generation facilities are expected to comply with CSA 22.2 No. 107.1 current distortion limits.

For inverters only capable of operating in voltage follower mode, voltage harmonic distortion limits are not specified, but may be addressed by Horizon Utilities. Inverters certified to CSA 107.1 are considered to meet these requirements. The CSA standard excludes current harmonics due to voltage distortions in Horizon Utilities' distribution system.

11.3. Limitation of DC Injection, IEEE1547

The embedded generation facility shall not inject a DC current greater than 0.5 per cent of the unit rated output current after a period of six (6) cycles following energization of Horizon Utilities' distribution system.

11.4. Protection from Electromagnetic Interference (EMI), IEEE 1547, C37.90

The influence of EMI should not interfere with operation of the embedded generation facility's interconnection system.

11.5. Surge Withstand Performance, IEEE 1547, C62.41.2 or C37.9.90, OESC 84-014

The interconnection system shall have the capability to withstand voltage and current surges.

11.6. Paralleling Device, IEEE 1547

The interconnection system paralleling-device shall be capable of withstanding 220 per cent of the interconnection system rated voltage.