System Installation Requirements

EMERALD PUD
Solar Electric Program

2017

Emerald People's Utility District
33733 Seavey Loop Road, Eugene, OR 97405-9602
541-746-1583 • www.epud.org

1.0 Acknowledgements

Emerald People's Utility District would like to sincerely thank the Energy Trust of Oregon for allowing us to adopt the System Requirements contained in this document.

2.0 Purpose

This Solar Electric System Installation Requirements document details the requirements and minimum criteria for a solar electric ("photovoltaic" or "PV") system ("System") installed by an Emerald People's Utility District ("Emerald") Solar Electric Program contractor ("Registered Contractor") under Emerald's Solar Electric Program ("Program").

The purpose of these installation requirements is to help promote the performance and longevity of systems that receive Emerald incentive funding. Emerald reserves the right to require compliance with installation specifications that may differ from those of a manufacturer or exceed applicable code. Any variations from the Program's installation requirements must receive prior approval from Emerald.

3.0 System Requirements

3.1 General

3.1.1 System shall be grid-connected and installed on real property receiving electric service directly from Emerald.

3.1.2 System shall meet Emerald interconnection and net metering requirements.

3.1.3 The installation shall be of industry standard and workmanlike quality.

3.1.4 System should be designed for optimal annual performance, without sacrificing good aesthetics. See Section 3.5.3.

3.1.5 System design shall be documented with a schematic diagram that accurately describes all electrical components to be installed and the wiring design. Diagram should include:

- Module series/parallel wiring
- Wire run from array to point of Emerald interconnection, including applicable panels, with pre-existing wiring or sub-panels used in the AC run clearly labeled
- Conductor and ground wire types and sizing
- Conduit types and sizing
- Voltage drop calculations
- AC and DC breaker sizing

3.1.6 System design shall be documented with a physical layout diagram that accurately describes locations of major system components. Diagram should include:

- Layout of roof or installation location including existing obstructions
- Locations of installed modules and inverter(s)
- Locations of pre-existing photovoltaic components
- Locations of submitted TSRF measurement(s)
- Location of all applicable electrical panels, meters, and disconnects.

3.1.7 System shall be properly permitted, inspected, and in compliance with all applicable building and electrical codes.

3.1.8 System equipment installers shall be licensed according to the Oregon Building Codes Division and shall be working for a contractor that is licensed according to the Oregon Construction and Contractors Board.

3.2 Materials

3.2.1 Materials used outdoors shall be sunlight/UV-resistant and listed for outdoor locations.

3.2.2 Materials used shall be designed to withstand the temperatures to which they are exposed.

3.2.3 Dissimilar metals that have galvanic action (such as aluminum and copper) shall be isolated from one another using industry standard practices (such as properly rated grounding lugs).

3.2.4 Aluminum shall not be placed in direct contact with concrete materials.

3.2.5 Fasteners used to secure modules and racking equipment shall be stainless steel. For substructure components, only high-quality fasteners shall be used (stainless steel is preferred). Stainless steel fasteners shall be coated with an anti-seize lubricant to prevent galling and allow for removal during system maintenance or repair.

3.2.6 Structural members shall be either:

- Aluminum
- Hot-dip galvanized steel per ASTM standard A123 equivalent or better
- Coated or painted steel (not allowed in marine environments)
- Stainless steel (recommended for marine environments)
- Pre-approved nonmetallic material. Nonmetallic mounting systems listed to the UL 2703 standard may be submitted for application review without pre-approval.
- Outdoor rated pressure treated lumber or laminated beams:
  - Shall be installed using roofing flashing methods to prevent water pooling and UV exposure on the top surface.
  - Shall not be installed in direct contact with roofing material, soil, or where exposed to extended periods of pooled water.

3.2.7 For a residential, roof-mounted array, rails used for mounting modules shall be aluminum or stainless steel.

3.3 Equipment and Installation

3.3.1 All installed System components shall be new.

3.3.2 All components shall be mounted securely.

3.3.3 All building penetrations shall be sealed and fire resistance maintained. To prevent intrusion by insects or vermin, all penetrations to building shell (walls, etc.) resulting from the installation of the solar system shall be permanently sealed with appropriate water and pest-proof materials. Any penetrations through fire-rated assemblies shall not reduce the fire resistance required by local codes and standards.

3.3.4 All electrical equipment shall meet appropriate current electrical standards and be listed by a nationally recognized testing laboratory (e.g., UL, ETL).

- Inverters shall meet IEEE 929, 1374, and 1547 (listed to UL 1741), or their successor standards and shall be certified by the California Energy Commission[1].
- Photovoltaic modules shall meet IEEE standard 1262 (listed to UL 1703), or their successor standards and shall be certified by the California Energy Commission[2].

[1] http://www.gosolarcalifornia.ca.gov/equipment/inverters.php

3.3.5 Manufacturer warranties shall cover:

- Inverter for a minimum of 5 years against manufacturer's defects
- Photovoltaic modules for a minimum of 20 years against degradation of performance below 80% of original output under standard test conditions

3.3.6 All electrical equipment shall be listed for the voltage and current ratings necessary for the application.

3.3.7 Equipment shall not be modified such that it voids the listing or manufacturer warranty.

3.3.8 All required over-current protection shall be included in the system and accessible for maintenance. The inspection or maintenance of combiner or feed through junction boxes shall not require the removal or displacement of modules or other obstructions.

3.3.9 Means of disconnection shall be provided at the inverter(s) such that the inverter(s) can be safely isolated from all sources of power (DC input and AC output circuits) for service or in an emergency and:

- To allow the inverter electronics to be removed for service, disconnect switches shall be physically separable from the inverter chassis containing the main power electronics.
- To allow safe, quick operation, the means of disconnection shall be at the location of the inverter or—for AC disconnection only—within sight of the inverter with adequate permanent signage providing the location of the disconnect per OESC 690.56(B).
- Disconnect switches shall be listed and designed for load-break operation (e.g., blade-type or circuit breaker). Pull-out style disconnects shall not be used.
- Microinverters shall be installed per the requirements of the local jurisdiction (e.g., may require installation of a rooftop AC disconnect, if roof-mounted).

3.3.10 All electrical terminations shall be torqued to specification, secured, and strain-relieved as appropriate. Wire ends shall be coated with terminating compound prior to termination to prevent loosening of the connection over time.

3.3.11 All cables, conduit, exposed conductors, and electrical boxes shall be secured and supported according to code requirements and in accordance with their performance ratings (i.e. NEMA). It is recommended that high current carrying conductors 4 AWG and larger be megohm tested to confirm integrity of insulation.

3.3.12 Conduit used for DC conductors shall be electrical metallic tubing (EMT). Flexible steel conduit or metal clad (MC) cable may be used as an alternative where allowed by the Oregon Electrical Specialty Code (OESC). PVC conduit may be used below grade and above grade in marine climates where approved by the local jurisdiction.

3.3.13 Array equipment grounding conductors (EGC) and DC grounding electrode conductors (GEC) shall be copper and shall be either minimum 6 AWG or protected from physical damage and sized to conform to the Oregon Electrical Specialty Code (OESC):

- Equipment grounding conductor (EGC) shall be sized and protected according to OESC 690.45(A) and 690.46.
- Grounding electrode conductor (GEC) shall be sized and protected according to OESC 690.47(C) and 250.64(B).
- If a single conductor is used for the AC EGC and the DC GEC, conductor sizing and protection shall conform to all of the OESC sections listed above.
- Registered Contractor is responsible for identifying any additional OESC sections that may apply.

[2] http://www.gosolarcalifornia.ca.gov/equipment/pv_modules.php

3.3.14 Twist-on wire connectors shall not be used on DC conductors or ground wires. Instead, these wire connections shall be made using terminal strips in combiner boxes, feed through blocks in junction boxes, or other similar mechanical wire splicing devices. When outdoors or exposed to moisture, twist-on wire connectors used for AC connections shall be listed for usage in a damp/wet location.

3.3.15 Junction boxes and combiner boxes shall be listed and suitable for their environment and conditions of use. Boxes used in damp or wet locations shall have water-tight or properly flashed covers, screw holes and conduit connections.

3.3.16 Permanent, UV-resistant labels with engraved, stamped or printed text (i.e., not hand-written) shall be applied to system components where signage is required by the Oregon Electrical Specialty Code. When required, inverter disconnect label shall be placed on or near the disconnect box and not on the inverter chassis.

- System-Utility Interconnection Label, located at the base of the interconnected meter, shall read:

Interactive Solar Photovoltaic Power Connected
Rated AC Output Current: xxx Amps
Nominal Operating AC Voltage: xxx Volts

3.3.17 Readily accessible disconnect switch covers (not switch handles) shall be secured closed for safety (i.e., padlock, zip tie, etc.). Because this may interfere with access during an inspection, the means to secure the cover plate may be left with the customer with instructions for use.

3.3.18 Inverters shall be installed according to manufacturer's specifications and:

- Inverter shall not be installed in an unconditioned attic.
- Inverter shall not be installed with direct sun exposure that will impact its performance (i.e., on an exterior wall with an azimuth between 120° and 300° unless permanently shaded between the hours of 12:00 pm and 5:00 pm).
- Inverter shall be installed in an accessible location.

3.3.19 Micro-inverters shall include the installation of manufacturer-provided equipment that allows local monitoring of system performance and identification of inverter errors.

3.3.20 Where PV source and output circuits are installed in readily accessible locations, circuit conductors shall be guarded or installed in a raceway.

- Note: Guards typically include close fencing of the entire array, of sufficient height to render the area inaccessible, or, installation of materials to the mounting structure intended to screen and protect the conductors.

3.4 Array Mounting

3.4.1 If roof-mounted, the roofing material shall have at least 10 years of useful life remaining to ensure the roof will not need repair or replacement early in the System's operational life. If in question, evidence of this requirement may be met by providing either a copy of a recent roof inspection or a receipt showing the date of the most recent roof replacement.

3.4.2 If roof-mounted, the roof system shall be capable of handling additional load of the System. Augmentation of the structure may be required by building codes.

3.4.3 Array racking and mounting systems shall be engineered and installed to meet local wind, snow, and seismic load requirements.

3.4.4 All roof penetrations shall be made watertight using roofing industry-standard methods of flashing that protect the warranty of the roof. Sealant compounds used shall be appropriate for the roofing material and application and shall not be the sole method of waterproofing.

Note: For asphalt shingle roofs this shall be accomplished with the use of some type of flat metal flange that extends around a penetration and is installed completely under shingles on the upslope side of a penetration, with the flange extending beyond the headlap of the roof covering. The bottom flange should then overlap the shingles on the downslope side (adapted from 2014 NRCA roofing manual).

3.4.5 All mounting hardware shall be installed according to manufacturer specifications.

3.5 Solar Access

3.5.1 Solar resource shall be measured with an Emerald sun chart or approved shading analysis tool from the point on the array where shading is most significant. Details on using sun charts are available on the Oregon Solar Radiation Monitoring Laboratory website.[3]

3.5.2 Total Solar Resource Fraction ("TSRF") shall be 85% or greater at all points on the array for string inverters. Projects may include individual modules with a TSRF of less than 85% if the modules are electrically isolated from one another using microinverters or other pre-approved technology; however, those modules that do not meet the 85% requirement will not be eligible for program incentives. See **Program Guide for EPUD Solar Electric Program** for TSRF calculation.

3.5.3 It is recommended that the system be installed in an aesthetic manner that blends in with the building architecture. Small trade-offs in System performance due to sub-optimal tilt and orientation can greatly enhance the aesthetics of the installation and thereby increase long term public support for solar.

3.6 Performance

3.6.1 Array shall be sized to operate within the current, voltage and power limits approved and warranted by the inverter manufacturer and shall not exceed 135% of inverter output power rating based on the DC nameplate capacity of the modules at STC. The temperature-adjusted array voltage shall remain within the inverter limits at the extreme high and low temperatures expected at the installation site. Where available and appropriate, ASHRAE dry-bulb design temperatures may be used (use the 0.4% high temperature and extreme mean minimum temperature). In areas where ASHRAE data is not available (e.g. at higher elevations), historical record high and low temperatures should be used.

At mid-day, module temperatures are typically much higher than ambient conditions. When calculating voltage at the extreme high temperature, use the appropriate adder from Table 1. Systems on a roof that are tilted up 10° or more from the roof plane may be considered "Rack" mounted.

Table 1. Temperature Adders for High Temperature Voltage Calculation

Array Mounting	Temperature Adder
Roof	35 °C
Rack	30 °C
Pole	25 °C

3.6.2 Wires shall be sized to keep voltage drop at or below 2% in the DC conductors from the array to the inverter. Voltage drop will be calculated using temperature-adjusted V_{mp} (max power voltage) of the array for the location's average high temperature adjusted with the temperature adders in Table 1 above.

3.6.3 Wires shall be sized to keep voltage drop at or below 2% in the AC conductors from the inverter to the point of connection. Example points of connection include the distribution panel that contains the main

[3] http://solardat.uoregon.edu/SelectEPUDShadeForm.html

service disconnect(s), a supply-side tap, a pre-existing sub-panel with other loads, a generator transfer switch, or a switchgear.

3.6.4 AC voltage at the inverter shall be within the inverter's operating limits. At locations were utility service is higher than typical voltage, this may require a larger AC wire size or a shorter AC run than allowed under Section 3.6.3 to minimize voltage rise between the point of utility interconnection and the inverter.

3.6.5 Voltage mismatch caused by partial shading of the array, different orientations of strings within the array and by variations in module voltages shall be minimized, allowing the inverter to operate within its maximum power point window. Modules in a single string shall be installed at the same tilt and orientation or with no more than 10° variation.

3.7 Production Meter

3.7.1 Each solar system shall have the ability to measure the total AC system production in kilowatt-hours with at least +/- 5% accuracy using one of the following methods:

- A production meter built-in to the inverter. It shall appear on the List of Eligible Inverters provided by the California Energy Commission[4] as having an approved built-in meter.
- A system performance meter (i.e., a microinverter monitor). It shall appear on the List of Eligible System Performance Meters provided by the California Energy Commission[5].
- A hard wired production meter. It shall appear on the List of Eligible System Performance Meters provided by the California Energy Commission5.Refurbished meters may be used with the Program's pre-approval.

3.7.2 Multiple inverter systems may either combine output through a dedicated sub-panel from which the output is metered or use one electric meter for each inverter.

3.7.3 When a hard wired production meter is installed, the solar system meter shall have a UV-resistant label identifying it as the Customer Owned Solar Generator Output.

3.7.4 All hard-wired meters shall be set at 000000 or 999999 at time of shipment to the installer to ensure accurate and consistent "start" readings for every system.

3.8 Battery-based Systems

3.8.1 Batteries shall be located in a secure enclosure that meets seismic requirements and is weatherproof as needed.

3.8.2 Access to live battery terminals shall be limited per Oregon Electrical Specialty Code.

3.8.3 Flooded lead acid batteries shall be housed in an enclosure with adequate spill containment and vented to the outdoors with a nearby clearly marked OSHA 29 approved safety kit.

3.8.4 Battery and inverter cables shall be properly sized, with secure crimps and lugs on ends. Lugs and terminals shall be listed for the wire type used.

3.8.5 Charge controller and inverter settings shall be appropriate for the installation's batteries and set for grid-tied optimum performance.

3.8.6 Temperature compensation probes for inverter and/or charge controller shall be installed to control battery charge properly.

3.8.7 Array configuration shall operate within current and voltage limits of charge controller, accounting for temperature-adjusted array voltage under record high and low temperatures for that location.

[4] http://www.gosolarcalifornia.ca.gov/equipment/inverters.php
[5] http://www.gosolarcalifornia.org/equipment/system_perf.php

3.8.8 For hybrid systems utilizing wind or micro-hydro turbines in addition to PV, battery overcharge protection using turbine regulation and/or diversion controller and diversion load shall be installed.

3.8.9 Ground fault protection shall be added to the system if required by code and not included in the inverter.

3.8.10 Customer manual shall include instructions for operation, maintenance and safety procedures for batteries, charge controller, and inverter.

3.8.11 Systems with lithium ion batteries must use an appropriate battery management system.

4.0 Customer Manual

Upon completion of installation, Registered Contractor shall provide the customer with a manual ("Customer Manual") and instruct the owner on proper system operation and maintenance.

The Customer Manual shall be bound in a durable binder. Please instruct the Customer to have the Customer Manual along with the system permit(s) available on site for Emerald's inspection. The Customer Manual shall include, at minimum:

- System Design and Operation
  - System size and operating conditions
  - Make and model of modules and inverter(s)
  - Start-up and shut-down procedures
  - Emergency and service contact information
- Electrical as-built diagram that accurately depicts:
  - All electrical components installed (modules, inverters, disconnects, meters, etc.), plus main service panel and utility connection
  - Module series/parallel wiring, conductor and ground wire types and sizing, conduit types and sizing, and voltage drop calculations.
  - Inputs from solar existing systems, if present.
- Contractor Warranty covering all parts and labor for a minimum of two years.
- Manufacturer data sheets for modules and inverter(s).
- Copy of approved electrical and, where applicable, building permit for the system installation.
- If a hard wired production meter is not installed, informational sheet describing how to read the system's total kilowatt-hour production from the inverter or system performance meter (i.e., microinverter monitor).
- The following *optional* items are recommended to be included in the Customer Manual and/or provided to the customer in digital format (PDF):
  - Final version of the signed Application for Incentive for showing incentive and system configuration approved by Emerald.
  - Inverter Owner's Manual
  - Manufacturer's Warranties
  - Emerald Interconnection and/or Net Metering Agreement
  - Parts and Source List with component serial numbers
  - Manufacturer data sheets for other system components.