Micro-Generation / Distributed Energy Resource Interconnection Guide

UTILITY DISTRIBUTION SYSTEMS - ELECTRIC
February 2025

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Medicine Hat

LIMITATION OF LIABILITY AND DISCLAIMER

This document is not a replacement for electrical codes or other applicable code and standards.

This document is not intended or provided as a design specification or as an instruction manual.

The MG or DER owner, employees or agents recognize that they are, at all times, solely responsible for the generator plant design, construction and operation.

The City of Medicine Hat Electric (City Electric) and any person employed on its behalf, makes no warranties or representations of any kind with respect to the MG or DER requirements contained in this document, including, without limitation, its quality, accuracy, completeness or fitness for any particular purpose, and City Electric will not be liable for any loss or damage arising from the use of this document, any conclusions a user derives from the information in this document or any reliance by the user on the information it contains. City Electric reserves the right to amend any of the requirements at any time. Any person wishing to make a decision based on the content of this document should consult with City Electric prior to making any such decision.

The criteria and requirements in this guide are applicable to MG or DER facilities with a maximum rated generation capacity, as determined by the City, that use a single phase or three phase inverter, or stand-alone AC generator or combined heat and power generation systems, or energy and battery storage systems, to generate or inject or redistribute AC electricity that is in parallel with City Electric distribution system and have a nominal operating voltage as prescribed by City Electric for the MG or DER Point of Common Coupling (PCC).

Revision History

DATE	COMMENTS
January 2022	- New Document. - Additional information included on AESO ride-through requirements.
January 2023	- Revised Section 14.2 Machine-based DERs, Table 6, UV1 Clearing times. - Revised definitions.
March 2023	- Removed Section 7 Environmental Attributes. - Updated Section 4.3.3 Point of Disconnection. - Added Revision page. - Added Table of Contents page. - Revised definitions.
March 2024	- Evolution to TIR. - Additional definitions provided. - Available secondary system voltages and a new primary voltage table added. - Technical specifications included. - Transformer and grounding requirements added. - Communication Requirements added.
February 2025	- Added Limitation of Liability Statement and Disclaimer section. - Added Meter and Metering definitions. - Added Combined Heat and Power (CHP) systems generation. - Additional Technical Requirements added for Large Microgeneration. - Definitions per the AUC Microgeneration Regulation. - Split UL 1741 requirements for Supplement B (SB) compliances for Micro-generation above 150 kW. - New Definition of “System Owner” added. - Added ESS and BESS Definitions and Requirements.

Contents

Micro-Generation / Distributed Energy Resource Interconnection Guide

1 Scope

The intent of this Guide is to establish the Technical Interconnection Requirements (TIR) of micro-generation (MG) or a Distributed Energy Resource (DER) with the City of Medicine Hat Electric (City Electric) distribution system and provide direction with respect to the process of interconnection of a MG or DER. While every precaution has been taken in the preparation of this Guide, it may contain inaccuracies or inconsistencies. The authors of this Guide assume no liability for errors or omissions, or damages resulting from the use or reliance upon the information contained herein.

This Guide has been developed without regard to whether its adoption may involve patents on articles, materials, or processes. Such adoption does not assume any liability to any patent owner, nor does it assume any obligation whatsoever to parties adopting this Guide.

2 Purpose

This document is an interconnection application guide that applies to grid-dependent and grid-interactive inverter-based MG or DER or combined heat and power (CHP) systems, and also included energy storage systems (ESS) and battery energy storage systems (BESS).

It establishes minimum uniform requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection of MG or DER systems with City Electric distribution system and is based on the following principles:

- The addition of MG or DER systems to the distribution system will not appreciably change the distribution system and its characteristics.
- The inverter(s) must meet the requirements of this Guide.
- Users, owners, and operators of MG or DER systems need not be technical experts but should have an understanding of how to safely and properly operate their system.
- The installation shall meet the requirements of the latest version of the Canadian Electrical Code (CEC).
- Strict adherence to the CSA C22.1:24, Sections 64-800 to 64-1100 inclusive, is required for the installation and sizing of all ESS/BESS installations and no deviations will be permitted.
- CHP installations must meet the additional requirements as named below in the “Applicable Codes and Standards Section.
- MG or DER systems are deemed to be operating unattended.
- MG or DER installations shall require a permit from the City of Medicine Hat Safety Code Services or the authority having jurisdiction in the City of Medicine Hat Electric service area outside the corporate boundaries of Medicine Hat.
- City Electric personnel will need to be aware of the MG or DER system specifications, operating characteristics, and installed location, as well as changes to existing systems.

3 Applicable Codes and Standards

The following codes and standards are applicable for all electrical installations and MG installations:

- CAN/CSA C22.1 Canadian Electrical Code (CEC) Part 1 (latest or most current edition);
- Alberta Electrical Utility Code, (latest or most current edition);
- CAN/CSA-C22.2 NO. 107.1 - Power conversion equipment;
- IEEE 1547 - Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces;
- UL 1741 - Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources;
    - Note: UL 1741 Suppliment A (SA) and/or Suppliment B (SB) are now requirements for City Electric for any micro-generation above 150 kW;
- CSA/ANSI 13.1:22 - Combined heat and power appliances;
- CSA B149.1:20 - Natural gas and propane installation code; and
- CSA B149.3:20 - Code for the field approval of fuel-burning appliances and equipment.

4 General Interconnection Requirements

Safety is paramount in generating, transmitting and distributing electricity. The MG or DER interconnection installation must meet all applicable national, provincial and local construction and safety codes. Refer to Canadian Electrical Code Part 1. CSA C22.1, Sections 64 – Renewable energy systems, energy production systems, and energy storage).

The owner of a MG or DER is required to install, operate and maintain in good order and repair at all times, in conformity with good electrical practice, the equipment required by this Guide for the safe parallel operation with City Electric distribution system.

4.1 Distribution System

The inverters utilized shall be certified to meet this Guide's provisions, as detailed in this section, which defines the power quality and characteristics of City Electric system to which the MG or DER is interconnecting. It is the responsibility of the manufacturers and system owner to ensure that the inverter operates in this environment.

4.1.1 System Frequency

The distribution system operates at 60 hertz. Frequency deviations are typically 59.7 Hz to 60.2 Hz.

4.1.2 Secondary System Voltage

Nominal System Voltages	Recommended voltage variation limits for circuits up to 600V, applicable at service entrance			
	Operating Conditions			
	Extreme	Normal		Extreme
Single Phase				
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
Three Phase 4-conductor				
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
Three Phase 3-conductor				
240	212	220	250	254
480	424	440	500	508
600	530	550	625	635

Source: CSA C235, Table 2

4.1.3 Primary System Voltage

Nominal System Voltages	Recommended voltage variation limits City Electric four-wire multi-grounded primary system applicable at service entrance			
	Operating Conditions			
	Extreme	Normal		Extreme
Three Phase 4-conductor				
7.9/13.8 kV Y	6.9/12.17	7.2/12.64	8.19/14.31	8.35/14.55

4.2 MG or DER Equipment

4.2.1 Inverter Operational Settings Sheet

The MG or DER system owner needs to ensure that the inverter has an Inverter Operational Settings Sheet (IOS) document. The IOS document must certify that the inverter operates within the ranges specified in section 4.1 Distribution System. Both ride-though settings and maximum tripping times must be adhered together.

4.2.2 Synchronism

Inverters will automatically restart following automatic re-closing of distribution facility electrical equipment as per CSA-C22.2 NO. 107.1 (or other equivalent and recognized standard such as UL 1741). It will not be possible for City Electric to co-ordinate inverter restart. A synchronizing scheme does not need to be submitted for grid-dependent inverters. However, synchronism will be required for all stand-alone AC generators.

4.2.3 Voltage Regulation and Power Factor

The system owner shall be responsible for ensuring that the voltage levels at the point of interconnection are maintained within the guidelines prescribed by City Electric and/or at least equal to the voltage levels, at all feeder load conditions, prior to the interconnection. City Electric will decide if voltage regulation is expected to be a concern and identify possible solutions at time of application. The system owner is not required to be capable of adjusting the power factor but shall operate in the range of ±0.9. City Electric will not require the inverter to operate in a power factor control mode.

4.2.4 Frequency Control

The MG or DER shall have Under frequency or Over frequency protection that automatically disconnects the Micro-generator as per corresponding tables in section 15 Frequency Tripping Requirements.

4.2.5 DC Injection and Stray DC Current

Under no circumstances will DC injection or stray DC from a MG or DER facility be permitted to be impressed on the City Electric AC distribution system. If at any time, DC injection or stray DC current is detected, then City Electric will disconnect the MG or DER facility from the City Electric AC distribution until the MG or DER facility owner/operator can demonstrate that they have identified and removed the source of DC injection or stray DC current.

5 Protection Requirements

5.1 Interconnection Facility

5.1.1 Safety

Safety of personnel, the public, and equipment is of primary concern in the design of the interconnection. The inverter manufacturer or protection scheme designer shall certify that their inverter/relay isolates all sources of fault contribution from a faulted line or distribution element, blocks the transmission of harmonic currents and voltages; and protects the low voltage side from high fault current damage.

5.1.2 Point of Common Coupling (PCC)

The PCC will be considered to be the service entrance unless otherwise stated.

5.1.3 Point of Disconnection

External Disconnecting Means (EDM) - To enable City Electric personnel to work on their facilities and be capable of isolating from the distribution during maintenance and emergency conditions. A manual disconnecting means is required between City Electric facilities and the system inverter or AC generator. The system owner is responsible for installation of the disconnecting means. City Electric requires an EDM provided by the customer, which:

i. is capable of being energized from both sides;
ii. is clearly labeled as a MG disconnect switch;
iii. plainly indicates whether it is in the open or closed position;
iv. has provision for being locked in the open position (LOTO);
v. is accessible by City Electric personnel;
vi. is not located in a hazardous location;
vii. is capable of being opened at rated load;
viii. is capable of being operated without exposing the operator to any live parts, equipment or devices;
ix. is capable of being closed with safety to the operator with a fault on the system;
x. bears a warning to the effect that inside parts can be energized from sources on both sides when disconnecting means is open.; and
xi. 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.

The characteristics of this disconnecting means must comply with the CEC Part 1 and is subject to the approval of the authority having jurisdiction enforcing the CEC.

5.1.4 Interconnection Grounding

The MG or DER facility must be grounded in accordance with applicable codes. Refer to CEC Part 1. (Sections 10 – Grounding and bonding, 36 – High Voltage Installations, and 84 – Interconnection of electric power production sources).

The interconnection of the MG or DER facility, through equipment such as an interface transformer and/or external disconnect means, with the City Electric distribution system shall be compatible with the neutral grounding method in use on the City Electric distribution system and shall be effectively grounded.

Three-phase MG or DER facilities connecting to the City Electric four-wire multi-grounded primary feeders shall not cause the maximum “Temporary Over Voltage” (TOV) to exceed 130% of nominal line-to-ground voltages

5.1.5 Phase and Ground Fault Protection

The system owner shall use an inverter or protection scheme that detects faults or power outages occurring on all ungrounded conductors to which it is connected and then promptly ceases to energize such conductors and does not re-energize until at least 5 minutes after the normal voltage of City Electric system is restored.

The MG or DER system shall employ over-current protection in the interconnection equipment.

5.1.6 Overvoltage and Undervoltage Protection

Overvoltage and undervoltage protection as per corresponding tables in section 14 Voltage Tripping Requirements.

Provided that the inverter utilized by the MG or DER system is certified to CSA-C22.2 NO. 107.1 (or other equivalent and recognized standard such as UL 1741), the MG or DER system will not be required to install additional relays to trip the circuit breaker when the voltage, measured phase-to-ground is outside the predetermined limits. All non inverter type generation will require over & under voltage protection.

This recognizes:

- That the certification to CSA-C22.2 NO. 107.1 (or other equivalent and recognized standard such as UL 1741) guarantees and tests the appropriate protection functionality to operate on abnormal voltage.
- The MG and DER generating equipment operates automatically and unattended.
- The generating facility is not manually controlled nor operated by the system owner beyond being turned off and on

The inverter manufacturer shall indicate the time delay for reconnection after City Electric distribution system voltage and frequency return to normal range and are stabilized. Minimum time for reconnection to be 5 minutes as per CSA-C22.2 NO. 107.1. Non-interverter generation will have the same reconnection delay.

The system owner and City Electric will work together to arrive at a solution to any concerns about the voltage levels on the distribution facility.

The MG or DER system automatic reconnection will not be governed by any local operating orders that require manual reconnection upon authorization from City Electric.

5.1.7 Over frequency and Under frequency Protection

Over frequency and under frequency protection as per corresponding tables in section 15 Frequency Tripping Requirements.

5.1.8 Anti-Islanding

The MG or DER facility must be equipped with protective hardware and software designed to prevent the generator from being connected to a de-energized circuit owned by City Electric.

Certification of the MG or DER inverter by an accredited certification organization shall be deemed to meet the anti-islanding requirements of this Guide without any further assessment requirements

The system owner is responsible for any damage caused to his equipment or City Electric infrastructure resulting from improper operation of the Micro-generator's anti-islanding protection.

In spite of the above certification of inverters, it is recognized that the effect on anti-islanding schemes used by different inverters may require on-site testing and/or further evaluation when there is a mixture of generation connected to the same feeder.

5.1.9 Special Interconnection Protection

No special inverter-specific protection and controls, such as out-of-step or loss of synchronism, will be required as this requirement is addressed as a MG or DER Facility requirement.

Within the City Electric distribution system, the downtown network was designed for loading reliability or simply to supply loads. MG or DER installations were not a consideration for this design. Due to the unique protection system in the downtown network the City may request that no backflow (reverse power flow) onto this portion of the distribution system be allowed. This will be evaluated on a case-by-case basis.

City Electric recognizes that the generation system inverter and its manufacturer preset protection limits are the prime protection mechanism that the Micro-generator will be employing. No additional protection other than the ones specified in this Guide will be required.

For non-inverter AC Generation the minimum protections as per Table 1 - Single (1∅) & Three Phase (3∅) Synchronous and Induction. Additional protections may be required and are application and location-specific.

5.1.10 Flicker

The MG or DER system shall not cause objectionable flicker on the distribution system. It is recognized that flicker is a site-dependent condition. See CAN/CSA-C61000-2-2 and City Electric for specific site requirements.

5.1.11 Harmonics

The MG or DER system employing an inverter certified to CSA-C22.2 NO. 107.1 is assumed to comply with harmononic distortion limits of City Electric. It is recognized that voltage harmonicsare a site-dependent condition. Exceeding the limits may require the system owner or City Electric to take compensatory measures the cost of which would be borne by the system owner.

5.2 Typical Interconnection Requirements

An Inverter Operational Settings document shall be made available by the system owner to City Electric to determine if the interconnection equipment and settings are acceptable to its system requirements.

The interconnection equipment shall meet the required protective functions specified in the following sections.

5.2.1 Synchronous and Induction Generators

Table 1 - Single (1∅) & Three Phase (3∅) Synchronous and Induction, of this Guide shows the protective functions for synchronous and induction generators.

5.2.2 Single-Phase Inverters

Table 2 - Single Phase (1∅) Inverters InterconnectionTable 2 - Single Phase (1∅) Inverters Interconnection, of this Guide shows the protective functions required to meet this Guide. Inverters must be certified to CSA-C22.2 NO. 107.1 (or other equivalent and recognized standard such as UL 1741).

5.2.3 Three-Phase Inverters

Table 3 - Three Phase (3∅) Inverters Interconnection, of this Guide shows the protective functions required to meet this Guide. Inverters must be certified to CSA-C22.2 NO. 107.1 (or other equivalent and recognized standard such as UL 1741).

5.2.4 Mitigation of Protection Scheme Failure

If the protective device functions required in Table 2 - Single Phase (1∅) Inverters Interconnection and Table 3 - Three Phase (3∅) Inverters Interconnection are performed by the MG or DER control, then the MG or DER shall be designed to have self-diagnostic and fail-safe features. In case of failure of the MG or DERprotection function, the MG or DER shall automatically cease to operate in parallel with City Electric system.

5.2.5 Maximum Generator Power to be Exported

The MG or DER system output shall never exceed the maximum approved system size as determined by the City of Medicine Hat.

5.3 Interconnection Protection Approval

The system owner shall provide to City Electric complete inverter documentation for review against the requirements of this Guide and for potential impacts on City Electric distribution system.

The documentation should include:

- A completed MG or DER Application form,
- An overall description of the inverter and its protection functions, including the manufacturer, model, and Inverter Operational Settings document along with Independent Testing Laboratory certification documentation or equivalent documentation provided by the inverter manufacturer that describes its protection settings,
- A detailed single-line diagram.
- The disconnecting means details (i.e., manufacturer, model, and associated certification).
- The system owner shall revise and re-submit the inverter or protection information for any proposed modifications to the design.
- For CHP installations, information regarding fuel and, if applicable, exhaust control or systems, will also be required.

6 Communication, Monitoring and Control Requirements

Real-time or polled data to be provided to City Electric by the MG or DER facility is dependent on the output rating of the MG or DER Facility as listed below:

6.1 Small MG or DER utilizing 1∅ inverters.

MG or DER facilities shall have the provision for monitoring the disconnecting device at the PCC. A SCADA connection is not required unless otherwise specified by City Electric.

6.2 Small MG or DER utilizing 3∅ inverters.

MG or DER facilities shall have the provision for monitoring the disconnecting device at the PCC. A SCADA connection is not required unless otherwise specified by City Electric.

6.2.1 Small MG or DER Synchronous or Induction Generators.

MG or DER facilities shall have the provision for monitoring the disconnecting device at the PCC. A SCADA connection is not required unless otherwise specified by City Electric.

6.3 Large MG or DER utilizing 3∅ inverters.

A SCADA connection to City Electric shall be required. A provision for Real-time data is required, however, transmission of real-time data is not required at this time (unless otherwise specified by the City Electric Utility). City Electric reserves the right to request polled data through a data concentrator, like a SEL RTAC.

6.3.1 Large Synchronous or Induction Generators.

A SCADA connection to City Electric shall be required. A provision for Real-time data is required, however, transmission of real-time data is not required at this time (unless otherwise specified by the City Electric Utility). City Electric reserves the right to request polled data through a data concentrator, like a SEL RTAC.

Note: Data points and SCADA requirements will be provided by the City Electric SCADA communication team prior to MG facility 30% design phase.

7 Construction

7.1 General

The generation facility must be constructed and installed to meet all applicable regulations. All permitting and safety code requirements must be completed and copies of inspection reports must be provided to City Electric.

CHP installations will also need to be constructed to satify all municipal, provincial and federal building, fuel transport, fuel storage and fuel connection requirements regarding combustion or combustable materials.

The MG or DER system must be designed and installed by a qualified installer and system components meet the Canadian Standards Association requirements for electrical safety, or equivalent certification to applicable Canadian standards and must be grid connected in accordance with the Government of Alberta's Micro-Generation Regulation (AR27/2008), as amended from time to time. The minimum installation size requirement is 1.5 kilowatts (kW).

All Single-line Diagrams provided to City Electric shall be drawn in accordance with IEEE standards and conventions.

MG or DER installations must be preapproved by the City of Medicine Hat. A system size review is required and the installed system size must not exceed the maximum system size as determined by the City's review. System size is based on historic consumption for existing properties and on comparable sites for new construction. Any deviation from the approved system size (watts DC or watts AC) may result in the installation being considered non-compliant, which may delay the installation of the bi-directional meter until the situation is resolved.

8 Metering

8.1 General

Metering must comply with Measurement Canada requirements and the latest revision of City Electric Bylaw 2244.

Bi-directional metering shall be installed so that kWh (delivered) and kWh (received) are separately recorded.

8.2 Meter Requirements

For MG or DER systems the bi-directional billing meter will be supplied and installed by City Electic. Cost of metering equipment will be borne by City Electric, but labour, equipment and material associated with the installation of the metering equipment and commissioning will be charged to the customer.

9 Inspection

The system owner shall maintain a quality control and inspection program according to the recommendations of the inverter manufacturer.

In addition to the system owner's normal inspection procedures, City Electric reserves the right to witness any part of work that concerns the subject equipment; to inspect materials, documents and installation procedures, to witness tests and to evaluate results of non-destructive examinations.

The system owner shall supply City Electric with a complete set of detailed drawings and information, which will be used by City Electric to assist in the inspection during the testing of equipment.

10 Testing

10.1 Type Testing

Is performed or witnessed once by an independent testing laboratory for a specific protection package. Once a package meets the type testing criteria described in this section, the design is accepted by City Electric.

10.2 Verification Testing

Prior to completion of commissioning of a MG or DER system, or when interconnection system hardware or software is changed, a verification test shall be performed. City Electric reserves the right to witness verification testing or to require written certification that the testing was performed. All verification tests relating to the interconnection system prescribed by the manufacturer or developed by the Micro-generator that are agreed to by City Electric shall be performed prior to interconnection. The system owner shall maintain verification test reports for inspection by City Electric.

Any system that depends upon a battery for trip power shall be verified to be of fail-safe design by disconnecting the battery and verifying that the system ceases to energize the distribution system.

10.3 Protective Function Testing

The non-islanding function shall be checked by operating a disconnecting means to verify that the inverter ceases to energize its output terminals and does not restart for the required time delay after the disconnecting means is closed.

11 Marking and Tagging

The disconnecting means shall be clearly marked in accordance with the CEC Part 1. (Sections 64 – Renewable energy systems, energy production systems, and energy storage).

12 Maintenance

The system owner has full responsibility for routine maintenance of the Microgenerator's complete system, control and protective equipment up to and including the PCC in accordance with the manufacturer's recommendations, and the keeping of records for such maintenance.

The system owner must maintain the equipment to accepted industry standards. Failure to do so may result in disconnection of the micro-generator at the PCC.

13 Protection Function Requirements

13.1 Table 1 - Single (1∅) & Three Phase (3∅) Synchronous and Induction

ANSI Device#	Protection Function	Required
52 or 89	Circuit Breaker or Interconnection Switch	X
25/25A	Synchronizing check	X
27	Undervoltage Relay	X
50	Instantaneous Overcurrent Relay	X
51	AC Time Overcurrent Relay	X
59	Overvoltage Relay	X
78V	Out-of-Step / Vector shift**	X
81O	Over Frequency	X
81U	Under Frequency	X
81R	Rate-of-Change Frequency*	X
-	Additional Elements	If Required

* May be provided by magnetic circuit breakers or fuses.

** May be required for export applications where passive anti-islanding protection is an option.

Notes:

1. To be in accordance with the Canadian Electrical Code.
2. Exporting to City Electric system may require coordination of operations with City Electric.
3. All elements used must be shown on the SLD.

13.2 Table 2 - Single Phase (1∅) Inverters Interconnection

Function	ANSI Device#	Protection Function	Required
E.g. "AC Source Disconnect"	-	Inverter Disconnect Means	X
-	25	Automatic Synchronizing*	X
-	27	Undervoltage Relay	X
-	51	AC Time Overcurrent Relay	X
	59	Overvoltage Relay	X
-	81O	Over Frequency	X
-	81U	Under Frequency	X
AI	-	Anti-Islanding**	X
-	-	Additional Elements	If required

* For inverters with standalone capability.

** As required in section 5.1.8 - Anti-Islanding.

Notes:

1. To be in accordance with the Canadian Electrical Code.
2. Exporting to City Electric system may require coordination of operations with City Electric.
3. All elements used must be shown on the SLD.

13.3 Table 3 - Three Phase (3∅) Inverters Interconnection

Function	ANSI Device#	Protection Function	Required	# of Phases to be Monitored
E.g. "AC Source Disconnect"	-	Inverter Disconnect Means	X	3
-	25	Automaitc Synchronizing*	X	1
-	27	Undervoltage Relay	X	3
-	50	Instantaneous Overcurrent Relay	X	3
-	51	AC Timed Overcurrent Relay	X	3
-	59	Overvoltage Relay	X	3
-	81O	Over Frequency	X	3
-	81U	Under Frequency	X	3
AI	-	Anti-Islanding**	X	3
-	-	Additional Elements	If Required	-

* For inverters with standalone capability.

** As required in section 5.1.8 - Anti-Islanding.

Notes:

1. MG facilities must ensure that upon loss of voltage in one or more phases of the main 3Ø supply, the generator shall:
   - be automatically disconnected from the system; and
   - not be reconnected until the normal voltage on all 3Ø of the main 3Ø supply system are restored.
2. To be in accordance with the Canadian Electrical Code.
3. Exporting to City Electric system may require coordination of operations with City Electric.
4. All elements used must be shown on the SLD.

14 Voltage Tripping Requirements

14.1 Inverter-based DERs

14.1.1 Table 4 - Mandatory Voltage Tripping Requirements

Trip function	Default Settings	
	Voltage (% of nominal voltage)	Clearing times (s)
OV2	120	0.16
OV1	110	2.0
UV1	88	10.0
UV2	45	0.16

Source: AESO - DER Ride-Through Performance Recommendations, Table 3 (June 2022)

14.1.2 Table 5 - Voltage Range Tripping Capability

Voltage range (% of nominal voltage)	Minimum ride-through time (s) (design criteria)	Maximum response time (s) (design criteria)	Response
V > 120	N/A*	0.16	Cease to energize
117.5 < V ≤ 120	0.2	N/A	Mandatory operation
115 < V ≤ 117.5	0.5	N/A	Mandatory operation
110 < V ≤ 115	1	N/A	Mandatory operation
88 ≤ V ≤ 110	Infinite	N/A	Continuous operation
65 ≤ V < 88	Linear slope of 8.7s/1p.u. voltage starting at 3s@0.65p.u.: $T_{VTR} = 3s + \frac{8.7s}{1p.u.}(V - 0.65p.u.)$	N/A	Mandatory operation
45 ≤ V < 65	0.32	N/A	Mandatory operation
30 ≤ V < 45	0.16	N/A	Mandatory operation
V < 30	N/A*	0.16	Cease to energize

* Cessation of current of DER in not more than the maximum specified time and with no intentional delay. This does not necessarily imply disconnection, isolation, or a trip of the DER.

Source: AESO - DER Ride-Through Performance Recommendations, Table 4 (June 2022)

14.2 Machine-based DERs

14.2.1 Table 6 - Mandatory Voltage Tripping Requirements

Trip function	Default Settings	
	Voltage (% of nominal voltage)	Clearing times (s)
OV2	120	0.16
OV1	110	2.0
UV1	88	2.0
UV2	45	0.16

Source: AESO - DER Ride-Through Performance Recommendations, Table 5 (June 2022)

14.2.2 Table 7 - Voltage Range Tripping Capability for Machine-based DERs

Voltage range (% of nominal voltage)	Minimum ride-through time (s) (design criteria)	Maximum response time (s) (design criteria)	Response
V > 120	N/A*	0.16	Cease to energize
117.5 < V ≤ 120	0.2	N/A	Mandatory operation
115 < V ≤ 117.5	0.5	N/A	Mandatory operation
110 < V ≤ 115	1	N/A	Mandatory operation
88 ≤ V ≤ 110	Infinite	N/A	Continuous operation
70 ≤ V < 88	Linear slope of 4s/1p.u. voltage starting at 0.7s@0.7p.u.: $T_{VTR} = 0.7s + \frac{4s}{1p.u.}(V - 0.7p.u.)$	N/A	Mandatory operation
50 ≤ V < 70	0.16	N/A	Mandatory operation
V < 50	N/A*	0.16	Cease to energize

* Cessation of current of DER in not more than the maximum specified time and with no intentional delay. This does not necessarily imply disconnection, isolation, or a trip of the DER.

Source: AESO - DER Ride-Through Performance Recommendations, Table 6 (June 2022)

15 Frequency Tripping Requirements

15.1 Table 8 - Mandatory frequency tripping requirement for DERs

Trip function	Default Settings	
	Frequency (Hz)	Clearing times (s)
OF2	62.0	0.16
OF1	61.2	300.0
UF1	58.5	300.0
UF2	56.5	0.16

Source: AESO - DER Ride-Through Performance Recommendations, Table 7 (June 2022)

15.2 Table 9 - Frequency tripping for DERs

Frequency range (Hz)	Minimum ride-through time (s) (design criteria)
f > 62.0	N/A
61.2 < f ≤ 62.0	299
58.8 < f ≤ 61.2	Infinite*
57.0 < f ≤ 58.8	299
f ≤ 57.0	N/A

* Applicable only for a per-unit ratio of voltage/frequency limit of V/f ≤ 1.1.

Source: AESO - DER Ride-Through Performance Recommendations, Table 8 (June 2022)

15.3 Table 10 - Parameters of Frequency-Droop (Frequency/Power) for inverter-based DER

Parameter	Default Settings
db_{OF}, db_{UF} (Hz)	0.036
k_{OF}, k_{UF}	0.05
$T_{response}$ (s)	5

Source: AESO - DER Ride-Through Performance Recommendations, Table 9 (June 2022)

16 Appendix – Definitions

The following terms are defined here to assist in the understanding of MG. Though some of these terms are not used in this Guide, they may arise in discussions of MG systems and so would be useful to understand.

Alternating Current (AC) - Electric current that regularly reverses its direction of flow, which in Canada is at 60 times per second.

Anti-Islanding – Is safety technology in a MG system that prevents it from feeding electricity into a distribution system during a utility electrical outage. Its purpose is to protect utility workers from working on a live distribution system.

Battery Energy Storage System (BESS) - A device or system used to hold energy after it has been generated using an electrochemical process. A BESS is an ESS (See definition for ESS). Depending on the application, various chemistries are available from lithium-ion (Li-Ion) to lead-acid (Pb-Acid) and others. A BESS is more than a simple battery, as it can monitor its condition and state of health (SOH) and report its state of charge (SOC) using power electronics and a Battery Management System (BMS).

Bi-Directional Cumulative Meter - Electricity-measuring device that measures in two separate data points the total electricity that has flowed in a circuit from one reading date to the next. One data point shows the amount of electrical energy that has been exported to the grid. The other data point shows the amount of electrical energy that has been imported from the grid.

Clearing Time - The time between the start of an abnormal condition and the DER ceasing to energize City Electric. It is the sum of the detection time, any adjustable time delay, the operating time plus arcing time for any interposing devices (if used), and the operating time plus arcing time for the interrupting device (used to interconnect the DER with City Electric).

Coefficient of Grounding (COG) - The ratio ELG/ELL expressed as a percentage, where:

- **ELG -** is highest root-mean-square (rms) line-to-ground power-frequency voltage on a sound phase, at a selected location, during a fault to earth affecting one or both of the other two phases.
- **ELL -** is to the line-to-line power-frequency voltage that would be obtained, at the selected location, with the fault removed.

Combined Heat and Power (CHP) generator - A form of generation where both electric power and thermal energy (typically for heating) are produced from a single energy source. This allows heat that would normally be lost in typical power generation to be recovered to provide heating. This is often also referred to as cogeneration.

DC Injection - Power electronic converters (inverters or rectifiers) are potentially capable of injecting DC currents into the utility's ac power system which can impact safety and reliability adversely unless adequately managed at the source.

Direct Current (DC) - Electric current that flows in one direction. Photovoltaic modules and battery systems operate using DC current.

Disconnecting Means - A device which disconnects a circuit from its source of supply.

Distributed Energy Resource (DER) - A source of electric power that is not directly connected to a bulk power system. DER includes both generators and energy storage technologies capable of exporting active power to an electric power system. DER includes DG and MG.

Distributed Generator (DG) - Power generators that are connected to a distribution system through a Point of Common Coupling (PCC).

Distributed Generator Source Disconnect - A disconnecting switch placed between a generator's output terminals and the wiring of its electrical loads and a distribution system.

Distributed Generator System Disconnect - A disconnecting switch placed between a generator's output terminals and a distribution system required to ensure the safety of electrical utility workers.

Effectively Grounded - A system grounded through sufficiently low impedance so that COG does not exceed 80%. This value is obtained approximately when, for all system conditions, the ratio of the zero-sequence reactance to the positive-sequence reactance, (X0/X1), is positive and ≤ 3, and the ratio of zero-sequence resistance to positive-sequence reactance, (R0/X1), is positive and < 1.

Energy Storage System (ESS) - A device or system used to hold energy after it has been generated. An ESS can store mechanical or chemical energy or a combination of both. An ESS can be considered a form of battery.

Flicker - A perceptible change in electric light source intensity due to a fluctuation of input voltage. (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 which is 60 Hz in North America. Harmonics create electrical noise in electrical systems.

Generator - Device that converts energy from one form into electrical energy.

Generator Rated Capacity (W, kW or MW) - Basic measurement unit for electrical power. It is the amount of electrical power that is produced by a generator at a defined set of operating conditions. A Wh is simply the energy produced by the system. It is the rate (measured in watts) at which electrical power flows in a circuit multiplied by the time (measured in hours) that the power is flowing at that rate. For example, one kWh equals 1,000 watts flowing for one hour and one MWh equals 1,000 kilowatts flowing for one hour.

Grid-Connected Inverter - Inverter that can operate in parallel with a distribution system.

Grid-Dependent Mode - An inverter which automatically ceases to operate upon loss of voltage from City Electric and resumes operation when City Electric voltage is restored.

Grid-Interactive Mode - An inverter which operates in parallel with City Electric and contains provision for synchronizing with City Electric.

Inverter - An electronic device that converts DC electricity into AC electricity and acts as the interface between your electricity generator and the City of Medicine Hats' electrical distribution system. Electricity from your generator (solar PV, fuel cells, wind turbines, etc.) is converted to a form that can be supplied to the utility grid.

Islanding - A condition in which a portion of City Electric is energized by a MG or DER facility through a PCC while that portion of City Electric is separated from the rest of City Electric distribution system. Islanding is not permitted in Alberta.

LOTO – Lockout/Tagout - This is a safety procedure used in industrial and maintenance settings to ensure the safe isolation of energy sources during maintenance, repair, or servicing of equipment or machinery. The primary goal of lockout/tagout is to prevent the unexpected startup of machinery or equipment, which could pose a serious risk to the safety of workers performing maintenance tasks.

Local Distribution Company (LDC) - is a service provider that offers delivery and distribution services for a range of energy products and energy services in a specific region. In the City of Medicine Hat, the LDC is Utility Distribution Services (UDS) – electric or "City Electric". **Meter -** The meter supplied by the LDC to measure the energy either produced or consumed at a site. Meters are installed at the Service Entrance to measure the energy transitioning from the LDC to the customer or from the customer to the LDC. All meters supplied by the LDC must be Measurement Canada approved and tested. For any generation applications the meter will be either:

- A **bi-directional cumulative meter -** which means a metering device or devices that measure the total electricity that has flowed in a circuit from one reading date to the next in each of 2 opposite directions, and that store in separate data registers the data respecting the flow of electricity in each direction; or
- A **bi-directional interval meter -** which means a metering device or devices that measure the total electricity that has flowed in a circuit during defined intervals in each of 2 opposite directions, and that store in separate data registers the data respecting the flow of electricity.
- **Metering in Canada** is governed by two pieces of federal legislation: the Weights and Measures Act (WMA) & the Electricity & Gas Inspection Act (EGIA) as well as the Canadian Electrical Code, which is a standard. Metering for electrical energy measurement will typically fall into two categories, either: **Net metering** allows electric energy generated by a consumer from an eligible on-site facility to offset energy from the utility during billing
- **Bi-directional metering** measures both delivered/imported and received/exported power, commonly used in renewable applications

Micro-Generator (MG) - Micro-generators producing excess electricity receive credits for what they feed to the grid. They are either;

- Small micro-generators that have a total nameplate capacity of less than 150 kW; or
- Large micro-generators that have a total nameplate capacity of at least 150 kW but not exceeding 5 MW.

Small micro-generators are typically, a residential or small commercial generator with a capacity less than or equal to one MW that is connected to the electrical distribution system. Whereas Large micro-generators are typically institutional or commercial generators. The electricity produced is for use within the facility and it is generally expected that on an annual basis generation will be less than consumption.

Micro-Generation Unit - is a generating unit of a customer or an energy storage resource of a customer that stores or discharges electric energy produced by the customer's generating unit that:

- exclusively uses sources of renewable or alternative energy to supply electric energy,
- is intended to meet all or a portion of the customer's total annual energy consumption at the customer's site or aggregated sites, and
- has a total nameplate capacity that does not exceed the lesser of 5 MW or the rating of the customer's service,

Point of Common Coupling (PCC) - The point where the supply authority's system is connected to the power producer's facilities or conductors.

Ride-Through - The ability to withstand voltage or frequency disturbances inside defined limits and to continue operating as specified.

SCADA - Supervisory Control and Data Acquisition. This is the control system that City Electric uses to monitor and control all the conditions and operational aspects of the AC distribution system.

Single-Phase (1∅) System - In an AC electrical distribution system, refers to the distribution of electricity with the use of one phase or hot wire and a neutral wire or two of the same phase wires and a neutral wire. The voltage is typically referred to as phase-to-ground, or phase-to-neutral voltage. Typical examples of 1∅ are 120 V (for a line-to-neutral/ground voltage), or 240 V (for two of the same 120 V phase wires and 1 neutral). Most residences and small appliances are 1∅.

Single-Phase (1∅) Inverter - An inverter that generates a single-phase electrical output.

Solar Photovoltaic (PV) Generator - Generator that uses solar radiation as its energy source.

Stand-Alone Mode - An inverter which operates in isolation from the City of Medicine Hat Electric Distribution System (City Electric).

Synchronous Inverter - Electrical inverter that changes direct-current (DC) electricity to alternating-current (AC) electricity.

System Owner - An individual, company or corporation that has direct care, control and responsibility for a MG or DER facility and installation. The system owner may delegate operating authority of the MG or DER to a 3rd party, but still bears full responsibility for the MG or DER facility and installation.

Three-phase (3∅) System - In an AC electrical distribution system, refers to the distribution of electricity with the use of three phase or hot wires and a neutral wire or simply three phase wires without a neutral wire. The voltage is typically referred to as phase-to-phase or line-to-line but can be expressed as phase-to-neutral or line-to-neutral. The three phases are 120° out of phase with each other but are equal in magnitude with each phase being distinctly identified by a letter (ABC) or colour (RED-WHITE-BLUE or RED-BLACK-BLUE). Typical examples of 3∅ are 208, 480, 600 V, 13.8 kV, 69 kV and 138 kV (for a line-to-line voltage), and can also be expressed as 120, 277, 347 V, 7.9 kV, 39.8 kV and 79.7 kV (line-to-neutral voltage). Large customers and medium to high voltage electricity distribution is done via 3∅ .

Three-phase (3∅) Inverter - An inverter that generates a three-phase electrical output.

Temporary Over Voltage (TOV) - An oscillatory phase-to-ground or phase-to-phase overvoltage at a given location of relatively long duration (seconds, even minutes) and that is un-damped or only weakly damped. Temporary over-voltages usually originate from switching operations or faults (for example, load rejection, single-phase fault, fault on a high-resistance grounded or ungrounded system) or from nonlinearities (ferro-resonance effects, harmonics), or both. They are characterized by the amplitude, the oscillation frequencies, the total duration, or the decrement.

Total Harmonic Distortion (THD) - The ratio of the rms value of the sum of the squared individual harmonic amplitudes to the rms value of the fundamental frequency of a complex waveform.

Trip - Cessation of output without immediate return to service; not necessarily disconnection.

Voltage-Following Inverter - An inverter in which the output follows the waveform of an external device.

Wheeling (electric power transmission) - Is a Service where the transportation of electric energy (megawatt-hours) from within an electrical grid to an electrical load outside the grid boundaries. In a simpler sense, it refers to the process of transmission of electricity through the transmission lines. Since the wheeling of electric energy requires use of a transmission system, there is often an associated fee which goes to the transmission owners.