UTAH MUNICIPAL POWER AGENCY AND MEMBER CITY

SOLAR POWER PROGRAM
INTERCONNECTION STANDARDS

SEPTEMBER 2017

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INTERCONNECTION STANDARDS

1.0 Scope and Intent

These Standards apply to the interconnection of solar photovoltaic generating systems (Solar Facility) to the distribution system of Member Cities within Utah Municipal Power Agency (Agency) in connection with the Agency and Member City's Solar Power Program. Such connections are subject to Member City's review and shall not be permitted unless approved by Member City.

The operation and design of a Solar Facility must meet all of the requirements contained in these Standards, the Interconnection Agreement, the Power Sales Agreement, Program Standards, and Applicable Law. **The Customer's design professional should review all of these Interconnection Standards and Program Standards before undertaking design of the Solar Facility.**

2.0 General Requirements

2.1. Limitations on Solar Facility Size

As provided in the Program Guidelines, the proposed Solar Facility's rating shall not exceed 750 kW. In addition, if the Solar Facility, with other interconnections, has a rating greater than 90% of the rating of the existing transformer, the Customer must, at its own expense, provide a dedicated transformer that meets Member City's standards and is installed by Member City.

2.2. Limitations of Member City's System

Member City's System is sized for safe and efficient delivery of electric power, not for the receipt of electric power. Adding Renewable Generation can quickly overload and damage Member City's equipment and interfere with service to other Customers. Member City therefore may refuse to allow interconnection of Renewable Generation that would exceed the following limitations:

2.2.1. *System Wide*: The aggregate rated maximum Renewable Generation (including the proposed Solar Facility) on Member City's System, as a whole, shall be less than 15% of the System's annual peak load.

2.2.2. *Circuit:* The aggregate rated maximum Renewable Generation (including the proposed Solar Facility) on the circuit serving the Solar Facility shall be less than 15% of the circuit's annual peak load.

2.2.3. *Transformer:* The aggregate rated maximum Renewable Generation kVA (including the proposed Solar Facility) shall not equal or exceed 90% of the rating of the transformer serving the Renewable Generation.

2.2.4. *Feeder/Protective Device:* The aggregate rated maximum Renewable Generation kVA (including the proposed Solar Facility) shall not exceed 15% of the rating of any protective device from the point of interconnection to the substation transformer and serving the Renewable Generation.

2.2.5. *Feeder:* The rated aggregate maximum Renewable Generation kW (including the proposed Solar Facility) on any feeder (major electrical distribution line tied

directly to the substation) or portion of a feeder shall be less than 15% of the annual peak load on that feeder or feeder section.

If the addition of a proposed Facility would exceed these limits, the Customer may request that Member City perform, at the Customer's expense, a system study to determine what, if any, System Upgrades or mitigation measures that the Customer may provide to eliminate the adverse impacts on Member City's System. These System Upgrades and measures will be paid for by the Customer and may exceed the requirements of these Interconnection Standards or the Program Standards.

2.3. Customer's Protection of Solar Facility.

The Customer is solely responsible for protection of the Customer's property, Solar Facility, and equipment from conditions on Member City's System such as outages, short circuits, voltage or frequency variations, or other disturbances. Member City will not install equipment to protect the Customer's property, Solar Facility, or equipment from these conditions. These Standards are designed to protect Member City's System and not specifically to protect the Customer's Solar Facility.

The Customer is solely responsible for designing the Solar Facility to detect any disturbances or unusual conditions on Member City's System and to disconnect the Facility from Member City's System when such disturbance may damage the Customer's property or Solar Facility. The Customer's protective devices must not impact the operation of other protective devices on Member City's System in a manner that would adversely affect Member City's ability to provide reliable service to its customers. The Solar Facility must, at a minimum, automatically disconnect itself from the System any time System conditions are outside acceptable ranges and is not permitted to reconnect to the System until System conditions return to normal and are maintained within the normal range for a minimum of thirty (30) minutes.

2.4. System Phase and Voltage

The Solar Facility may interconnect to Member City's System at any service voltage available at the site. If the site contains a three-phase system, the Solar Facility must be three-phase. If only a single-phase service is available, a single-phase Solar Facility may be allowed. Member City may allow other voltages on a case-by-case basis, at the Customer's expense.

2.5. System Reclosing

Member City utilizes automatic reclosers to clear temporary faults. The Solar Facility must be designed to ensure that the Solar Facility will disconnect from Member City's System in the event an automatic reclose occurs. Industry standards require that a Solar Facility must automatically disconnect from an islanded system. Member City requires a design that disconnects within 10 cycles. If the existing reclosing interval is faster than 10 cycles, Member City will reset it to accommodate the Solar Facility.

2.6. Islanding

Islanding occurs when a Solar Facility becomes separated from the main generation source on a distribution system, but continues to independently serve a portion of the distribution system. A Solar

Facility shall be equipped with protective devices and controls designed to prevent the Solar Facility from being connected to a de-energized distribution system. Islanding is not permitted on Member City's System.

The Customer's protective devices must prevent the Solar Facility from contributing to an island. If Member City feeder connected to the Solar Facility is de-energized for any reason, the Solar Facility must sense this and disconnect itself within 10 cycles of the de-energization of the feeder. Member City will require that the Customer install, at its own expense, additional protective devices or systems, such as transfer trip equipment, to insure the safe operation of Member City's System.

2.7. Improper Operation of the Solar Facility

The Customer's design, construction, operation, maintenance and repair of the Solar Facility must meet the requirements of these Interconnection Standards, the Interconnection Agreement, Program Standards and Applicable Law. The Solar Facility shall not adversely impact the operation of Member City's System in any way and shall not:

2.7.1. produce adverse amounts of unbalanced currents or voltages;
2.7.2. produce high or low voltages, or unacceptable frequencies;
2.7.3. inject DC or harmonics into the System beyond what is allowed by these Interconnection Standards and Program Standards;
2.7.4. cause excessive operations of the System's voltage regulating devices such as load tap changers and voltage regulators; and
2.7.5. not adversely affect System grounding or ground fault protection.

If the Solar Facility does not operate properly, Member City may: (a) require the Customer, at its own expense, to correct the deficiency or (b) disconnect the Solar Facility as provided in the Interconnection Agreement.

2.8. Submittal Requirement

As provided by the Program Guidelines, the Customer shall submit the design and specification for the Solar Facility. The Customer shall not begin construction of the Solar Facility until the Agency and Member City approves the Application and supporting documents.

3.0 Standards and Definitions

3.1. Standards

The current edition of the National Electric Code, the National Electrical Safety Code, the standards of the Institute of Electrical and Electronic Engineers, and standards of Underwriters Laboratories shall govern the design, construction, operation, and maintenance of the Solar Facility and of the interconnection.

3.2. Definitions

The capitalized terms in these Interconnections Standards are as follows:

3.2.1. ANSI-American National Standards Institute
3.2.2. IEEE-Institute of Electrical and Electronic Engineers
3.2.3. KVA-Kilovolt-amps
3.2.4. KW-Kilowatt
3.2.5. MW-Megawatt
3.2.6. NEC-National Electrical Code
3.2.7. NEMA-National Electrical Manufacturers Association
3.2.8. NESC-National Electrical Safety Code
3.2.9. UL-Underwriters Laboratories
3.2.10. VAR-Volt-Amps reactive (reactive power)

4.0 Solar Facility Design and Installation Requirements

4.1. General Requirements

The design and installation of any Solar Facility shall meet the relevant requirements of the Interconnection Standards, Interconnection Agreement, Program Standards, (NEC) and the (NESC). The Customer must obtain all necessary building permits and pass all applicable building department inspections. Unless otherwise modified in this document, the interconnection must meet the requirements of IEEE Std. 1547.

4.2. Interconnection Disconnect Switch

A Solar Facility must have a manually operated, lockable, disconnect switch that provides a visual break. In all cases, the disconnect switch: (a) must be rated to interrupt the Facility's maximum output; (b) must be rated for the Facility's voltage and fault current requirements; and (c) must meet applicable NEMA, UL, ANSI, IEEE, and NEC standards as well as local and state electrical codes.

The disconnect switch shall have a permanent label stating that the disconnection switch is for the Solar Facility. The labeling shall also clearly indicate the open and closed position of the switch.

The disconnect switch must, at all times, be visible to and accessible by Member City personnel to allow the Solar Facility to be disconnected safely. The switch must be located next to Member City's Production Meter on the output or load side of the Solar Facility such that the entire Solar Facility can be isolated from Member City's System. If the site contains several generators, a single disconnect switch may be used, provided that the switch's rating is sufficient for all generators and that, when switch is open, there is a visible open point between all generators and Member City's System.

Other devices such as circuit breakers may be considered as a substitute for a disconnect switch but only if each of the following conditions is met:

4.2.1. The circuit breaker must be a draw-out circuit breaker capable of being locked into the disconnected position.
4.2.2. The circuit breaker is visible and accessible to Member City, at all times.

All lock-out and tag-out capabilities must also be available for the devices used and must be assessable to Member City personnel.

4.3. Interrupting Devices Required

Circuit breakers or other interrupting devices located at the Point of Common Coupling (PCC) must be certified or "Listed" (as defined in Article 100, the Definitions Section of the NEC) as suitable for their intended application. This includes being capable of interrupting the maximum available fault current expected at their location. The Customer's Solar Facility and associated interconnection equipment must be designed so that the failure of any single device will not potentially compromise the safety and reliability of Member City's System

4.4. Solar Facility's Protective Functions

The Solar Facility shall include protection and safety devices to protect Member City's System, its workers, Customers, and the general public. Protective devices installed on the Solar Facility shall ensure that the fault current supplied by the Solar Facility will be interrupted in the event a fault occurs on Member City's System. When a fault occurs, the Solar Facility must be designed to automatically disconnect from Member City's System until the System is restored to normal operation.

The Solar Facility's protective functions must sense abnormal conditions on Member City's System that are outside the normal range and disconnect the Solar Facility from Member City's System during abnormal conditions. A Solar Facility must be capable of sensing line-line-line, line-line, and line-ground faults on the distribution feeder supplying the Solar Facility and must disconnect from the line to protect both the line from further damage and the generator from damage due to excessive currents or unusual voltages. The settings of these relays will be coordinated with Member City's substation relay setting.

The following are the minimum protective devices required for a Solar Facility connected to Member City's System:

4.4.1. The Inverter must be tested to meet IEEE 1547, and IEEE 1547.1 and shall have a UL sticker or listing

4.4.2. The Solar Facility will have current trip functions (50/51) which may be included in a breaker trip-unit. This device must be separate from the inverter control system and internal disconnect device.

4.4.3. Member City may conduct an on-site inspection to observe calibration and testing of the inverter functions.

5.0 Facility Grounding

The Solar Facility's grounding system must not adversely impact Member City grounding or ground fault protective relaying. The Solar Facility grounding must not cause high voltages to occur under any condition, either normally occurring or occurring during a System fault such as allowing high voltages to exist on the un-faulted phases during a single-line-to-ground fault.

5.1. Equipment Bonding Conductor

The Customer must install an equipment-grounding conductor, in addition to the ungrounded conductors and grounded conductor (neutral), between the Solar Facility and Member City's System. The grounding conductor must be permanent, electrically continuous, and must be capable of safely carrying the maximum fault current that could be imposed on it by the systems to which it is connected. Additionally, the equipment-grounding conductor must be of sufficiently low impedance to facilitate the operation of over current protection devices under fault conditions. All conductors shall comply with the NEC. The Solar Facility must not be designed or implemented such that the earth becomes the sole fault current path.

5.2. Surge Protection

Member City strongly recommends, but does not require, surge protection devices be used to protect Solar Facility equipment.

5.3. Solar Facility Grounding

Member City requires that all Solar Facilities be designed to contribute to an effectively grounded system. Effective grounding prevents the occurrence of excessively high voltages during ground faults and protects Member City's equipment. Effective grounding of the Solar Facility may desensitize existing Member City's ground fault protection, which could require changes in Member City's ground fault relay setting or modifications in the design of the Solar Facility.

The transformer supplied to interconnect the Solar Facility voltage to Member City's System will normally be a grounded-wye to grounded-wye transformer. This connection will not provide a grounding source by itself and will not provide an effectively grounded system from the Solar Facility side of the interconnection unless effective grounding of Solar Facility is provided. When designing the grounding system for the Solar Facility, the designer should consider the condition that will result when a ground fault occurs on the line serving the Solar Facility. This ground fault would be cleared on Member City side of the line by opening a breaker or recloser in Member City substation. This will result in momentarily islanding the line on the Solar Facility until it opens its breaker. Under this condition, where the line is islanded and being supplied by the Solar Facility, the Solar Facility must remain effectively grounded.

6.0 Prevention of Interference

The Customer shall not operate the Solar Facility in a way that causes a System disturbance or that superimposes a voltage or current upon Member City's System that results in interference with Member City operations, service to Member City's customers, or other Member City's equipment and facilities. In such a case, Member City may disconnect the Solar Facility as provided in the Interconnection Agreement.

7.0 Unacceptable Operating Conditions

7.1. Voltage Regulation

The Solar Facility shall not actively regulate the voltage at the point of common coupling (PCC) unless the effects of this are first reviewed and approved by Member City. If a study has been done by Member City which determines that it is advantageous for a Solar Facility to actively control its voltage, Member City will inform the Customer and the Customer will be required to control the Solar Facility's terminal voltage. In the case of a Solar Facility, the PCC is the Production Meter.

7.2. Facility Voltage

Customer's power production control system shall comply with NEC Articles 690 and 705; and applicable and current IEEE Standards, including Standard 1547 "Interconnecting Distributed Resources with Electric Power Systems" for parallel operation with Member City's System; in particular the:

7.2.1. Power output control system shall automatically disconnect from Member City's source upon loss of voltage and not reconnect until Member City's voltage has been restored for at least five (5) minutes continuously.

7.2.2. Power output control system shall automatically initiate a disconnect from Member City source within six (6) cycles if Customer's voltage falls below 60 Volts rms to ground (nominal 120 V rms base) on any phase.

7.2.3. Power output control system shall automatically initiate a disconnect from Member City's System within two (2) seconds if the voltage rises above 132 Volts rms phase to ground or falls below 104 Volts rms phase to ground (nominal 120 V rms base) on any phase.

7.2.4. Power output control system shall automatically initiate a disconnect from Member City's System within three (3) cycles for any reverse power flow condition.

Customer shall provide a written description of how the protection devices will achieve compliance with the requirements of these Standards as part of the Application.

Whenever Member City's System voltage at the PCC varies from normal (nominally 120 volts) by the amounts as set forth in Table 7-1 the Solar Facility's protective functions shall disconnect the generator(s) from Member City's System with delay times no longer than those shown.

Table 7-1: Voltage trip settings.
(Adapted from IEEE 1547-2003 and ANSI C84.1-2006)

Voltage at Point of Common Coupling (% of base Voltage)	Maximum Tripping Time Delay (seconds/cycles)
V-PCC < 50%	0.16 / 10
50% < V-PCC < 88%	2.0 / 120
92% < V-PCC < / 105%	Normal operating range
110% < V-PCC < 120%	1.0 / 60
120% < V-PCC	0.16 / 10

7.3. Other Unacceptable Operating Conditions

The Solar Facility shall comply with the System's frequency, synchronization, flicker, harmonics, and power factor limitations in the applicable Electric Codes.

8.0 Remote Monitoring and Control Requirements

The design and construction of a Solar Facility with a rating of 100 kW or higher shall include, upon request of Member City and at the Customer's expense, equipment for Member City's remote monitoring and control of the Facility.

Member City will provide an enclosure with remote monitoring and control equipment at the Customer's expense. The Customer shall also be responsible for mounting the equipment enclosure.

The monitoring and control system shall be designed to allow Member City to perform the following:

- Trip the Facility's breaker for unstable system conditions such as frequency, voltage, and fault conditions
- Place a HOT LINE TAG on the Facility's breaker that would block its close circuit to prevent its closing
- Initiate a generator startup for future power dispatching by the Agency and Member City. (This would normally be blocked locally unless requested by the Agency.)
- Monitor the generator breaker status to determine if the generator is on or off line
- Monitor generator output power (real and reactive), voltage, harmonics etc. (This will require current and voltage inputs from the Solar Facility equipment.)

The Solar Facility Customer must provide all the necessary interface design to accomplish the functions listed above. The Solar Facility Customer must submit drawings of the proposed design to Member City for review.

9.0 Testing

The Customer shall pay the cost of all required testing. **The Customer must notify Member City two weeks in advance of the time of the testing so that a Member City representative may observe the tests.**

9.1. Commissioning Tests Required by Equipment Manufacturer

The Customer shall perform all commission testing required by this Section 9.0 and the equipment manufacturer. The Customer shall provide Member City with a written report of the test results at the time of Member City's final inspection.

9.2. Additional Commission Testing and Inspection

In addition to any commissioning tests required by the equipment manufacturers, the following tests must be performed before Member City issues a Permit to Operate and the Customer commences operation of the Solar Facility:

9.2.1. Visual inspection to ensure proper grounding.
9.2.2. Visual inspection shall confirm the presence of the disconnection device described in section 4.2 and the device shall be tested for operation.
9.2.3. Trip tests must be performed to prove each device which is required to trip any breaker is capable of doing so.
9.2.4. Relays or protective functions provided by the Customer must be tested and relay test reports must be made available to Member City
9.2.5. The ability of the control system to disconnect the Solar Facility within 10 cycles in the event of islanding must be tested.

9.3. Periodic Maintenance Tests

Functional testing must be performed every year to prove the proper operation of the isolation device and all breakers and relays. The Customer must maintain written records of these tests and provide the records to Member City in January, following each year of operation.

9.4. Qualified Testing Personnel

All testing and calibration shall be done by qualified personnel. Member City will provide a list of contractors qualified to provide this service.