NET METERING PROGRAM

Technical Interconnection Requirements

June 2020

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INTRODUCTION

Qulliq Energy Corporation (QEC) operates in Nunavut and is the sole provider of electrical power to Nunavummiut. All electrical needs are met by imported fossil fuels. To counter-balance the effects of fossil fuels and reduce dependency on diesel, QEC has developed a Net Metering Program to allow for the introduction of renewable energy into the communities. This program will allow for renewable generators to connect to the community's grids in a safe and reliable manner without jeopardizing the reliability and security of the existing distribution network.

This document is intended to help net metering customers to understand their role, responsibilities and technical requirements when connecting to QEC's distribution system as a renewable energy generator such as PV and wind etc.

Customers are encouraged to evaluate the amount of energy they expect to produce and the economics of the project to determine the net metering customer's overall cost of electricity in line with this document.

This document addresses the technical interconnection requirements. It does not address the system design requirements of the net metering customer.

For definitions and terms appearing in this document refer to Appendix A.

PURPOSE

The primary purpose of this guideline is to ensure that renewable generation interconnections do not adversely impact the power quality or reliability of the QEC system and neighboring customers, the safety of QEC personnel or the general public working in the generating facility/distribution system.

These guidelines establish criteria and technical requirements for interconnection of the renewable generator with the secondary side of QEC's distribution systems operating at a voltage of 600 volts or lower (Appendix D). These requirements include operation, testing, maintenance and safety considerations of a renewable generation interconnection.

SCOPE

These technical requirements for interconnection apply to micro renewables where the total nominal (nameplate) generation is 10 kW (AC) or less with a maximum limit of 12 kW (DC) for single phase or three phases system (DC to AC ratio ≤ 1.2).

This document outlines protection and control, engineering standards, and operational requirements that must be followed to successfully connect to QEC's electrical system in a safe and practical manner.

This document is not an operating agreement and as such, does not address:

a. Contractual arrangements.
b. Additional network connections, protection of the net metering customer's other equipment, and upgrades,
c. Planning, design, and operation of the distribution system,
d. Interconnection of renewable resources and distribution systems that are not connected to QEC's distribution system/ grid, allowing remote off grid (Standalone) system.

LIMITATIONS

The technical requirements in this document are applicable to all renewable generation technologies and to the secondary voltages (≤ 600 V) of the electric power in a distribution system. The main focus of this document is for the installation of a renewable generator on the secondary side of the distribution system. The requirements for renewable generation shall be met at the service entrance although the location of the protective devices may not necessarily be at that point.

The interconnection guideline is a minimum requirement for the interconnection of a renewable generator. Net metering customers and QEC have to meet additional requirements to ensure that the final interconnection design meets all local and national standards and codes, and that the design is safe for the intended application.

LIABILITY

Guidelines in this document do not address any liability provisions agreed to elsewhere such as in interconnection and operating agreements between the net metering customer and QEC.

Net metering customers are also responsible for making changes to the net metering customer's facilities as required to meet new or revised standards or due to system changes. In addition, when advised by QEC, the net metering customer will make changes requested by QEC to the net metering customer's facilities. Therefore, the net metering customer must make provision to accommodate such changes efficiently. The net metering customer shall be responsible for the cost of any required changes, including those changes requested by QEC.

This guideline does not absolve the net metering customer of responsibility to maintain their equipment and to protect their equipment, QEC's equipment and personnel, and public safety as applicable.

SAFETY

Safety is a paramount requirement in generating, transmitting and distributing electricity at QEC. Renewable generation facilities must meet all applicable federal, territorial, and local construction, operation and maintenance related safety codes, including the Canadian Electrical Code, Nunavut Electrical Protection Act, and Nunavut Safety Act, etc.

All installations must conform to the Canadian Electrical Code Part 1 (CSA C22.1-02) and all QEC amendments where applicable.

All installations must be inspected by an Electrical Inspector with the Government of Nunavut Safety Services Division.

QEC OPERATION

QEC operates and maintains 25 isolated power systems across Nunavut. These systems are purely radial distribution grade feeders tied directly to generation bus networks at each power plant. There is no bulk transmission of power over transmission or sub-transmission lines and terminal stations. Diesel generation is the prime power source for these systems.

For best fuel efficiency, diesel generator systems are operated at optimum load to the fullest extent possible. This creates low spinning reserves and consequently low fault current levels within the respective power system. Sudden load swings or loss of generation capacity, can result in load shedding that impacts customer power quality elements, such as voltage sag, frequency drop, or complete outage time and can cause system operating reliability issues.

Overall diesel power systems require well-coordinated protection and control system to mitigate adverse effects on the power system. When a supplier is suddenly disconnected from the distribution system the result could be high speed load shedding to maintain system stability and consequently outage time to the net metering customer.

GENERAL TECHNICAL REQUIREMENTS

This section provides the technical interconnection requirements. The renewable 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 responses to abnormal conditions are also listed.

Point of Interconnection (POI)

Net metering will only be available to customers on the secondary side of QEC's distribution system.

For QEC service voltage on secondary side (120 volts to 600 volts), the net metering customer shall ensure that metering and isolation devices for net metering customer's equipment is located within five meters (horizontal) of the service entrance.

Technical Compatibility Requirements

QEC will review the renewable generator technical characteristics with respect to the following requirements before any renewable energy generation system installation is started by the proponent (future applicant or customer).

Customer Specific Requirements

Any measures necessary to meet these requirements will be at the net metering customer's cost. QEC will not provide a transformer and or any other equipment for the sole purpose of connecting net metering customers' generator to the distribution system.

a. The renewable generator shall not exceed 80% of the total capacity of the customer's existing electrical service. To meet this requirement, the customer's existing electrical service may need to be upgraded.
b. The renewable generator operating voltage range must be compatible with the standard service voltage range. The type and voltage of the renewable generator must be matched with existing power connection to the customer.
c. In order for the voltage to remain within the limits of Table 1 (Appendix D) under all system operating conditions, the total connected renewable generation system shall not cause the voltage rise on the secondary service conductor to exceed 1% of operating voltage. To meet this requirement, re-routing or replacement of the service drop may be required.
d. QEC shall not allow net metering interconnection to primary side of QEC's distribution system.

Operating voltages

QEC operating voltages are presented in Table 1 of Appendix D.

System Grounding

The renewable generation system must be grounded in accordance with applicable codes and manufacturer's recommendations. The net metering customer shall note the permafrost conditions and provide the grounding as necessary. The net metering customer shall refer to QEC grounding and bonding requirements and provide a compatible grounding system to prevent over voltages during phase-to-ground fault.

Transformers

a. 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 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 higher rating at applicant / customer cost. Transformers rated 50 kVA or higher may use 100% of the transformer nameplate rating for the total connected generation capacity.
b. For renewable generation 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 higher rating at applicant / customer cost.

System Requirements

a. Community limits for the total amount of power from net metering are set as calculated by QEC. Also the total generation to be connected to a distribution system circuit line section shall not exceed 7% of the annual feeder section average peak load (average peak based on last twelve months peaks). Feeder section peak load refers to the section of line to which the renewable generator connection is proposed, including all downstream lines on the same phase(s) and the line upstream to the nearest automatic reclosing protective device.
b. The total interconnected generation, including the proposed generator, will not cause any disturbance to protective devices (including but not limited to breakers, fuse cutouts, etc.) 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.
c. The total generation to be interconnected to the distribution system, including the proposed generator, must respect limitations on the distribution system identified by QEC.

Protection and Control Requirements

This section outlines protection and control requirements related expectations from renewable generation facilities. Net metering customers must make themselves aware of these requirements to protect their and QEC systems against damage.

Interrupting Device

An interrupting device (e.g. circuit breaker) is required to automatically disconnect from all ungrounded conductors of the distribution system that the net metering customer's generator source feeds in accordance with CSA C22.1 Section 84. This is required to ensure safety

and mitigate the risk of damage to the equipment of others.

Overcurrent Protection

Equipment and conductors that are energized from both directions shall be provided with over-current protection from each source of supply. The renewable generation system shall detect and promptly cease to energize for overcurrent fault conditions in the net metering customer's facility.

Ground Fault Protection

Ground fault protection shall be provided in accordance with standards set by the Government of Nunavut Safety Services Division.

Abnormal System Voltage Protection

The net metering customer's facility (generator) shall disconnect from QEC's distribution system at abnormal voltage levels and clearing times specified in Table 2 in Appendix D.

Abnormal System Frequency Protection

The net metering customer's facility (generator) shall disconnect from QEC's distribution system at abnormal frequencies and clearing times specified in Table 3 in Appendix D.

Synchronization

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%. This is achieved by different means, depending on the type of proposed generation and is to be achieved by net metering customer.

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 net metering customer's renewable generator and the distribution system voltage waveform are within the following limits:

a. Frequency difference less than 0.3 Hz
b. Voltage magnitude difference less than 10 percent
c. Phase angle difference less than 20 degrees
(Source : IEEE 1547-2018 – Table 5)

System Protection

The net metering customer shall be responsible for protection of their equipment and shall not cause damage to, and/or adversely affect, other distribution system connected customers for all QEC distribution system operating conditions whether or not their renewable generator is in operation. Conditions may include but not limited to:

a. Distribution system faults
b. Abnormal voltage or frequency excursions
c. Transient voltage due to lightning, load fluctuations and switching
d. Equipment failures
e. Loss of a single phase of supply (for three-phase generators)
f. Excessive harmonic and negative sequence voltages
g. Synchronizing generation
h. Re-synchronizing the generation after QEC restores supply. The customer shall certify that the system cannot inject power on the distribution system when QEC distribution system is not stabilized.
i. Islanding; Separation from supply

Anti-islanding

The inverter of the renewable generator shall have built-in anti-islanding functionality that is compatible with all applicable codes and standards.

The inverter's anti-islanding functionality shall not have the ability to be reprogrammed or disabled. Inverter anti-islanding functionality shall not be programmed or disabled in any case if they are field programmable

The renewable generator shall cease to energize QEC system within two seconds of the formation of an island on the distribution system as per CSA C22.2 No. 257-06.

QEC considers that the equipment certified with Certificate CSA C22.2 No. 107-1-01 Section 15 meets this requirement.

Shared Transformer

The net metering customer shall co-ordinate for the following with QEC and other customers sharing the same distribution transformer:

a. In case of fire in premises of any customer fire fighter/QEC may disconnect all the customers sharing the transformer.
b. The net metering customer to adapt the overcurrent protection/settings as required for co-ordination with customers sharing the same transformer.

OPERATING REQUIREMENTS

All systems shall meet all applicable standards (Appendix B), QEC requirements (outlined here in this document including other related) and all expectations laid out by the Government of Nunavut Safety Services Division.

System Integrity

Compliance in respect of the following is required to ensure the safety and reliability of QEC's distribution system. Failure to maintain industry acceptable protocols and maintenance standards may result in disconnection of the facility from the distribution system, at QEC's discretion.

Voltage Stability

If high-voltage, low-voltage or voltage flicker complaints arise from other customers due to the operation of the renewable generation facility, QEC reserves the right to require that the renewable generation facility be isolated from the distribution system until the problem has been resolved at the net metering customer's cost, without compensation by QEC.

Harmonics

The renewable generation facility shall not inject harmonic current that causes unacceptable voltage distortion on QEC's Power Distribution System. The total harmonic distortion of the output current/voltage over the entire Renewable generation for operating range shall be less than 5% of the rated fundamental current and less than 8% of the rated fundamental voltage (as per CSA Standard in Appendix B). Individual harmonics shall not exceed the limits stated in Appendix D, expressed in relation to rated fundamental current and voltage.

DC Current Injection

The renewable generation facility shall not inject a direct current (dc) greater than 0.5% of its rated output current as per CSA C22.2 No. 107.1.

Voltage regulation

The renewable generator shall not attempt to regulate voltage and shall not affect voltage at the PCC.

Flicker

The renewable generator shall not exceed the compatibility levels of voltage flicker presented in Appendix D.

Voltage unbalance

The renewable generator shall not exceed the compatibility levels of voltage unbalance presented in Appendix D.

METERING

A bi-directional meter is required for the net metering installation to measure the load consumption and power generation. QEC will be responsible for the purchase and install of the bi-directional meter.

For typical metering arrangements used for the Net Metering Program, refer to Appendix E.

OPERATION AND MAINTENANCE

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 renewable 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 QEC and industry acceptable facilities and maintenance standards can result in disconnection of the renewable generation facility.

The renewable generator shall discontinue parallel operation when requested by QEC after reasonable prior notice so that maintenance and/or repairs can be performed on the distribution system.

The renewable generator shall not energize the distribution system after loss of utility supply until this supply has been restored for a minimum of five minutes. The renewable generation facility shall be designed to prevent the renewable generator from being connected/energized to a de-energized distribution system.

For safety reasons, backup or emergency generators must utilize either open transition switching in order to ensure no back feed or closed transition, which must not be greater than 100 ms (6 cycles). This is a critical safety requirement. Therefore, QEC prefer open transition over close transition.

NET METERING APPLICATION REQUIREMENTS

Updated list of the documents required for the net metering application can be found on QEC website or can be requested on from QEC engineering department servicedesk@qec.nu.ca.

APPENDIX A: DEFINITIONS

Anti-islanding: A protective functionality aimed at preventing the continued existence of an unintentional electrical island (see “Islanding” below) to avoid safety concerns and potential damage to customer equipment. The renewable generator system shall cease to energize the utility distribution system after the formation of an unintentional island (i.e. for inverter-based generations the inverter shall meet the anti-islanding requirements of CSA C22.2 No. 107.1). Anti-islanding equipment shall not be reprogrammed or disabled.

Approved Electrical Equipment: Equipment that bears CSA certification mark.

Combiner box: A box used in solar PV installations to combine multiple PV source circuits into one PV output circuit. A combiner box may also contain PV generator overcurrent devices.

Customer /Net Metering Customer: Means any person, partnership, corporation, or any other entity, whether public or private, who obtains distribution service at a customer delivery point and who is a customer of record of QEC for its own electricity consumption.

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.

Renewable Generation Source Disconnect: Disconnecting means to disconnect the renewable generation source from the equipment that it supplies.

Renewable Generation System Disconnect (Utility Disconnect): Disconnecting means to disconnect the Renewable generator from the utility distribution system. This disconnect shall be outside readily accessible to QEC staff, fused, visible break and lockable. This disconnect ensures the safety of electrical utility workers by allowing them to disconnect the generator from the utility system in case they have to service or repair the electrical supply to net metering customer home, farm or business. Also referred to as “utility disconnect”.

Disconnecting means: A device, group of devices, or other means whereby the conductors of a circuit can be disconnected from their source of supply. Examples of disconnecting means are a switch or a circuit breaker.

Distribution Panel: The distribution panel contains overcurrent devices and distributes electricity to the various electrical circuits and equipment in net metering customer home, farm or business.

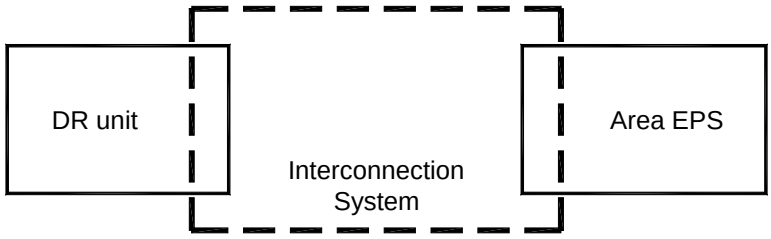
Distribution System: A system for distributing electricity, including any structures, equipment or other things used for that purpose. A distribution system is comprised of the main system capable of distributing electricity to many customers and the connection assets used to connect a customer to the main distribution system.

Electric power system (EPS): Facilities that deliver electric power to a load.

Electric power system, area (Area EPS): An EPS that serves Local EPSs.

For relationship of interconnection terms see diagrams below:

Source – IEEE 1547-2018



Electricity Revenue Meter**:** The Local Distribution Company supplies and installs the electricity revenue meter that measures consumption (Load Meter) or generation (Generation Meter) of electrical energy by the customer.

External Disconnect Switch: The utility-accessible alternating current (AC) external disconnect switch (EDS) for Renewable generators, is a hardware feature that allows a utility's employees to manually disconnect a customer-owned generator from the electricity grid (same as utility disconnect).

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).

Generator: Equipment that produces electric power. Examples of inverter-based micro generators are wind turbine and photovoltaic array, both of which produce Direct Current (DC) power.

Grid Dependent Inverter: An inverter that is able to operate in parallel to the distribution system and in order to operate there must be power available from the electric utility's electricity grid. Loss of power from the grid will initiate a shutdown of the inverter to prevent islanding. Renewable generation systems using a grid dependent inverter will not provide back-up power during a utility power outage.

Grid-Interactive Inverter: An inverter that is able to operate in both stand-alone and grid parallel modes according to the availability of the distribution system. It can be considered as an uninterruptible power supply that is also able to operate in grid-parallel mode. This type of inverter initiates grid-parallel operation.

Harmonics: Sinusoidal voltages and currents at frequencies that are integral multiples of the fundamental power frequency which is 60 Hz.

Inverter: A device that converts direct current (DC) electricity into alternating current (AC) electricity.

Island: A condition in which a portion of an Area EPS is energized solely by one or more Local EPSs through the associated PCCs while that portion of the Area EPS is electrically separated from the rest of the Area EPS.

Islanding: A condition in which a portion of a transmission and/or distribution system is energized solely by one or more generators, including renewable generators, while that portion is electrically separated from the rest of the transmission or distribution system.

Meter Connection: The meter connection configuration determines the application type for the project.

Net Billing: Means subtracting electric energy supplied out of a customer's site during the billing period from electric energy supplied into the customer's site during the billing period, and calculating a net charge or credit to the customer based on the resulting net usage of electric energy during the billing per period.

Net Metering Connection: The installation includes one revenue load meter. The generator is connected beyond the load meter, the generated power is used for load displacement.

Net Metering: Net Metering means the process of measuring the difference between electricity delivered by QEC customer facility and fed back to QEC. Net metering measures the quantity of electricity used by net metering customer against the quantity of electricity generated by net metering customer resulting in a "net" total from which net metering customer's bill is calculated. Under our Net Metering Agreement, excess generation credits can be carried forward for up to 12 months to offset future electricity costs.

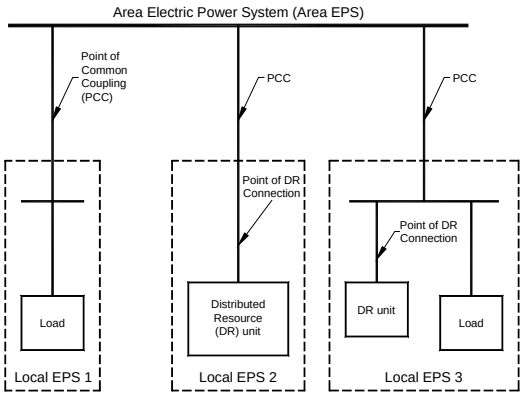
Overcurrent Device: A device capable of automatically opening an electric circuit, under both predetermined overload and short-circuit conditions, either by fusing of metal or by electromechanical means (a fuse or circuit breaker). An approved fuse or circuit breaker is required to protect people and the electrical system from a short circuit or overload failures. This is an important safety device.

Parallel Meter Connection: The installation includes two revenue meters, connected in parallel; the Load meter and the Generation meter. The two meters could have one connection point.

Point of Renewable Generation Connection (point of renewable generation connection): The point where a renewable generation unit is electrically connected in an EPS.

For relationship of interconnection terms see diagrams below:

Source – IEEE 1547-2003



Note – Dashed lines are EPS boundaries. There can be any number of local EPSs.

QEC: Qulliq Energy Corporation.

Renewable Generation (RG): Electric generation facilities connected to an Area EPS through a Point of Common Coupling (PCC) - a subset of renewable generation.

Renewable Resources (RR): Sources of electric power that are not directly connected to a bulk power transmission system. Renewable generation includes both generators and energy storage technologies**.**

Series Meter Connection: The installation includes two revenue meters, connected in series. The Load meter and the Generation meter. The generation meter and the generator are connected beyond the load meter. This meter connection is not acceptable.

Service Box: An approved assembly consisting of an enclosure that can be locked or sealed, containing either fuses and a switch, or a circuit breaker, and of such design that it is possible to operate either the switch or circuit breaker to the open position by manual means when the box is closed**.**

Service Entrance: The point where a Local EPS is connected to an Area EPS. The Service Entrance with respect to an embedded generation facility means the connection point where electricity produced by the generation facility is injected into the distribution system.

Stand-Alone Inverter: An inverter that operates only in stand-alone mode and thus contains no facility to synchronize its output energy to a Utility Distribution.

Synchronization: The state and operation where the renewable generation facility is connected to the distribution system and supplies loads along with the electric grid.

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.

Utility-Accessible External Disconnect Switch (EDS)-This is same as disconnecting means defined above.

Utility-Interconnected Inverter: An inverter that is able to operate in grid parallel mode with the utility distribution facility. Thus contains provision for anti-islanding and for synchronizing Renewable generation output voltage, phase and frequency to the utility distribution. Also known as “Grid Connected”, or “Grid Tie Inverter”. There are two types of utility-interconnected inverter; a Grid Dependent and a Grid Interactive.

Voltage Unbalance: Voltage unbalance is a condition in which the relative phase voltage magnitudes are different. Measuring unbalance is to compare the voltage deviation of the worst deviating phase with the average voltage of the three phases.

APPENDIX B: APPLICABLE CODES AND STANDARDS

The renewable generation interconnection shall conform to this guideline and to the applicable sections of the following codes and standards. When the stated version of the following standards is superseded by an approved revision, then that revision shall apply.

Specific types of interconnection schemes, renewable generation technologies, and distribution systems may have additional requirements, standards, recommended practices, or guideline documents external to this guideline. The applicability and hierarchy of those with respect to the requirements herein are beyond the scope of this guideline. Users of this guideline shall address those concerns. This list of standards is therefore not to be regarded as all-inclusive.

Main Standards

Compliance with the following codes and standards is required to qualify for interconnection:

- CAN/CSA-C22 No. 257/06 Interconnecting Inverter-based Micro-distributed resources to distributed systems
- CSA C22.3 No-9/08 Interconnection of Distributed Resources and Electricity Supply Systems
- C22.2 No. 107.1-01 General Use Power Supplies
- CAN/CSA C61000-2-2 Electromagnetic compatibility (EMC) - Part 2-2: Environment - Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems
- CAN/CSA C61000-3-6 Electromagnetic compatibility (EMC) - Part 3-6: Limits - Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems
- CSA no. C22-1 Canadian Electrical Code
- IEEE 1547 Standard series for Distributed Resources Interconnected with Electric Power Systems

Complementary Standards

- CSA Standard CAN3 C235-83 - Preferred Voltage Levels for AC Systems 0 to 50,000 V
- ANSI C12.20 Electricity Meters 0.2 And 0.5 Accuracy Classes
- IEEE Std.1100-1992 IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment (IEEE Emerald Book)
- IEEE Std. 519-IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems
- IEEE Std. 1159-1995 IEEE Recommended Practice for Monitoring Electric Power Quality
- IEEE Std. 1250- IEEE Guide for Identifying and Improving Voltage Quality in Power Systems
- IEEE Std. 100-1997 IEEE Standard Dictionary of Electrical and Electronics Terms
- IEEE Std. 315- Graphic Symbols for Electrical and Electronics Diagrams (Including Reference Designation Letters)
- IEEE C37.2 IEEE Standard Electrical Power System Device Function Numbers

- IEEE 1262 Recommended Practice for Qualifications of Photovoltaic Modules.
- UL 1449 Surge Protective Devices (SPD)
- IEC 61730-Photovoltaic (PV) module safety qualification
  IEEE Std. 929-1988 IEEE Recommended Practice for Utility Interface of Residential and Intermediate Photovoltaic (PV) Systems

APPENDIX C: REFERENCES

Note that referenced links may change over time.

1. **Measurement Canada**

   http://www.ic.gc.ca/eic/site/mc-mc.nsf/eng/lm04345.html

2. **ESA (Electric Safety Authority)**

   ESA Requirements and guidelines

   ESA-SPEC-004 Electrical guidelines for inverter-based micro-generating facility 10 kW and smaller; and

   ESA-SPEC-005 Process Guideline for the Installation of Parallel Generating Systems, 10 kW or Greater

   http://esasafe.com/GeneralPublic/sgi_002.php?s=24

   http://esasafe.com/pdf/Electrical_Guidelines_for_InverterBased_Micro_Generation_Facilities.pdf

3. **NRCan (Natural Resources Canada)**

   Connecting Micro-power to the Grid: A Status and Review of Micro-power Interconnection Issues and Related Codes, Standards and Guidelines in Canada 2nd Edition

   http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/eng/renewables/integration_der/publications/2006073.html

   The RET Screen Clean Energy Project Analysis

   www.retscreen.net

4. **Micro-generation Regulation**

   Alta Reg 27/2008, s 1 <http://canlii.ca/t/kmb4#sec1> retrieved on 2015-07-04.

APPENDIX D: TABLES

Table 1 - Operating voltages

Nominal System Voltages	Recommended voltage variation limits for circuits up to 1,000 V, applicable at service entrance			
	Extreme Operating Conditions	Normal Operating Conditions		
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

Source: CSA CAN3-C235, Table 3

Table 2- Response to abnormal voltage levels

Voltage	**Clearing Time**
V<50%	6 cycles (0.1 sec)
50%<V<88%	120 cycles (2 sec)
88%<V<110%	Tripping prohibited
110%<V<137%	120 cycles (2 sec)
V>137%	2 cycles (0.033 sec)

Table 3- Response to abnormal frequencies

Frequency	**Clearing Time**
> 60.5 Hz	6 cycles (0.1 sec)
< 59.3 Hz	6 cycles (0.1 sec)

Table 4- Limits of Total Harmonic Distortion

	Even harmonics	**Odd harmonics**
Harmonic order h	% of I1	% of I1
2 ≤ h ≤ 9	1.0	4.0
10 ≤ h ≤ 15	0.5	2.0
16 ≤ h ≤ 21	0.4	1.5
22 ≤ h ≤ 33	0.2	0.6
Above 33	0.1	0.33
THD current = 5 %		

Source: CSA C22.2 No. 107.1, Table 15

Table 5 : Limit of voltage harmonic distortion

Harmonic order h	Odd harmonic non-multiple of 3 % of V1	Harmonic order h	Odd harmonic multiple of 3 % of V1	Harmonic order h	Evec harmonic % of V1
5	6	3	5	2	2
7	5	9	1.5	4	1
11	3.5	15	0.4	6	0.5
13	3	15	0.3	8	0.5
17 ≤ h ≤ 49	2.27*17/h – 0.27	21 ≤ h ≤ 45	0.2	10 ≤ h ≤ 50	0.25*10/h – 0.25
THD voltage = 8 %					

Source: CSA C61000-3-6

APPENDIX E: TYPICAL METERING CONNECTION

Note:

1. Connection point and installation / replacement is at sole discretion of QEC.
2. Meters shall be installed at sufficient height from ground to stay above the snow and away from back splattered rain.

Typical Net Metering Connection

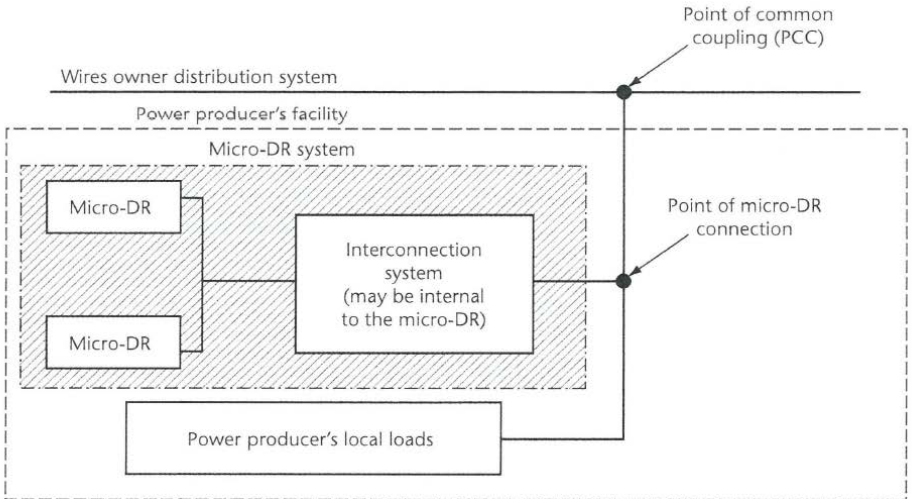
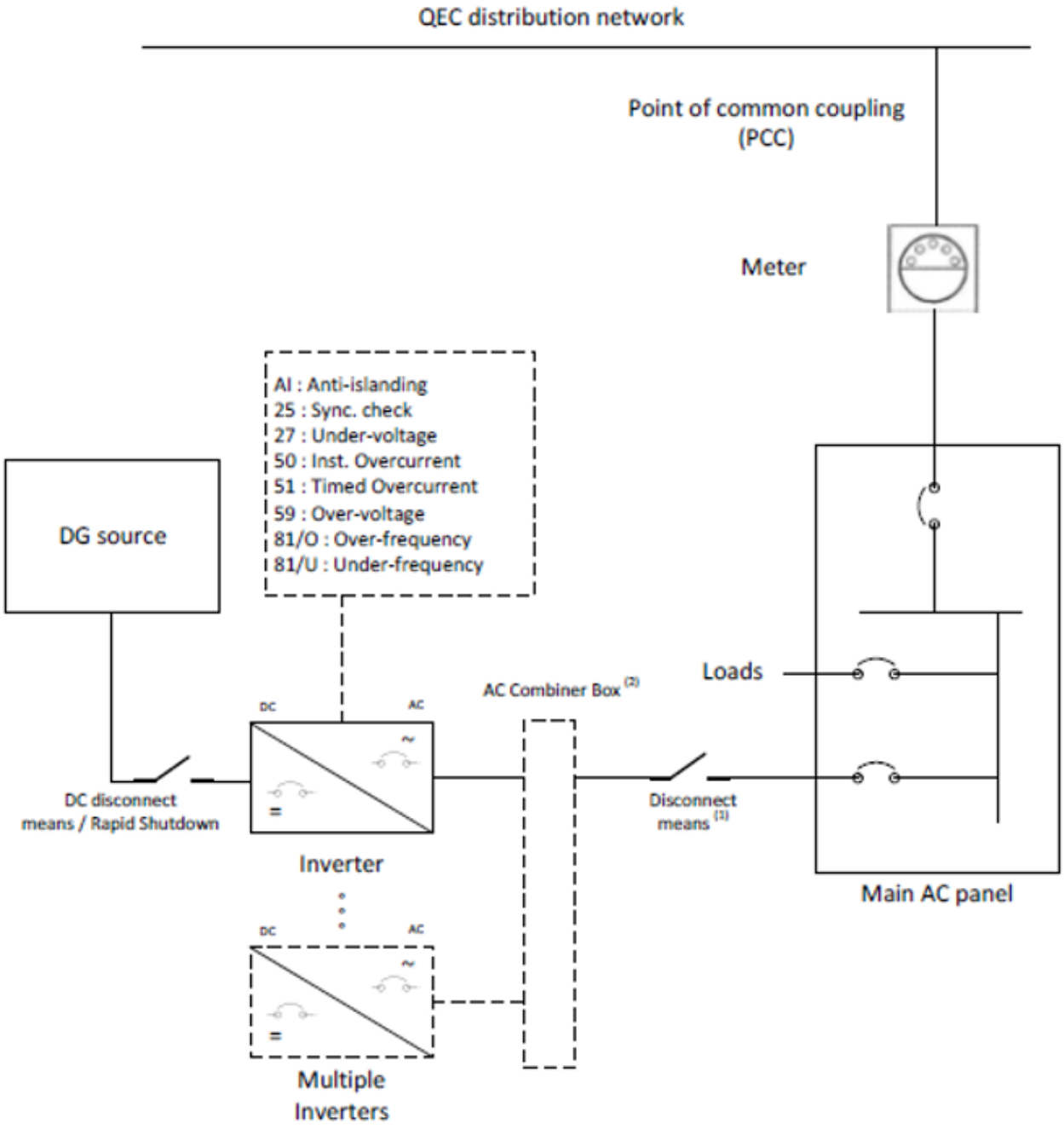


Figure 1 : Relationships between the DG system and tother interconnection terms (CAN/CSA-C22.2 No. 257-06 Figure 1)



Notes :
1) AC External (outside) Utility Disconnect, Lockable, Visible break, fused and readily accessible
2) Require for multiple inverters system

Figure 2 : Single Line Diagram of a Typical Inverter-Based DG System
(CAN/CSA-C22.2 No. 257-06 Figure B.1)