



# DER Commissioning Guidelines

## Community Scale PV Generation Interconnected Using Xcel Energy’s Minnesota Section 10 Tariff

Version 1.5, 11/16/18

### 1.0 Scope

This document is currently limited in scope to inverter interfaced PV installations that are not certified. Typically non-certified PV installations are at the industrial, community, and utility scale which use UL 1741 certified components but also require additional components or multiple inverters. The UL 1741 certification of the inverters simplifies the commissioning process when compared to generator facilities that contain no certified components.

### 2.0 Introduction

The following contains excerpts from Xcel Energy’s section 10 tariff in italic formatted text followed by discussion and a summary of the resulting requirements. Each Generation System is unique and it is the responsibility of the Interconnection Customer to supply information, as well as design and perform tests, which adequately address the tariff requirements that originate from the MN Statewide Interconnection Rules.

### 3.0 Guidelines

Note: The following sections use Section 10 Tariff numbering starting on original sheet number 156.

#### **8.0 Testing Requirements**

##### **A) Pre-Certification of equipment**

[Section Tariff language omitted here and can be found on Original Sheet No 156]

##### Discussion

The tariff discussed pre-certified “equipment packages” which shall include “all interface components including switchgear, inverters, and other interface devices”. This concept of vendors offering equipment packages, envisioned when the MN Statewide rules were written around the years 2003-2004, never materialized. Instead, inverter equipment is type tested in a laboratory and is certified to the UL 1741 standard. Many of the remaining components, listed in the equipment package description, are supplied and installed by various manufacturers and integrators and need to be tested as appropriate.

##### Summary of requirements

- Equipment not part of the certified inverters is to be commission tested as appropriate

##### **B) Pre-Commissioning Tests**

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*i) Non-Certified Equipment*

*(1) Protective Relaying and Equipment Related to Islanding*

*(a) Distributed generation that is not Type-Certified (type tested), shall be equipped with protective hardware and/or software designed to prevent the Generation from being connected to a deenergized Xcel Energy system.*

Discussion

Although the equipment package is not type-certified, Xcel Energy accepts a UL 1741 certified inverter as a means to meet this requirement. The Interconnection Customer shall submit proof of UL 1741 certification of the as-built inverter equipment.

The Interconnection Customer shall verify that inverter protection settings and firmware have not been modified from the factory set points or that the appropriate tests have been repeated. Per IEEE 1547-2018, if functional software or firmware changes have been made, hardware components have been replaced, protection settings have been modified, or protection functions have been adjusted, reverification of interconnection and interoperability requirements may be required.

Summary of requirements

- Proof of UL 1741 certification for inverter equipment

*(b) The Generation may not close into a de-energized Xcel Energy system and protection provided to prevent this from occurring. It is the Interconnection Customer's responsibility to provide a final design and to install the protective measures required by Xcel Energy. Xcel Energy will review and approve the design, the types of relays specified, and the installation. Mutually agreed upon exceptions may at times be necessary and desirable. It is strongly recommended that the Interconnection Customer obtain Xcel Energy written approval prior to ordering protective equipment for parallel operation. The Interconnection Customer will own these protective measures installed at their facility.*

Discussion

The UL 1741 certification shall be submitted to Xcel Energy to satisfy this requirement. The Interconnection Customer shall also supply the protection coordination study for the site at this time.

Summary of requirements

- Proof of UL 1741 certification for inverter equipment
- Protection Coordination Study

*(c) The Interconnection Customer shall obtain prior approval from Xcel Energy for any revisions to the specified relay calibrations.*

Discussion

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If default inverter settings have been specified, the Interconnection Customer shall verify that inverter protection settings and firmware have not been modified from the factory set points that the unit was certified under or that the appropriate tests have been repeated. In some cases Xcel Energy will specify settings that differ from the IEEE 1547 defaults. For example, a non-unity fixed power factor is sometimes specified to mitigate voltage rise, and Xcel Energy verifies this setting is used and that other settings have not been modified. Any separate relaying equipment shall have the appropriate tests performed and documentation available for Xcel Energy’s review.

Summary of requirements

- Written verification that the inverter firmware version has not been modified from the version that was used for UL 1741 certification.
- If default IEEE 1547 inverter settings were specified, written verification that inverter settings have not been modified from the settings used during UL 1741 certification.
- If inverter settings are specified that differ from IEEE 1547 default settings, the Interconnection Customer shall provide a complete list of the inverter settings programed in the installed equipment.

**C) Commissioning Testing**

**The following tests shall be completed by the Interconnection Customer. All of the required tests in each section shall be completed prior to moving on to the next section of tests. Xcel Energy has the right to witness all field testing and to review all records prior to allowing the system to be made ready for normal operation. Xcel Energy shall be notified, with sufficient lead time to allow the opportunity for Xcel Energy personnel to witness any or all of the testing.**

Discussion

Per the Section 10 Tariff and MN Statewide Interconnection Rules, it is the Interconnection Customer’s responsibility to perform commissioning testing. Xcel Energy’s role is to witness the tests and review records. It is beyond the scope of Xcel Energy’s tariffed responsibilities to design test procedures, sign off on test steps, or provide any other guidance that assures the Interconnection Customer equipment is designed, installed, and operating as approved in the interconnection application. A successful commissioning test does not equate to an implied or express warranty that the generator equipment is suitable for the Interconnection Customer’s intended use. The Interconnection Customer shall provide qualified personnel to design and perform interconnection tests in order to adhere to applicable tariff, laws, codes, and national standards. The Interconnection Customer shall provide test equipment necessary to perform required tests. Xcel Energy’s required tests are intended to assure the interface equipment meets applicable requirements. The equipment labeling details supplied shall match the labeling on the final as-built one line diagrams. The labeling details shall clearly distinguish co-located garden equipment. For example, each main meter at a co-located site shall have unique labeling.

Summary of requirements

- Design, Production, and Commissioning tests developed under the supervision of qualified personnel
- Equipment labeling details
- Qualified personnel to perform the tests.

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*i) Pre-testing - The following tests are required to be completed on the Generation System prior to energization by the Generator or Xcel Energy. Some of these tests may be completed in the factory if no additional wiring or connections were made to that component. These tests are marked with a “\*”.*

*(1) Grounding shall be verified to ensure that it complies with this standard, the NESC and the NEC.*

Discussion

The Interconnection Customer shall verify that the equipment safety ground connections and other associated grounding equipment (i.e. grounding rods and grids) satisfy NEC and NESC requirements.

Xcel Energy has published ground referencing requirements<sup>1</sup> which are designed to assure IEEE 1547-2018 requirement found in section 7.4, *Limitation of overvoltage contribution*<sup>2</sup>, is met. The Section 10 tariff references IEEE 1547 and thus we see Xcel Energy’s ground referencing requirement and the Section 10 tariff grounding requirement as one in the same.

The interconnection customer shall provide a final factory nameplate drawing, as-built, of all ground referencing equipment. Updated calculations that show compliance with the ground referencing requirements shall be provided.

The protection scheme, that causes the Generation System to trip in the event that the ground referencing equipment is taken out of service, shall be provided.

Summary of requirements

- Grounding equipment nameplate drawing
- Ground referencing calculations
- Drawing of ground referencing equipment protections scheme
- Written verification that grounding equipment meets NEC and NESC requirements

*(2) \* CT’s (Current Transformers) and VT’s (Voltage Transformers) used for monitoring and protection shall be tested to ensure correct polarity, ratio and wiring.*

Discussion

If applicable<sup>3</sup>, all CTs and PTs shall be installed as indicated in design drawings. The Interconnection Customer shall verify the equipment is rated properly and is installed with correct

<sup>1</sup> PV and Inverter-based DER Ground Referencing Requirements and Sample Calculations, <https://www.xcelenergy.com/staticfiles/xe/PDF/MN-SRC-Inverter-Based-Ground-Referencing-Requirements-and-Sample-Calculations.pdf>

<sup>2</sup> IEEE 1547-2018 Section 7.4: ”The DER shall not cause the fundamental frequency line-to-ground voltage on any portion of the 12 Area EPS that is designed to operate effectively grounded, as defined by IEEE Std C62.92.1, to 13 exceed 138% of its nominal line-to-ground fundamental frequency voltage for a duration exceeding 14 one fundamental frequency period.”

<sup>3</sup> Many inverter interfaced DER systems do not employ separate relaying, instrument transformer, and breaker equipment

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the ratio, polarity and wiring. This verification shall be performed and signed-off by qualified personnel.

If the site overcurrent protection is accomplished with fusing, the fuse types and sizes shall be listed. If the protection is a breaker and relaying, the relay settings shall be provided.

Summary of requirements

- Written verification that the correct PTs and CTs are installed.
- Details on main site protection

***(3) CT's shall be visually inspected to ensure that all grounding and shorting connections have been removed where required.***

Discussion

CTs most often are shipped and installed as shorted for safety reasons. Shorted connections that are not part of the design shall be verified as removed.

In accordance with good practice in protection systems, and to assure reliable operation, CTs shall not be grounded in multiple circuit locations.

Summary of requirements

- Written verification that CTs shorts and grounds have been removed when applicable.

***(4) Breaker / Switch tests – Verify that the breaker or switch cannot be operated with interlocks in place or that the breaker or switch cannot be automatically operated when in manual mode. Various Generation Systems have different interlocks, local or manual modes etc. The intent of this section is to ensure that the breaker or switches controls are operating properly.***

Discussion

Interlock systems typically apply to Generation Systems applied to large industrial or campus facilities. For large scale solar or wind plants, interlock schemes typically do not apply.

The test for this section shall verify that the controls and operating mechanisms for all breakers and switches are operating properly. The indication of breaker or switch status shall be verified to match the actual device statuses.

Summary of requirements

- Written verification that all breakers, switches, and associated controls function properly

***(5) \* Relay Tests – All Protective relays shall be calibrated and tested to ensure the correct operation of the protective element. Documentation of all relay calibration tests and settings shall be furnished to Xcel Energy.***

Discussion

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Proper operation of relays is critical to safety and reliability. The Interconnection Customer shall calibrate and test relays in accordance with applicable standards and best practices. The tests and results should be documented and repeatable. The interconnection shall have qualified personnel to develop, perform, and sign-off on relay calibration and testing.

Summary of requirements

- Documentation of relay calibration and testing signed

*(6) Trip Checks - Protective relaying shall functionally tested to ensure the correct operation of the complete system. Functional testing requires that the complete system is operated by the injection of current and/or voltage to trigger the relay element and proving that the relay element trips the required breaker, lockout relay or provides the correct signal to the next control element. Trip circuits shall be proven through the entire scheme (including breaker trip)*

*For factory-assembled systems, such as inverters the setting of the protective elements may occur at the factory. This section requires that the complete system including the wiring and the device being tripped or activated is proven to be in working condition through the injection of current and/or voltage.*

Discussion

Functional testing of relays shall apply to any relay packages that are external to inverters. The type tests in UL 1741 allow certified devices to be considered functionally tested.

*(7) Remote Control, SCADA and Remote Monitoring tests – All remote control functions and remote monitoring points shall be verified operational. In some cases, it may not be possible to verify all of the analog values prior to energization. Where appropriate, those points may be verified during the energization process*

Discussion

The Interconnection Customer shall verify the communication network designed to provide Remote Monitoring is properly functioning prior to commissioning and that the facilities to furnish the Xcel Energy owned communication cabinet are complete prior to commissioning.

*(8) Phase Tests – the Interconnection Customer shall work with Xcel Energy to complete the phase test to ensure proper phase rotation of the Generation and wiring.*

Discussion

UL 1741 inverters are incapable of operating in standalone mode (i.e. not in parallel with utility grid) and verifying phases and rotation will not apply to these types of systems. A certified inverter will follow the grid phasing and rotation during normal operation.

Summary of requirements

- Proof of UL 1741 certification for inverter equipment

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*(9) Synchronizing test – The following tests shall be done across an open switch or racked out breaker.*

*The switch or breaker shall be in a position that it is incapable of closing between the Generation System and the Xcel Energy system for this test. This test shall demonstrate that at the moment of the paralleling-device closure, the frequency, voltage and phase angle are within the required ranges, stated in IEEE 1547. This test shall also demonstrate that if any of the parameters are outside of the ranges stated; the paralleling-device shall not close. For inverter-based interconnected systems this test may not be required unless the inverter creates fundamental voltages before the paralleling device is closed.*

Discussion

For the reasons described above in the Synchronizing Test section, this test does not apply to UL 1741 certified inverters.

Summary of requirements

- Proof of UL 1741 certification for inverter equipment

*ii) On-Line Commissioning Test – the following tests will proceed once the Generation System has completed Pre-testing and the results have been reviewed and approved by Xcel Energy. For smaller Generation Systems, Xcel Energy may have a set of standard interconnection tests that will be required. On larger and more complex Generation Systems the Interconnection Customer and Xcel Energy will get together to develop the required testing procedure. All on-line commissioning test shall be based on written test procedures agreed to between Xcel Energy and the Interconnection Customer.*

Discussion

Prior to scheduling the on-line commissioning tests, the Interconnection Customer shall submit all pre-testing results, as-built drawings, inverter settings, relay settings, grounding calculations and any other applicable information.

Summary of requirements

- Proof of UL 1741 certification for inverter equipment
- Pre-testing results
- As-built drawings
- Inverter settings
- Relay settings
- Ground referencing calculations

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*Generation System functionally shall be verified for specific interconnections as follows:*

*(1) Anti-Islanding Test – For Generation Systems that parallel with the utility for longer than 100msec.*

*(a) The Generation System shall be started and connected in parallel with the Xcel Energy source*

Discussion

The steps required to energize the Generation system and parallel with utility shall be listed. This might include closing a number of disconnects and/or fuses. Steps to verify the generation system has been energized and is outputting power should be present in the procedure including the location and method of measurement.

Both voltage and current shall be verified. Xcel Energy equipment, such as the Xcel Energy production meter, shall not be used for data verification. For PV systems, this test needs to occur during the daytime with enough insolation to produce energy. For sites that cannot achieve output greater than 15% of the nameplate capacity, a fixed metering device such as an inverter display or customer check meter shall be used to determine the direction of power flow. Output greater than 15% of nameplate capacity may use a portable or handheld meter to measure current of power output. The generator operator may intentionally curtail the output of the generation system facilitate the test, but all inverters must remain generating. All device names in the procedure, and all labelling onsite, shall correspond with the names of the devices in the one-line.

*(b) The Xcel Energy source shall be removed by opening a switch, breaker etc.*

Discussion

The Interconnection Customer shall simulate loss of utility source by opening a switch, breaker, or other device between the Generation System and utility source. This device should be located so that all anti-islanding protective devices are tested simultaneously. This device should be located upstream of the ground referencing equipment, so that the ground referencing equipment also experiences the simulated open-phase condition. The test is required to be performed for each phase independently and for all three phases simultaneously. The specific device that is going to be operated shall be listed on the procedure submitted to Xcel Energy prior to scheduling the commissioning test. All device names in the procedure, and all labelling onsite, shall correspond with the names of the devices in the one-line.

Protection schemes using negative sequence, zero sequence, or other imbalance detection relays to detect the open phase shall demonstrate that this scheme has no non-detection zone prior to testing. If unable to demonstrate this, the test shall be performed with this function disabled on the recloser or breaker, or may perform the test at a 20% output, provided all inverters are generating. This is to prevent potential false-positives of successful tests. Disabled settings may be re-enabled at the conclusion of the test. The disabling steps or reduced output steps shall be included in the test procedure.

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(c) *The Generation System shall either separate with the local load or stop generating*

Discussion

The expected action from the generation system for simulating loss of utility source shall be shown. For three-phase tests, no voltage shall be present on the inverter side of the opened device. For single phase tests, the voltage on all phases shall remain below 110% of the nominal system voltage on the inverter side of the open point. The location and method for verifying the Generation System has ceased to energize shall be listed in the procedure. Xcel Energy equipment, such as the Xcel Energy production meter, shall not be used for this verification. Both voltage and current shall be verified. The device should be of suitable accuracy to measure and display voltages for purposes of determining compliance with this requirement. Typically, this means a digital read out via a volt-meter or through a computer display. Analog displays will not be accepted.

(d) *The device that was opened to remove the Xcel Energy source shall be closed and the Generation System shall not re-parallel with Xcel Energy for at least 5 minutes.*

Discussion

The device that was opened shall be closed again. The location and method for verifying the generation system does not energize the system for at least 5 minutes shall be listed in the procedure. Xcel Energy equipment, such as the Xcel Energy production meter, shall not be used for this verification. Both voltage and current shall be verified.

Summary of requirements

- Anti-islanding test procedure with, at minimum, the following components
  - Steps to energize the Generation System including specific devices that are being operated or verified. The device names should match those in the one-line.
  - Steps to verify the Generation System is energized *and* generating, including the method used for verification.
  - Steps to simulate loss of utility source for each individual phase and for simultaneous three-phase, including specific devices names for each device being operated. The device names should match those in the one-line.
  - Steps to re-connect Generation System
  - Steps to verify the Generation System delays energization for at least 5 minutes including measurement method and location.
  - Location for Interconnection Customer signature stating that the procedure has been properly completed and the system passed the test.

iii) *Final System Sign-off.*

(1) *To ensure the safety of the public, all interconnected customer owned generation systems which do not utilize a Type-Certified system shall be certified as ready to operate by a Professional Electrical Engineer registered in the State of Minnesota, prior to the installation being considered ready for commercial use.*

Discussion

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As described in the discussion section of 8 A) in this document, most large scale Generation Systems are not pre-certified, though the system may contain some pre-certified components. The Section 10 and MN Statewide Interconnection rules require that a Professional Electrical Engineer (PE), registered in the state of MN, shall certify the system as ready to operate. In making this certification, the PE is confirming adherence to all applicable statewide rules, national standards, and codes. This final sign-off shall occur after a successful on-line commissioning test and before the Generation System begins commercial operation.

Summary of requirements

- A signed letter from a Professional Engineer, trained in the Electrical Engineering discipline, certifying that the Generation System is ready to operate.

iv) *Periodic Testing and Record Keeping*

*(1) Any time the interface hardware or software, including protective relaying and generation control systems are replaced and/or modified, Xcel Energy shall be notified. This notification shall, if possible, be with sufficient warning so that Xcel Energy personnel can be involved in the planning for the modification and/or witness the verification testing. Verification testing shall be completed on the replaced and/or modified equipment and systems. The involvement of Xcel Energy personnel will depend upon the complexity of the Generation System and the component being replaced and/or modified. Since the Interconnection Customer and Xcel Energy are now operating an interconnected system. It is important for each to communicate changes in operation, procedures and/or equipment to ensure the safety and reliability of the Local EPS and the Xcel Energy system.*

Discussion

Anytime modifications are made to the Generation System hardware or software is made, Xcel Energy shall be notified. These types of changes include, but are not limited to, the following situations:

- Inverter firmware changes
- Inverter setting changes
- Protective setting changes
- Control system changes
- Instrument transformer (i.e. CT or PT) changes
- Protective device type changes
- Inverter replacements

The above list is not intended to be comprehensive, but rather to provide additional examples of the types of Generation System changes that should trigger notification. Xcel Energy should be contacted for any modification to the Generation System hardware or Software to determine if additional review is required.

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*(2) All interconnection-related protection systems shall be periodically tested and maintained, by the Interconnection Customer, at intervals specified by the manufacture or system integrator. These intervals shall not exceed 5 years. Periodic test reports and a log of inspections shall be maintained, by the Interconnection Customer and made available to Xcel Energy upon request. Xcel Energy shall be notified prior to the period testing of the protective systems, so that Xcel Energy personnel may witness the testing if so desired.*

Discussion

The Interconnection Customer shall define a periodic testing schedule for the protection systems Generation System based on manufacturer or system integrator recommendations, but should not exceed 5 year intervals. This schedule shall be readily available to Xcel Energy. The reports and logs of testing shall also be readily available to Xcel Energy upon request.

*(a) Verification of inverter connected system rated 15kVA and below may be completed as follows; The Interconnection Customer shall operate the load break disconnect switch and verify the Generator automatically shuts down and does not restart for at least 5 minutes after the switch is close*

Discussion

This is not applicable to the current Solar\*Rewards Community program.

*(b) Any system that depends upon a battery for trip/protection power shall be checked and logged once per month for proper voltage. Once every four years the battery(s) must be either replaced or a discharge test performed. Longer intervals are possible through the use of "station class batteries" and Xcel Energy's approval.*

Discussion

Generation Systems that use a battery for protection or tripping functions shall be tested on a monthly basis in order to verify sufficient voltage to operate the intended devices.

## 4.0 Summary

The list below summarizes the pre-commissioning and commission requirements which result from the MN Statewide Interconnection Rules and Xcel Energy's Section 10 Tariff.

- Proof of UL 1741 certification for inverter equipment
- Protection Coordination Study
- Written verification that the inverter firmware version has not been modified from the version that was used for UL 1741 certification.
- If default IEEE 1547 inverter settings were specified, written verification that inverter settings have not been modified from the settings used during UL 1741 certification.
- If inverter settings are specified that differ from IEEE 1547 default settings, the Interconnection Customer shall provide a complete list of the inverter settings programed in the installed equipment.
- Design, Production, and Commissioning tests developed under the supervision of qualified personnel
- Equipment Labeling details
- Qualified personnel to perform the tests.
- Grounding equipment nameplate drawing

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- Ground referencing calculations
- Drawing of ground referencing equipment protections scheme
- Written verification that grounding equipment meets NEC and NESC requirements
- Anti-islanding test procedure with, at minimum, the following components
  - Steps to energize Generation System including specific device information
  - Steps to verify Generation System is energized including measurement method and locations
  - Steps to simulate loss of utility source including specific device information
  - Steps to re-connect Generation System
  - Steps to verify the Generation System delays energization for at least 5 minutes including measurement method and location.
  - Location for Interconnection Customer signature stating that the procedure has been properly completed and the system passed the test.
- A signature from a Professional Engineer, trained in the Electrical Engineering discipline, certifying that the Generation System is ready to operate.

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