



# Micro-embedded Generation Technical Interconnection Requirements (MicroTIR)

## Functional

## Distribution – Generation

**Keywords:** MicroTIR, Micro-embedded Generation, MicroDER

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## 1 INTRODUCTION

The “Micro-embedded Generation Technical Interconnection Requirements (MicroTIR)” outlines the technical requirements for the installation and modification of Micro-embedded Generation Facilities connecting in parallel to Hydro One Networks Inc.’s (“Hydro One”) Distribution System feeders at 50kV and below. Typically, the Micro-embedded Generation Facilities are for small residential projects.

The requirements for Distributed Energy Resources (DER) with larger name-plate rated capacity than Micro-embedded Generation Facilities are outlined in the “Distributed Energy Resources Technical Interconnection Requirements at Voltages 50kV and Below” (DP-12-001) and “Background Guide to Distributed Energy Resources Technical Interconnection Requirements at Voltages 50kV and Below” (DP-12-002).

Connection of Micro-embedded Generation Facilities to Distribution System feeders can impact the steady-state and transient voltage profiles and current distribution along a feeder in response to changing supply, load and fault conditions. To ensure that the safety, reliability and efficiency of Hydro One’s Distribution System is not adversely affected by the connection of Micro-embedded Generation Facilities to Hydro One’s Distribution System, a Micro-embedded Generation Facility must:

- i. Adhere to all requirements applicable to the Micro-embedded Generation Facility:
  - a. Under any federal or provincial legislation including, without limitation, the Distribution System Code (“DSC”), DER Connection Procedures (“DERCP”) issued by the Ontario Energy Board, the Market Rules issued by the IESO and the Ontario Electrical Safety Code (“OESC”) and;
  - b. In the applicable CSA and IEEE standards; and
- ii. be designed and operated to be compatible with Hydro One’s standard operating, protection, control and metering systems and practices.

To accomplish this, the design of the power equipment, protection, control, and metering systems used at or for the connection of the Micro-embedded Generation Facility must meet specific minimum requirements. Depending on the capacity and electrical characteristics of the connecting Micro-embedded Generation Facility, specific additions and/or modifications may be required to Hydro One’s power equipment, protection, control, and metering systems to facilitate the connection.

The MicroTIR has been developed with reference to the Canadian Standards Association such as CAN/CSA C22.3 No. 9:20 – Interconnection of Distributed Resources and Electricity Supply Systems, the DSC, and international standards such as the Institute of Electrical and Electronics Engineers (IEEE) Standard 1547 – Interconnecting Distributed Resources with Electric Power Systems.

It is imperative that these requirements are understood as required by those delegated or contracted by the Micro-embedded Generation Owner, Hydro One and other affected Local

Distribution Company (LDC) owners for the planning, design, equipment manufacture and supply, construction, commissioning, operation and maintenance of the Micro-embedded Generation Facility and Distribution Systems.

## 1.1 SCOPE AND APPLICABILITY

The MicroTIR applies to the following Micro-embedded Generation Facilities connecting in parallel to Hydro One's Distribution System (50kV and below):

- Micro-embedded Generation Facilities (or, more simply "MicroDER") projects, where the generation facility has a name-plate rated capacity of 12 kW or less.

These requirements are not intended to apply to generation units connecting momentarily (100 ms or less) through automatic transfer switches or other schemes (such as Emergency Back-up Generators).

## 1.2 OBJECTIVES

Hydro One is committed to connecting Micro-embedded Generation Facilities to the Distribution System while preserving a safe and reliable electrical supply to all of its customers. The connection of the Micro-embedded Generation Facilities must conform to relevant Ontario and Canadian regulations and international design standards. The MicroTIR has been developed in accordance with the following objectives. These objectives shall be integrated into all steps to the connection process - design specification, construction, operation and maintenance of the Micro-embedded Generation Facility.

### 1.2.1 Safety

The connection, installation and operation of a Micro-embedded Generation Facility must not create a safety hazard for the general public, customers, Hydro One employees or others that work on the Distribution System, nor to personnel working in the Micro-embedded Generation Facility.

### 1.2.2 Power Quality

The connection of a Micro-embedded Generation Facility must not materially degrade the power quality of Hydro One's Distribution System below acceptable levels.

### 1.2.3 Reliability

The connection of a Micro-embedded Generation Facility must not materially compromise the reliability of Hydro One's System as required by the DSC and defined by Hydro One's Conditions of Service document.

### 1.2.4 Achievability

The connection requirements for Micro-embedded Generation Facilities must be achievable, fair, and competitive to allow equitable access for all Micro-embedded Generation Owners.

### 1.2.5 Operability

The connection of a Micro-embedded Generation Facility must not restrict the operation of Hydro One's Distribution System. All aspects of the connection that can impact Hydro One's Distribution System must be compatible with Hydro One's standard operating, protection, control and metering systems and practices.

## 1.3 RESPONSIBILITIES

Connecting Micro-embedded Generation Facilities to Hydro One's Distribution System involves several steps and both Hydro One and the Micro-embedded Generation Owner have distinct responsibilities.

### 1.3.1 Hydro One is responsible for:

- i. the safety, reliability, power quality and operation of Hydro One's Distribution System, and ensuring the connection of the Micro-embedded Generation Facility does not adversely affect the system or the operations of Hydro One's existing customers;
- ii. maintaining the integrity of Hydro One's Transmission and Distribution Systems;
- iii. operating in compliance with all applicable laws (including its license and codes issued by the Ontario Energy Board) and within the guidelines of all applicable Ontario, Canadian and international standards; including but not limited to telecommunication regulation and best practices and
- iv. establishing the terms and conditions for this MicroTIR that are consistent with the "Objectives" described above in Section 1.2.

### 1.3.2 Micro-embedded Generation Owners are responsible for:

- i. the safety, design, construction, operation, metering, protection and control, and maintenance of the Micro-embedded Generation Facility;
- ii. operating in compliance with all applicable laws (including its license and codes issued by the Ontario Energy Board) and within the guidelines of all applicable Ontario, Canadian and international standards; including but not limited to telecommunication regulation and best practices
- iii. ensuring that the Micro-embedded Generation Facility is compatible with Hydro One's standard operating, protection, control and metering systems and practices; and
- iv. abiding by the terms and conditions of this MicroTIR.

## 1.4 REQUIREMENT ORIGINS

To qualify for interconnection, Micro-embedded Generation Facilities shall comply with the following codes and standards as applicable:

- Ontario Electrical Safety Code (OESC)
- CSA C22.2 No. 107.1:16 (Power Conversion Equipment)
- CSA C22.3 No. 9:20 (Interconnection of Distributed Energy Resources and Electricity Supply Systems)
- IEEE 1547-2018 (IEEE Standard for Interconnection and Interoperability of

- Distributed Energy Resources with Associated Electric Power Systems Interfaces)
- Distribution System Code (DSC) and DER Connections Procedures (DERCP) of Ontario Energy Board
- Hydro One Condition of Services (COS) ([Conditions of Service | Hydro One](#)) and Hydro One Retail Metering Guide 2024 Edition ([Hydro One Retail Metering Guide 2024 Edition](#))
- UL 1741 SA, Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources
- UL 1741 SB, Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources

## 1.5 TERMINOLOGY

Throughout the MicroTIR, the term:

- i. “shall” is used to express a mandatory requirement – i.e. a provision that the Micro-embedded Generation Facility is obligated to satisfy in order to comply with the requirements of this MicroTIR;
- ii. “should” is used to express a recommendation or that which is advised but not required;
- iii. “may” is used to express an option or that which is permissible within the limits of this MicroTIR; and
- iv. “can” is used to express possibility or capability.

### 1.5.1 Abbreviations & Definitions

The following Section contains the definition of special terms and abbreviations used in this Technical Requirement.

*Table 1 – Abbreviations & Definitions*

Term	Definition
Anti-Islanding	A protection system aimed at detecting islanded conditions (see island) and disconnecting the DER (or Micro-embedded Generation) Facility from the Distribution System if an island is formed
Breaker	Fault Interrupting Device: this may be a breaker, circuit switcher, high voltage interrupter (HVI), low voltage interrupter (LVI)
Clearing Time	The duration for a protective device to detect a fault and disconnect the affected circuit, essential for system safety and stability. Also, known as Trip Time.
Customer	A generator or consumer whose facilities are connected to or are intended to be connected to Hydro One’s Distribution System. This includes developers of residential or commercial sub-divisions. An embedded distributor is deemed to be a customer.
DER	Distributed Energy Resource - A resource that can generate, store, or discharge electrical energy, directly linked to a Distribution System or to an end-use customer’s premises connected to the Distribution System, including, without limitation, solar panels, wind turbines, battery storage, combined heat and power systems, and electric vehicles.



	*Formerly referred to as DG – Distributed Generator
DER Facility	All equipment including generators, inverters, energy storage, transformers, protections, and line on the DER Facility side of the PCC.
DER Owner	A person who owns or operates a DER Facility.
DERCP	Distributed Energy Resources Connections Procedures – Consolidation of the procedures, timing, workflows, and template forms issued by the OEB to facilitate the communication and implementation of a standardized procedure for the connection of DERs (or Micro-embedded Generations) to Distribution Systems.
DG	Refer to Distributed Energy Resources (DER).
Distribution Lines	Distribution lines that operate at nominal line-line voltages below 27.6 kV.
Distribution System	Any power line facilities under the operating authority of the Wires Owner (Hydro One or Local Distribution Company) that operate at nominal line-line voltages of 50 kV or below. This includes sub-transmission power lines that operate at 27.6 kV or 44 kV and distribution lines that operate at voltages below 27.6 kV.
Distributor	A person owning or operating a Distribution System.
DSC	Distribution System Code
EBG	Emergency Back-up Generator Generation facility – A standby power system that is installed on a customer site for the sole purpose of providing electrical power if the primary or system power has been interrupted or is unavailable.
Exporting DER / Exporting Micro-embedded Generation	DER (or Micro-embedded Generation) Facility that supplies power into the Distribution System through the point of common coupling (PCC)
External Disconnect Switch	The utility-accessible alternating current (AC) external disconnect switch (EDS) for distributed generators, is a hardware feature that allows a utility’s employees to manually disconnect a customer-owned generator from the electricity grid.
Feeder	A single-phase or three-phase line emanating from a substation to supply load.
Flicker	A perceptible change in electric light source intensity due to a fluctuation of input voltage. (Note: The general meaning of this term could apply to the pulsation of luminous flux from a low-inertia source, such as gas discharge lamps, caused by the zero crossings of the supply voltage at twice the power-system frequency. However, in the context of power supply disturbances, the term applies to perceptible, subjective, objectionable and random or periodic variations of the light output).
Harmonics	Sinusoidal voltages and currents at frequencies that are integral multiples of the fundamental power frequency (60Hz).
High Voltage	In MicroTIR, high voltage refers to Hydro One’s system voltage and can be referred to as medium voltage.
IESO	Independent Electricity Safety Operator



Island	An operating condition where a DER (or Micro-embedded Generation) Facility or facilities supply loads that are electrically isolated from the main electric utility grid, creating a self-contained power system.
Load	The amount of power supplied or required at a specific location.
MicroDER Facility	All equipment including generators, inverters, energy storage, transformers, protections, and line on the MicroDER Facility side of the PCC.
MicroDER Owner	A person who owns or operates a MicroDER Facility.
Micro-embedded Generation Facility	An embedded generation facility with a name-plate rated capacity of 12 kW or less. All equipment including generators, inverters, energy storage, transformers, protections, and line on the Micro-embedded Generation Facility side of the PCC.
Micro-embedded Generation Owner	A person who owns or operates a Micro-embedded Generation Facility.
MicroTIR	This document as well as any updates of technical interconnection requirements in the form of bulletins and/or amendments that are published periodically by Hydro One on its website.  Abbreviation for “Micro-embedded Generation Technical Interconnection Requirements”.
Net-Metering	A provincial electricity billing program under O. Reg 541/05 (Net Metering) that lets homes and businesses generate their own renewable electricity and receive credits on their electricity bill for any excess power they send back to the Distribution System. A Micro-embedded Generation Facility that is a renewable energy generation facility (as that term is defined in the Electricity Act, 1998 (Ontario)) is an eligible generator under the Net Metering program.
Non-exporting DER / Non-exporting Micro-embedded Generation	A DER (or Micro-embedded Generation) Facility where the sole purpose of electricity generation at the site is to supply the load at the same PCC as the DER (or Micro-embedded Generation) Facility and where under no circumstances the DER (or Micro-embedded Generation) Facility will be operated in such a way to supply power into the Distribution System at any time.
Non-parallel Operation	A mode of operation where the DER (or Micro-embedded Generation) Facility and the load it supplies are both disconnected from the Distribution System.
OEB	Ontario Energy Board
OESC	Ontario Electrical Safety Code
Parallel Operation	The simultaneous connection and operation of a DER (or Micro-embedded Generation) Facility with the main electric grid, where the DER (or Micro-embedded Generation) shares the load and supplies electricity along with the Distribution System. This mode of operation allows the DER (or Micro-embedded Generation) to operate concurrently with the Distribution System, contributing to the overall power supply and stability.
PCC	Point of Common Coupling - The point where the distributor’s Distribution System ends, and the DER (or Micro-embedded Generation) assets or the existing load customer’s assets begin.



Stabilized	A Distribution System returning to normal frequency and voltage after a disturbance for 5 minutes or as determined by the Wires Owner.
Synchronized	See Parallel Operation
THD	Total Harmonic Distortion – a measurement of the harmonic distortion present. It is defined as a ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency.
TIR	Abbreviation for “Distributed Energy Resources Technical Interconnection Requirements at Voltages 50kV and Below”.
TOV	Temporary Overvoltage – oscillatory power frequency overvoltages of relatively long duration – from a few cycles to hours.
Wires Owner	The entity who owns and/or operates a Distribution System or distribution lines.

## 1.6 MICRO-EMBEDDED GENERATION CAPACITY LIMITATIONS

Capacity limitations for Micro-embedded Generation Facilities are established to ensure reliability and operability, as well as considering thermal, short circuit and safety aspects of Hydro One’s system.

Certain limitations may only apply to those Micro-embedded Generation Facilities that supply power into Hydro One’s Distribution System (exporting Micro-embedded Generation Facility), while other limitations may apply to all Micro-embedded Generation Facilities including non-exporting Micro-embedded Generation Facilities.

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## 2 TECHNICAL INTERCONNECTION REQUIREMENTS

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### 2.1 GENERAL REQUIREMENTS

Safety is paramount in generating, transmitting and distributing electricity. Micro-embedded Generation Facilities must meet all applicable federal, provincial, and local construction, operation and maintenance related safety codes, such as the Canadian Electrical Code, Ontario Electrical Safety Code, Occupational Health and Safety Act, etc.

This section provides the technical interconnection requirements. The Micro-embedded Generation Facility interconnection equipment must comply with these requirements in order to be connected to the Distribution System. Typical operating conditions, protection functions and correct response to abnormal conditions are also listed.

### 2.2 SYSTEM GROUNDING

#### 2.2.1 Grounding Codes

The Micro-embedded Generation Facility must be grounded in accordance with all applicable codes including the OESC. Refer to OESC (Sections 10 – Grounding and bonding, 36 – High Voltage Installations, and 84 – Interconnection of electric power production sources).

#### 2.2.2 Grounding Method

The interconnection of the Micro-embedded Generation Facility, through equipment such as an interface transformer and/or external disconnect switch (2.4.2), with the Hydro One Distribution System shall be compatible with the neutral grounding method in use on the Hydro One Distribution System.

#### 2.2.3 Temporary Over-Voltage

Three-phase Micro-embedded Generation Facilities connecting to Hydro One four-wire multi-grounded primary feeders shall not cause the maximum “Temporary Over-Voltage” (TOV) to exceed 130% of nominal line-to-ground voltages.

### 2.3 TECHNICAL REQUIREMENTS

Hydro One will be reviewing the Micro-embedded Generation Facility’s technical characteristics with respect to the following requirements.

#### 2.3.1 Customer Specific Requirements

Any measures required to meet these requirements will be at the Micro-embedded Generation Owner’s cost. Hydro One will not provide a transformer for the sole purpose of connecting a Micro-embedded Generation Facility to the Distribution System.

- i. The name-plate rating of the Micro-embedded Generation Facility shall not exceed the capacity of the Customer’s existing electrical service. To meet this requirement, the Customer’s existing electrical service may need to be upgraded.

- ii. The Micro-embedded Generation Facility’s operating voltage range must be compatible with the standard service voltage range. To meet this requirement, matching transformation may need to be installed.
- iii. In order for the voltage at the service entrance to remain within the limits of Table 2 under all system operating conditions, the total connected capacity of the Micro-embedded Generation Facility shall not cause the voltage rise on the secondary service conductor to exceed 1% of operating voltage. To meet this requirement, re-conductoring of the service drop may be required.

*Table 2 – Recommended Service Voltage Variation Limits*

Nominal System Voltages	Recommended voltage variation limits for circuits up to 1,000 V, applicable at service entrance			
	Extreme Operating Conditions			
	Normal Operating Conditions			
<u>Single Phase</u>				
120/240	106/212	110/220	125/250	127/254
240	212	220	250	254
480	424	440	500	508
600	530	550	625	635
<u>Three phase 4-conductor</u>				
120/208Y	110/190	112/194	125/216	127/220
240/416Y	220/380	224/388	250/432	254/440
277/480Y	245/424	254/440	288/500	293/508
347/600Y	306/530	318/550	360/625	367/635
<u>Three phase 3-conductor</u>				
240	212	220	250	254
480	424	440	500	508
600	530	550	625	635

Based on CSA CAN3-C235 (R2015), Table 3

- iv. For transformers rated 50 kVA or higher, the total connected generation capacity, including the proposed generation units, must be limited to the nameplate kVA rating of the respective transformer winding. To meet this requirement, the transformer may need to be replaced with one of higher rating (e.g. for a 50 kVA transformer, the maximum permissible generator rating is 50 kW at unity power factor).
- v. Transformers rated less than 50 kVA (typically 10 kVA and 25 kVA) have higher winding resistance. For these, the total connected generation capacity including the proposed generation units must be limited to 50% of the nameplate kVA rating of the respective transformer winding. To meet this requirement, the transformer may need to be replaced with one of a higher rating.

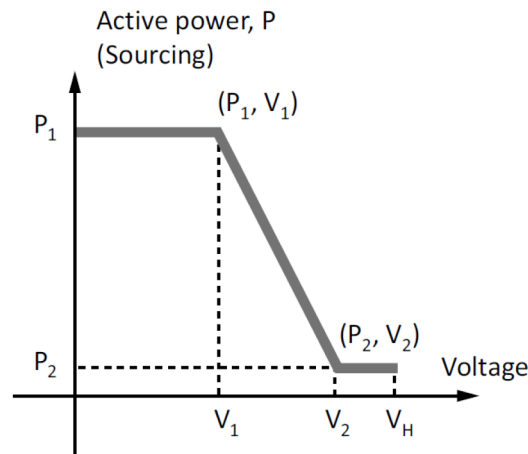
- vi. For generation units connected between line-to-neutral terminals of the transformer secondary, the total connected generation capacity shall not exceed 25% of the transformer nameplate kVA rating. To meet this requirement, the transformer may need to be replaced with one of a higher rating.

**2.3.2 Distribution System Requirements**

- i. The total generation to be interconnected to a Distribution System circuit line section, including the proposed generation units, will not exceed 7% of the annual line section peak load. Line section peak load refers to the section of line to which the Micro-embedded Generation Facility connection is proposed, including all downstream line on the same phase(s) and the line upstream to the nearest automatic reclosing protective device (normally a single-phase line recloser). The total generation excludes generation units that cannot export power from a customer’s site. To meet this requirement, supply station capacity upgrades may be required and anti-islanding concerns due to cumulative generation will need to be addressed.
- ii. Line sections where the total generation, including the proposed generation units, exceeds 7% of the annual line section peak load may be considered for connection with additional requirements including:
  - a. Inverters must be UL1741SA (or later) certified or CSA 22.3 No. 9:20.
  - b. Implement Volt-Watt smart inverter settings per Table 3. Settings may be subject to Hydro One review and approval. Figure 1 illustrates typical Volt-Watt characteristics for reference.
  - c. Prior to connection the Micro-embedded Generation Facility must be capable of power factor set-point changes (ie. field adjustable) at all times.

*Table 3 – Volt-Watt parameters for smart inverters settings*

<b>P(V) parameters</b>	<b>Hydro One default parameter values for smart inverter settings</b>
V1	1.051 p.u.
P1	Rated Power
V2	1.061 p.u.
P2	0 kW
Open loop response time	10 sec



Based on CSA C22.3. NO. 9:20

*Figure 1: P(V) Characteristics*

- iii. The total interconnected generation, including the proposed generation units, shall not cause any distribution protective devices and equipment (including but not limited to substation breakers, fuse cutouts and line re-closers) or Customer equipment on the system, to exceed 100% of the short circuit interrupting capability. To meet this requirement, protective devices may need to be upgraded.
- iv. Voltage unbalance on the distribution feeder must be limited to no more than 2% (calculated by dividing the maximum deviation from average voltage on a single-phase by the average voltage, with the result multiplied by 100). To meet this requirement, either the single-phase service to which the proposed generation units is to be connected must be moved to a different phase, or feeder reconfiguration or upgrades may be required.
- v. The total generation to be interconnected to the Distribution System, including the proposed generation units, must respect limitations on the transmission system identified by the regulatory requirements or the transmitter. To meet this requirement, transmission system upgrades may be required.

## 2.4 PROTECTION AND CONTROL REQUIREMENTS

This section outlines protection and control requirements and expectations for Micro-embedded Generation Facilities.

### 2.4.1 Interrupting Device

An interrupting device (e.g. circuit breaker) is required to automatically disconnect from all ungrounded conductors of the Distribution System that the generation source feeds, due to the need to ensure safety and mitigate the risk of damage to the equipment of others (as set out in the protection requirements outlined in Section 2.4.3 to 2.4.12 below). It must meet the requirements of OESC Sections 14, 28, 36 and 50 as applicable.

#### 2.4.2 Isolation Device

A customer owned, utility-accessible external disconnect switch (EDS) is required to isolate the Micro-embedded Generation Facility for the purpose of safety during maintenance and during emergency conditions. The isolation device shall be a disconnect switch in compliance with the OESC<sup>1</sup>; including but not limited to the following requirements;

- a. be capable of being energized from both sides<sup>1</sup>;
- b. plainly indicate whether in the open or closed position<sup>1</sup>;
- c. be capable of being opened at rated load (Load Break Switch)<sup>1</sup>;
- d. be readily accessible by Hydro One<sup>1</sup>;
- e. not be located in a hazardous location<sup>2</sup>;
- f. have provision for being locked in the open position<sup>1</sup>;
- g. be capable of being closed with safety to the operator with a fault on the system<sup>1</sup>;
- h. be capable of being operated without exposing the operator to any live parts;
- i. bear a warning to the effect that inside parts can be energized from sources on both sides when disconnecting means is open<sup>1</sup>;
- j. is clearly labeled as a MicroDER disconnect switch; and
- k. is either at the primary voltage level, which may include load-break cutouts, switches and elbows, or is on the secondary voltage level, which may include a secondary breaker or switch.

#### 2.4.3 Over-current Protection

Over-current protection shall be provided in accordance with OESC Rule 84-010 “Equipment and conductors that are energized from both directions shall be provided with over-current protection from each source of supply.”

#### 2.4.4 Ground Fault Protection

“Ground fault protection shall be provided in accordance with OESC Rule 84-016, and OESC Rule 14-102.”

#### 2.4.5 Abnormal System Voltage Protection

The generator shall disconnect from Hydro One’s Distribution System at abnormal voltage levels and clearing times specified in Table 4.

Inverters will be required to demonstrate ride-through capability. This can be accomplished by adopting and being compliant with CSA C22.3 No. 9:20 requirements or through UL 1741 SA (2016 or later) certification.

*Different settings may be used for the under-voltage and over-voltage trip levels or time delay with the agreement with Hydro One*

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<sup>1</sup> In accordance with OESC Section 84-024

<sup>2</sup> As defined by OESC Section 18

*Table 4 – Over/Under Voltage Protection Setting and Clearing Times*

Voltage Range (% of base voltage)	Clearing Time (sec)
V < 45	0.16
V < 88	5.00
V > 110	1.00
V ≥ 120	0.16
V ≥ 130	Instantaneous (with no intentional delay)

Based on CSA C22.3 No. 9:20

**2.4.6 Abnormal System Voltage Protection for Three-Phase Generation**

For three-phase generation, the voltage thresholds specified in Table 4 apply to each phase individually.

**2.4.7 Abnormal System Frequency Protection**

The Micro-embedded Generation Facility shall disconnect from Hydro One’s Distribution System at the frequency levels within the clearing times specified in Table 5.

Inverters will be required to demonstrate ride-through capability. This can be accomplished by adopting and being compliant with CSA C22.3 No. 9:20 requirements or through UL 1741 SA (2016 or later) certification.

*Different settings may be used for the under and over frequency trip levels or time delays with the agreement of Hydro One.*

*Table 5 – Over/Under Frequency Protection Set Points and Clearing Times*

Frequency Range (Hz)	Clearing Time (sec)
f > 62.0	0.16
f > 61.2	299
f < 58.8	299
f < 57.0	0.16

Based on CSA C22.3 No. 9:20

**2.4.8 Paralleling Generation**

The act of paralleling generation to the Distribution System can cause current and voltage on the Distribution System to be disturbed. Connection of generation to the Distribution System shall not cause a steady state voltage fluctuation of more than ± 4% at the PCC. This is achieved by different means, depending on the type of the proposed generation units:

Generating systems that can generate and control alternating current (ac) voltage independent of the Distribution System require synchronization capabilities in order to

connect to the Distribution System. For these types of generating systems, the synchronizing controls must connect only when the differences between the Micro-embedded Generation Facility and the Distribution System voltage waveform are within the following limits:

- i. Frequency difference less than 0.3 Hz
- ii. Voltage magnitude difference less than 10 percent
- iii. Phase angle difference less than 10 degrees

Other types of generation that cannot generate and control AC voltage independent of the Distribution System may require different methods of limiting voltage fluctuations to acceptable levels. Examples are soft-start control systems or speed-matching for induction machines.

#### **2.4.9 System Protection**

The Micro-embedded Generation Owner shall be responsible for protection of its equipment and shall not cause damage to, and/or adversely affect, other Distribution System connected Customers for all Hydro One Distribution System operating conditions whether or not their Micro-embedded Generation Facility is in operation. Conditions may include, but are not limited to:

- i. Distribution System faults;
- ii. abnormal voltage or frequency excursions;
- iii. transient voltage due to lightning and switching;
- iv. equipment failures
- v. loss of a single-phase of supply (three-phase generators)
- vi. excessive harmonic and negative sequence voltages
- vii. synchronizing generation
- viii. re-synchronizing the generation after Hydro One restores supply; and
- ix. islanding; Separation from supply.

#### **2.4.10 Anti-islanding**

The Micro-embedded Generation Facility shall cease to energize the Hydro One Distribution System within two seconds of the formation of an island on the Distribution System. Hydro One does not currently allow islanded operation.

#### **2.4.11 Feeder Reclosing Coordination**

To maintain reliability, Hydro One uses automatic reclosing on distribution feeders. The Micro-embedded Generation Facility Owner needs to take this into consideration when designing Micro-embedded Generation Facility system protection schemes to ensure that the Micro-embedded Generation Facility system ceases to energize the Distribution System prior to automatic reclose of the feeder breakers or line re-closers. The typical automatic reclosing time is two seconds. The Micro-embedded Generation Facility's protection and controls must be designed to coordinate with Hydro One's reclosing practices.

#### **2.4.12 Load Displacement**

Generation units that are non-exporting for the purpose of displacing load must ensure no

export of power from the Micro-embedded Generation Facility. A bi-directional meter will be required for all load displacement projects.

## 2.5 OPERATING REQUIREMENTS

MicroDER Facilities must comply with a number of operating requirements that Hydro One has in place to safeguard the reliability and integrity of the Distribution System. Compliance with the following operating requirements is required to protect the safety and reliability of Hydro One's distribution network. Failure to maintain industry acceptable facilities and maintenance standards may result in disconnection of the MicroDER Facility from the Distribution System, at Hydro One's discretion, in accordance with the requirements of the Distribution System Code and the Distribution Connection Agreement made between the owner of the MicroDER Facility and Hydro One.

### 2.5.1 Voltage Flicker

If high-voltage, low-voltage or voltage flicker complaints arise from other customers due to the operation of the Micro-embedded Generation Facility, Hydro One reserves the right, in accordance with the requirements of the Distribution System Code, to require that the Micro-embedded Generation Facility be isolated from the Distribution System until the problem has been resolved at the Micro-embedded Generation Facility Owner's cost, without compensation from Hydro One.

### 2.5.2 Voltage and Current Harmonics

- i. The MicroDER Facility shall not inject harmonic current that causes unacceptable voltage distortion on Hydro One's Distribution System. The current distortion limits shall apply to the PCC primarily based on harmonic producing loads. For installations with primarily IBRs, IEEE Std. 1547 and 2800 are applied. For installations where there is a mix of both loads and IBRs, the decision tree in Figure 1 in IEEE Std. 519 shows when IEEE Std. 519 limits shall apply.
  - a. The inductive values for some odd harmonic current emission limits are listed in CAN/CSA C61000-3-06 Table 2. The voltage THD planning level for 4-27.6kV/44kV system is 6.5%/3%.
- ii. The MicroDER Facility shall be able to operate within the voltage distortion/ compatibility levels as indicated in IEEE Std. 519 or CAN/CSA C61000-3-06, whichever is higher. The voltage Total Harmonic Distortion (THD) compatibility level for 4-27.6kV systems for long term/very short-term effects shall be 8%/11%. The THD level for 44kV systems shall be 5%.
- iii. The MicroDER Owner and/or Hydro One may be required to implement measures that will mitigate the harmonic distortions caused by the MicroDER Facility such as by adding harmonic filters, at the MicroDER Owner's sole expense.
- iv. The MicroTIR does not impose design limits to limit harmonic-caused telephone or telecommunications interference problems as it is almost impossible to predict. However, the MicroDER Owner shall make sure that the design complies with all applicable standards and shall not cause telephone or telecommunications interference.

### **2.5.3 Direct Current (DC) Injection**

The Micro-embedded Generation Facility shall not inject a direct current (dc) greater than 0.5% of its rated output current.

### **2.5.4 Discontinue Parallel Operation**

The Micro-embedded Generation shall discontinue parallel operation when requested by Hydro One after reasonable prior notice, except in an emergency, so that maintenance and/or repairs can be performed on the Distribution System.

### **2.5.5 Energization after Loss of Utility Supply**

The Micro-embedded Generation shall not energize the Distribution System after loss of utility supply until this supply has been restored for a minimum of five minutes. The Micro-embedded Generation Facility shall be designed to prevent the Micro-embedded Generation Facility from being energized to a de-energized Distribution System.

## **2.6 DERATED GENERATION**

A generation facility may be derated to reduce its maximum generation capacity to 12 kW or less in order to qualify as a Micro-embedded Generation Facility. The Customer must ensure that their Micro-embedded Generation Facility does not generate more than the capacity approved by Hydro One. Hydro One reserves the right to disconnect any Micro-embedded Generation Facility that fails to maintain its derating limit and generates more than its approved capacity.

A Micro-embedded Generation Facility shall meet the following conditions in DERCP Section 5.1 to receive Hydro One's approval for derating:

1. The derated capacity is clearly indicated on the equipment, adjacent to the nameplate,
2. Proper labeling must specify site-specific power and current values,
3. Documentation provided by the inverter manufacturer must state the maximum continuous derated output current in amperes, and
4. A restricted access protocol must be in place to prevent unauthorized capacity changes.

## **2.7 REVENUE METERING REQUIREMENTS**

Metering requirements vary with the type and intent of the Micro-embedded Generation Facility. Please consult the IESO Market Rules and Section 5 of the Distribution System Code for details. Hydro One has published a Metering policy for Micro-embedded Generation Facilities and it is located at the following link:

[https://www.hydroone.com/businessservices\\_/Documents/Hydro-One-Retail-Metering-Standards-Guide.pdf](https://www.hydroone.com/businessservices_/Documents/Hydro-One-Retail-Metering-Standards-Guide.pdf)

## **2.8 MAINTENANCE**

The Micro-embedded Generation Owner has full responsibility for routine maintenance of its Micro-embedded Generation Facility and keeping records of such maintenance to the recommendations of the equipment manufacturer and accepted industry standards, in

particular Ontario Electrical Safety Code (OESC), section 2-300.

Operation of interconnection system functions shall be verified according to the manufacturer's recommended schedule, or at least annually if there is no manufacturer recommendation. In particular, operating the disconnecting means and verifying that the Micro-embedded Generation Facility automatically ceases to energize the Distribution System and does not resume energizing until the Distribution System is stabilized after the disconnecting means is closed is required.

Failure to maintain OESC and industry acceptable facilities and maintenance standards can result in disconnection of the Micro-embedded Generation Facility.

## **2.9 MONITORING**

Hydro One reserves the right, at any time, to require monitoring of both existing and new MicroDERs using a method of its choosing to support Distribution System planning.

## **2.10 CONNECTION PROCESS REQUIREMENTS**

For Connection Process Requirements please visit:

<https://www.hydroone.com/business-services/generators/connection-process>

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### 3 REFERENCES

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These are the revisions reviewed and approved by Hydro One at the time of this standard's writing. Any changes to interconnection requirements due to future revisions will need to be reviewed by Hydro One.

1. **CSA C22.1:24**, *Canadian Electrical Code, Part I: Safety Standard for Electrical Installations (Ontario Electrical Safety Code)*, Canadian Standards Association, 2024.
2. **CSA C22.2 No. 107.1:16 (R2021)**, *General Use Power Supplies*, Canadian Standards Association, 2016, reaffirmed 2021.
3. **CSA C22.3 No. 9:20**, *Interconnection of Distributed Energy Resources and Electricity Supply Systems*, Canadian Standards Association, 2020.
4. **IEEE 1547-2018**, *IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces*, Institute of Electrical and Electronics Engineers, 2018.
5. **IEEE 1547.1-2020**, *IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces*, Institute of Electrical and Electronics Engineers, 2020.
6. **Ontario Energy Board**, *Distribution System Code (DSC)*, [Online]. Available: <https://www.oeb.ca/regulatory-rules-and-documents/rules-codes-and-requirements/distribution-system-code-dsc>
7. **Ontario Energy Board**, *Distributed Energy Resources Connection Procedures (DERCP)*, Version 1.0, March 22, 2022. [Online]. Available: <https://www.oeb.ca/sites/default/files/DER-Connection-Procedures-DERCP-20220322.pdf>
8. **UL 1741 SA**, *Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources*, Underwriters Laboratories, Supplement A, 2016 Edition.
9. **UL 1741 SB**, *Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources*, Underwriters Laboratories, 3rd Edition.
10. **UL 3141**, *UL LLC Outline of Investigation for Power Control Systems*, Underwriters Laboratories, 2nd Edition.