System Installation Requirements

EPUD
Solar Electric Program

2011

1.0 Acknowledgements

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

2.0 Purpose

This Solar Electric 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 system 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 electrical 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.

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
- Conductor and ground wire types and sizing
- Conduit types and sizing
- Voltage drop calculations
- AC breaker sizing

3.1.6 System design shall be documented with a physical layout diagram that accuratelydescribes 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)

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 steel) shall be isolated from one another using industry standard practices (such as non-conductive shims, washers, or other methods).

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:

- Corrosion-resistant 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)
- 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.

3.3 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.

- Photovoltaic modules shall meet IEEE standard 1262 (listed to UL 1703), or their successor standards and shall be certified by the California Energy Commission.

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 A listed means of disconnection from ALL sources of power (both AC and DC) shall be provided such that inverter source and output circuits can be safely isolated and removed for service. Disconnects shall be designed to be switched under load without an arcing hazard (e.g., blade-type or circuit breaker). Pull-out style disconnects shall not be used.

3.3.10 All electrical terminations shall be torque to specification, secured, and strain-relieved as appropriate. Wire ends shall be coated with anti-corrosive compound prior to termination.

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). Heavy-weight flexible steel conduit or hospital grade metal clad (MC) cable may be used as an alternative where allowed by the Oregon Electrical Specialty Code (OESC).

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

- EGC shall be sized and protected according to OESC 690.45(A) and 690.46.
- GEC shall be sized and protected according to OESC 690.47(A)(7) and 290.64(B).
- If a single conductor is used for the EGC and GEC, conductor sizing and protection shall conform to all of the OESC sections listed above.

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. Bell-type boxes shall not be used in a damp or wet location.

3.3.16 Permanent labels shall be applied to system components as required by OESC.

3.3.17 Disconnect switch coverplates (not switch handles) should be secured closed for safety (i.e., padlock, zip tie, etc.).

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 unless shaded by a
- permanent structure.
- ▪ Inverter shall be installed in an easily accessible and readable 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 Safety Labeling shall adhere to the following:

- All labels shall be UV resistant, written on a permanent base material, and designed to withstand long-term environmental exposure.
- DC Disconnect Label shall read:

SOLAR DC DISCONNECT
Rated Max Power Point Current: xxx ADC
Rated Max Power Point Voltage: xxx VDC
Maximum System Voltage: xxx VDC
Short-Circuit Current: xxx ADC

Warning - Electric Shock Hazard
DO NOT TOUCH TERMINALS
Terminals on both Line and Load sides may be energized in the Open Position.
DC VOLTAGE IS ALWAYS PRESENT WHEN SOLAR MODULES ARE EXPOSED TO SUNLIGHT

- AC Disconnect Label shall read:

SOLAR AC DISCONNECT
Rated AC Output Current: xxx Amps
Nominal Operating AC Voltage: xxx Volts

- Ground-Fault Protection Label shall read:

WARNING – ELECTRIC SHOCK HAZARD
If a ground fault is indicated, normally grounded conductors may be ungrounded and energized

- 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

3.4 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 Roof penetrations shall be made watertight using methods that are standard to the roofing industry and 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.

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 collector(s) where shading is most significant. Details on using sun charts is available on the Oregon Solar Radiation Monitoring Laboratory website.2

3.5.2 Total Solar Resource Fraction ("TSRF") at the location of the System shall be equal to or greater than 85%. See **Program Guide for EPUD Solar Electric Program** for TSRF calculation. Array orientation shall not be greater than 90 degrees east or west of true south (not magnetic south).

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 125% of inverter output power rating. The temperature-adjusted array voltage shall remain within the inverter limits at the historical record high and record low temperatures for the location where the System will be installed. 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 2. 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

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

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 including the existing wire whips on the PV modules. Voltage drop will be calculated using temperature-adjusted Vmp (max power voltage) of the array for the location's average high temperature.

3.6.3 Wires also shall be sized to keep voltage drop at or below 2% in the AC conductors from the inverter to the service panel to maintain the AC voltage within the inverter's operating limits.

3.6.4 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.

3.6.5 Annual delivered energy is the estimated annual kWh output of a System.

- Annual delivered energy (kWh/yr) = Local production capacity (kWh/W-DC – yr) X Total installed capacity (W-DC) X TSRF (%).

3.6.6 Total installed capacity is the array size in W-DC. Multiply the DC power rating of the modules at standard test condition by the number of modules.

3.6.7 Peak AC output is the AC power output the Customer should expect to see under full sun conditions.

- Peak AC output (W-AC) = Peak system efficiency (%) X Total installed capacity (W-DC)

3.6.8 Peak system efficiency is the expected conversion efficiency from DC to AC under full sun conditions. The Registered Contractor shall calculate this value based on the Total Installed Capacity and the inverter and module rated efficiencies. Other factors influencing peak system efficiency may include module mismatch, inefficient wiring, inverter and module mismatch, and the use of battery backup.

3.7 Output Meter

3.7.1 A new *revenue quality* electric meter which meets the following specification shall be installed on the AC output of the solar electric system, which measures ONLY the AC output of the PV array(s).

- ANSI C-12 tested and certified revenue meter.
- Electronic meters accurate to within 1% of actual system output (ANSI C-12.16)
- One of the following configurations:
  - Single-phase 120 volt – Form 1S – Class 100
  - Single-phase 240 volt – Form 2S – Class 200
  - Three-phase 120 to 480 volt – Form 14-16S – Class 200
- Meter warranty of not less than 1 year
- Digital or cyclometer display for easy reading by system owner.

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 Because the meter may be located near the utility meter, the solar system meter shall have a UV-resistant label identifying it as the "Solar Generator Output."

3.7.4 All meters shall be set at 000000 at time of shipment to the installer to accurate and consistent "start" readings for every month.

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 safety kit.

3.8.4 Battery interconnect 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.

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.

4.0 Customer Manual

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

The Customer Manual provides accurate system documentation for the current system owner, as well as future owners and potential service personnel. The Customer Manual shall be bound in a durable and professional-looking binder, and shall contain, at minimum, three sections: 1) System Design and Operation, 2) Warranties and Installation Documentation, 3) Manuals and Data Sheets.

4.1 Section 1 – System Design and Operation

4.1.1 System Overview Page
Solar Electric System Overview Page supplied by Emerald, or equivalent, that summarizes the system's operating conditions and provides emergency information.

4.1.2 Operation & Maintenance Instructions
Installer's written instructions for system start-up and shutdown procedure, troubleshooting guidelines and guidelines and recommended routine maintenance schedule.

4.1.3 Electrical As-built Diagram

Schematic diagram that accurately depicts all electrical components installed, plus main service panel and utility connection. Diagram shall depict module series/parallel wiring, conductor and ground wire types and sizing, conduit types and sizing, and voltage drop calculations.

4.1.4 Mechanical Design
Include description of array support structure, including engineering specifications of structural elements and manufacturer installation instructions. Provide drawings describing racking, pole mount or roof attachment methods systems.

4.1.5 Physical Layout Diagram
Diagram indicating the location of the major system components with respect to the structure or property

4.2 Section 2 – Warranties and Installation Documentation

4.2.1 Contractor Warranty
Registered Contractor's 2-yr minimum full system warranty covering labor and materials.

4.2.2 Manufacturer's Warranty
Written warranties and product registration instructions for PV modules and inverters.

4.2.3 Incentive Application
Final version of the signed for showing incentive and configuration approved by Emerald.

4.2.4 Permit(s)
Copy of approved electrical and, where applicable, building permit for the system installation.

4.2.5 Emerald Interconnection and/or Net Metering Agreement
Copy of the agreement between the Program participant and Emerald.

4.3 Section 3 – Manuals and Data Sheets

4.3.1 Parts and Source List
Bill of material listing all system components including part numbers. If feasible, inverter and module serial numbers should be recorded to facilitate replacement in the case of product recall or recovery in the case of theft.

4.3.2 Inverter Owner's Manual
Documentation from inverter manufacturer.

4.3.3 Manufacturer Data Sheets for Major Components
Including, but not limited to: inverters, PV modules, rack/mounting system, charge controller, batteries, disconnect switches, ground fault protection equipment