BLACK (bold & underlined): Model Code Language
BLUE: Committee Recommended New Language
~~RED: Committee Recommended Deleted Language~~

Oregon Solar Energy Code

Draft Document

September 2009

Chapter 1: Administration

Title, Purpose and Scope

Title
This document shall be known as the "Oregon Solar Energy Code" and will be referred to as "OSEC" herein. The term "solar electric" as used in this document shall have the same meaning as Solar Photo-voltaic Systems".

Purpose
The OSEC is created to provide for the protection of property and citizens in Oregon and to provide minimum installation requirements for Solar Electric, and other Solar Electric related installations.

Plans Required
The Authority Having Jurisdiction may only require plans, specifications, drawings, engineering or other information if the completed solar installation meets any of the following;

a) **The structure was built prior to 1955.**
b) **The completed system adds more than 5lbs of "dead load" to the existing roof.**
c) **The manufacturer's installation instructions do not provide wind, uplift and attachment information.**
d) **The completed system exceeds 600-amps or 600-volts.**
e) **The system is installed in or enters a hazardous location as defined in Articles 500-516 of the OESC.**

Manufacturer's installation instructions or engineered drawings that provide attachment options, including wind and uplift specifications, shall be provided with the permit application. Approved plans and specifications shall not prevent the Authority Having Jurisdiction from requiring correction of OSEC violations nor from issuing a "stop order" if violations of the OSEC are not corrected.

Structural Design
The arrays, racking, associated equipment and support structure assemblies, including building components and attachments, shall be designed and constructed to withstand the following loads in accordance with the applicable Oregon Building Codes.

a) **Dead loads**
b) **Live loads**
c) **Snow loads**
d) **Wind loads**
e) **Seismic loads**
f) **Expansion and contraction loads resulting from temperature changes.**

Fire fighter access
Solar system installations shall be designed to allow firefighter access to attic and overhang areas. See attached best practice documents as guidelines.

Scope
The provisions of this Code shall apply to the construction, installation, alteration, addition, repair, relocation, replacement, addition to, use, of any solar systems. This code applies to all buildings,

structures and ground mounted solar installations in residential, agricultural, commercial, institutional and industrial settings.

Repairs and Alterations
In existing buildings or premises in which solar installations are to be altered, repaired, or renovated, deviations from the provisions of this code are permitted, provided such deviations are found to be necessary and are first approved, in writing, by the Authority Having Jurisdiction.

Existing Installations
Solar installations in existing buildings in the State of Oregon that complied with the minimum OSEC standards in effect at the time of installation shall not be considered in violation of the current minimum OSEC standards, unless the use or occupancy of the building is changed requiring different methods, alterations, or additions. Additions, alterations, repairs, and replacement of solar systems shall comply with the provisions for new systems.

Conflicts between Codes
If the requirements within this code conflict with the requirements of the adopted Oregon residential, electrical, structural, mechanical, manufactured dwelling, floating structures or pre-fabricated structures codes, the requirements in this code shall prevail.

Moved Buildings
Solar systems which are not part of the original buildings or structures moved into the State of Oregon or re-located in the State of Oregon shall comply with the provisions of this code for new installations.

Authority to Disconnect Solar Installations during Emergencies
The Authority Having Jurisdiction, Fire Department, or local utility shall have the authority to disconnect a solar system to a building, structure, or equipment regulated by this code in case of emergency where necessary to eliminate an immediate hazard to life or property.

Inspections
All solar systems for which a permit is required by this code shall be inspected by the Authority Having Jurisdiction to insure compliance with all the requirements of this Code. No portion of any solar system shall be concealed until inspected and approved. Neither the Authority Having Jurisdiction nor the jurisdiction shall be liable for expenses entailed in the removal or replacement of material required to permit inspection. When the installation of a solar system is complete, an additional and final inspection shall be made. Solar systems regulated by this code shall not be connected to the water, energy fuel supply, utility or the sewer system until authorized by the Authority Having Jurisdiction.

Corrections
Notices of code violation shall be in writing by the Authority Having Jurisdiction with the appropriate code violation cited. Corrections of code violations shall be completed within twenty (20) days of notice unless additional time for corrections is approved by the authority having jurisdiction.

Approval
Upon the satisfactory completion and final inspection of the solar system, a final inspection notice shall be issued by the Authority Having Jurisdiction.

Chapter 2: Definitions

Definition of Terms

– A –

Absorber – That part of the solar collector which receives the incident radiation energy.
Absorptance – The collecting of heat, measured as percent of total radiation available.
Accessible (as applied to equipment) - Admitting close approach; not guarded by locked doors, elevation, or other effective means.
Accessible (as applied to wiring methods) - Capable of being removed or exposed without damaging the building structure or finish or not permanently closed in by the structure or finish of the building.
Accessible, Readily (Readily Accessible) - Capable of being reached quickly for operation, renewal, or inspections without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, and so forth.
Air Mass – The ration of the mass of atmosphere, in the actual earth-sun path, to the mass which would exist if the sun were directly overhead at sea level.
Alternating-Current (ac) Module (Alternating-Current Photovoltaic Module) - A complete, environmentally protected unit consisting of solar cells, optics, inverter, and other components, exclusive of tracker, designed to generate ac power when exposed to sunlight.
Ambient Temperature – Surrounding temperature.
Angle of Incidence – The angle between the direct solar irradiation and the normal to the aperture plane.
Approved-Acceptable to the authority having jurisdiction.
Approved Testing Agency – An organization primarily established for purposes of testing to approved standards and approved by the Administrative Authority Having Jurisdiction.
Appurtenance, Solar – A manufactured device, a prefabricated assembly, or an on-the-job assembly of component parts, which is an adjunct to a solar system.
Area, Absorber – The total projected heat transfer area from which the absorbed solar irradiation heats the transfer media.
Area, Aperture – The maximum projected area of a solar collector through which the un-concentrated solar radiant energy is admitted.
Area, Gross Collector – The maximum projected area of the complete collector module, including integral mounting means.
Array-A mechanically integrated assembly of modules or panels with a support structure and foundation, tracker, and other components, as required, to form a direct-current power-producing unit.
Authority Having Jurisdiction (AHJ)-An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

– B –

Ballasting - The use of materials or weights to hold down the racking system of a solar installation. Ballasting generally does not require roof penetration or attachment to a structure.
Bipolar Photovoltaic Array - A photovoltaic array that has two outputs, each having opposite polarity to a common reference point or center tap.
Blocking Diode - A diode used to block reverse flow of current into a photovoltaic source circuit.
Bonded (Bonding) - Connected to establish electrical continuity and conductivity.
Bonding Jumper - A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected.
Bonding Jumper, Equipment - The connection between two or more portions of the equipment grounding conductor.

Building - A structure that stands alone or that is cut off from adjoining structures by fire walls with all openings therein protected by approved fire doors.
Building Code – As defined in ORS 455
Building Integrated Photovoltaics - Photovoltaic cells, devices, modules, or modular materials that are integrated into the outer surface or structure of a building and serve as the outer protective surface of that building.

– C –
Charge Controller - Equipment that controls dc voltage or dc current, or both, used to charge a battery.
Code – When used alone shall mean these regulations, subsequent amendments thereto or any emergency rule or regulation which the Authority having jurisdiction may lawfully adopt. A standard that is an extensive compilation of provisions covering broad subject matter or that is suitable for adoption into law independently of other codes and standards.
Collector – See Solar Collector.
Collector, Concentrating – A solar collector which uses reflectors, lenses, or other optical elements to concentrate the radiant energy passing through the aperture onto an absorber of which the surface area is smaller than the aperture area.
Collector Tilt – The angle above horizontal at which a solar heat collector is positioned.
Concentration Ratio – The ratio of the aperture area to the absorber area (in concentrating solar collectors).
Concentrator – Reflector of lens designed to focus solar energy into a reduced area.
Cover, Collector (Glazing) – The material covering the aperture to provide thermal and environmental protection.

– D –
Dead Load - The weight of materials of construction incorporated into the building, including but not limited to walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, cladding and other similarly incorporated architectural and structural items, and the weight of fixed service equipment, such as cranes, plumbing stacks and risers, electrical feeders, HVAC systems and fire sprinkler systems.
Diameter – Unless specifically stated, the term "diameter" is the nominal diameter as designated commercially.
Distribution System – That section of the solar system from the storage system to the point of use.
Diversion Charge Controller - Equipment that regulates the charging process of a battery by diverting power from energy storage to direct-current or alternating-current loads or to an interconnected utility service.

– E –
Electrical Code, (OESC) - For the purpose of this code, any reference to the Electrical Code shall mean the Oregon Electrical Specialty Code.
Electrical Production and Distribution Network - A power production, distribution, and utilization system, such as a utility system and connected loads that is external to and not controlled by the photovoltaic power system.
Emittance – The amount of heat radiated back from the solar collector, measured as percent of energy absorbed by the collector.
Existing Work – Existing work is a solar system or any part thereof which has been installed prior to the effective date of this Code.

– F –
Flat Plate Collector – A panel (non-concentrating type) of suitable material that converts solar energy into usable energy and the absorbing surface is essentially planar.

– G –

Ground - The earth.

Grounded (Grounding) - Connected (connecting) to ground or to a conductive body that extends the ground connection.

Grounded, Solidly - Connected to ground without inserting any resistor or impedance device.

Grounded Conductor - A system or circuit conductor that is intentionally grounded.

Grounding Conductor - A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes.

Grounding Conductor, Equipment (EGC) - The conductive path installed to connect normally non–current-carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor, or both.

FPN No. 1: It is recognized that the equipment grounding conductor also performs bonding.

~~*FPN No.2:See also 250.118 for a list of acceptable equipment grounding conductors*~~

Grounding Electrode - A conducting object through which a direct connection to earth is established.

Grounding Electrode Conductor - A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system.

– H –

Hangers – See Supports.

Hazardous Material – Any substance or mixture of substances which is toxic, corrosive, flammable, an irritant, a sensitizer, and which presents a potential threat to the health of humans or animals.

Heliostat – A reflecting surface mounted on an axis to direct the sun's rays to a fixed point.

Hybrid System - A system comprised of multiple power sources. These power sources may include photovoltaic, wind, micro-hydro generators, engine-driven generators, and others, but do not include electrical production and distribution network systems. Energy storage systems, such as batteries, do not constitute a power source for the purpose of this definition.

– I –

Insolation – The rate of solar energy received on a unit surface in a unit time.

Interactive System - A solar photovoltaic system that operates in parallel with and may deliver power to an electrical production and distribution network. For the purpose of this definition, an energy storage subsystem of a solar photovoltaic system, such as a battery, is not another electrical production source.

Inverter - Equipment that is used to change voltage level or waveform, or both, of electrical energy. Commonly, an inverter [also known as a power conditioning unit (PCU) or power conversion system (PCS)] is a device that changes dc input to an ac output. Inverters may also function as battery chargers that use alternating current from another source and convert it into direct current for charging batteries.

Inverter Input Circuit - Conductors between the inverter and the battery in stand-alone systems or the conductors between the inverter and the photovoltaic output circuits for electrical production and distribution network.

Inverter Output Circuit - Conductors between the inverter and an ac panelboard for stand-alone systems or the conductors between the inverter and the service equipment or another electric power production source, such as a utility, for electrical production and distribution network.

Irradiation, Instantaneous – The quantity of solar radiation incident on a unit surface area in unit time, measured in btu/hr-ft2(W/m2).

Irradiation, Integrated Average – The solar radiation incident on a unit surface area during a specified time period divided by the duration of that time period.

– J –

No Definitions

– K –
No definitions

– L –
Labeled - Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.
Langley – A unit of measurement of insolation, equal to 3.69 btu per square foot (1 gram-calorie per square centimeter).
Listed - Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.
FPN: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. Use of the system employed by the listing organization allows the authority having jurisdiction to identify a listed product.
Listing Agency – An agency approved by the Division and which maintains includes initial and ongoing product testing, a periodic inspection program on current production or of listed (certified) products models, and which makes available a published report of such listing in which specific information is included that the material or product conforms to applicable standards and has been tested to approved standards and found safe for use in a specified manner.
Live loads (roof)-Those loads produced (1) during maintenance by workers, equipment and materials; and (2) during the life of the structure by movable objects such as planters and by people.
Live Parts - Energized conductive components.
Lot – Lot means a single or individual parcel or area of land legally recorded or validated by other means acceptable to the Authority Having Jurisdiction on which is situated a building or which is the site of any work regulated by this code , together with the yards, courts, and unoccupied spaces legally required for the building or works, and which is owned by or is in the lawful possession of the owner of the building or works.

– M –
May – The word "may" is a permissive term.
Mechanical Code (OMSC) – For the purpose of this code, any reference to the Mechanical Code shall mean the Oregon Mechanical Specialty Code.
Module - A complete, environmentally protected unit consisting of solar cells, optics, and other components, exclusive of tracker, designed to generate dc power when exposed to sunlight.

– N –
No definitions

– O –
Out-Gassing – As applied to thermal energy, the thermal process by which materials expel gas.

– P –
Panel - A collection of modules mechanically fastened together, wired, and designed to provide a field-installable unit.
Photolysis – Chemical decomposition caused by radiation.

Photosynthesis – The building up of chemical compounds with the help of radiation.
Photovoltaic – Relating to electricity produced by the action of solar radiation on a solar cell.
Photovoltaic Output Circuit - Circuit conductors between the photovoltaic source circuit(s) and the inverter or dc utilization equipment.
Photovoltaic Power Source -An array or aggregate of arrays that generates dc power at system voltage and current.
Photovoltaic Source Circuit - Circuits between modules and from modules to the common connection point(s) of the dc system.
Photovoltaic System Voltage - The direct current (dc) voltage of any photovoltaic source or photovoltaic output circuit. For multi-wire installations, the photovoltaic system voltage is the highest voltage between any two dc conductors.
Plenum – An air compartment or chamber to which one or more ducts are connected and which forms part of either the conditioned air supply, circulating air or exhaust air system, other than the occupied space being conditioned.
Pyranometer – A device used to measure the total solar radiation incident upon a surface per unit time per unit area.
Pyrheliometer – A device used to measure the direct radiation on a surface normal to the sun's rays.

– Q –
No definitions

– R –
Racking - The material, supports, attachment, frame, skeleton used to attach a solar system to a building, other structure or directly on the ground.
Residential Code, (ORSC) - For the purpose of this code, any reference to the Residential Code shall mean the Oregon Residential Specialty Code.
Roughing-In – Roughing-in is the installation of all parts of the solar system which can be completed prior to the installation of fixtures or appurtenances. This includes electrical wiring, conduits, racking, equipment, and vent piping and the necessary supports prior to cover.

– S –
Selective Surface – A special coating applied to solar collectors, having high absorption and low emission factors.
Shall – Mandatory term indicates a mandatory requirement.
Size – See Diameter.
Solar Cell - The basic photovoltaic device that generates electricity when exposed to light.
Solar Photovoltaic System - The total components and subsystems that, in combination, convert solar energy into electric energy suitable for connection to a utilization load.
Solar Collector – A device used to absorb energy from the sun.
Solar Constant – The average amount of solar radiation reaching the earth's atmosphere per unit time (about 2 langleys per minute).
Solar Photovoltaic System - The total components and subsystems that, in combination, convert solar energy into electric energy suitable for connection to a utilization load.
Solar System – As used in this code is any configuration of equipment and components to collect, convey, store and convert the sun's energy for a purpose.
Stand-Alone System - A solar photovoltaic system that supplies power independently of an electrical production and distribution network.
Standard Air – Air weighing 0.075 lb/ft3(1.2 kg/m3) and is equivalent in density to dry air at a temperature of 70°F (21.1°C) and standard barometric pressure of 29.92 in. Hg. (1.01 x 105 kPa).
Stored Energy – Accumulated energy which is available for use.

Structural Code, (OSSC) - For the purpose of this code, any reference to the Structural Code shall mean the Oregon Structural Specialty Code.
Supports – Supports, hangers, and anchors are devices for properly supporting and securing pipe, appurtenances, fixtures, and equipment.

– T –
Total Incident Irradiation – The total solar radiant energy incident upon a unit surface area during a specified time period, expressed in btu/ft2(J/m2).

– U –
Utility-Interactive Inverter - An inverter intended for use in parallel with an electric utility to supply common loads that may deliver power to the utility.

– V –
Venetian Blind Collector – A solar collector in which movable vanes are employed to absorb or reject energy.

– W –
No definitions

– X –
No definitions.

– Y –
No definitions.

– Z –
No definitions.

Chapter 3: Structural Requirements

Racking Installations; General:
Frames, braces and attaching devices exposed to the weather shall be constructed of materials approved for exterior locations and protected from corrosion or deterioration. Racking and racking supports shall be mounted to structural components and will be attached to the structural components through the use of screws, bolts, j-bolts, or other approved means in accordance with manufacturer's or engineer's instructions. Screws smaller than No. 10 or bolts smaller than ¼" shall not be allowed, in addition, the use of plywood, particle board or chipboard as the sole supporting means for racking shall not be allowed.

Arrays: Roof Mounted
Array panels shall be anchored to roof structural components in a manner to resist wind, snow, vibration or seismic loading in compliance with the applicable Oregon Building Codes. Anchors secured to and through roofing material shall be made in a manner to maintain the water integrity of the roof covering. Roof drainage shall not be impaired by the installation of panels or racking. Panels which are not an integral part of the roofing system shall be installed in a manner so as to preserve the integrity of the roof surface; inspection of the attachment method shall occur prior to setting of panels.

Arrays: Pole or other structure mounted systems:
Arrays mounted to pole or structures other than a roof shall be anchored in a manner to resist wind, snow, vibration, or seismic loading. Engineered drawings detailing soil conditions, depth of concrete base, concrete base rebar makeup may be required to approval of permit. Any pole mounted solar installation shall have the concrete or supporting base no less in depth than the frost line as required in the Oregon Structural Specialty Code. Alternate attachment and support methods may be approved by the authority having jurisdiction.

Arrays: Ground Mounted
In addition to being anchored in a manner to resist wind, snow, vibration, or seismic loading, panels installed at ground level shall be at least six (6) inches (152 mm) above the ground level.

Equipment Location:
Components shall not be so located as to interfere with the normal operation and use of windows, doors, or other required facilities or obstruct access to equipment such as: inverters, batteries, electrical disconnects, meters, valves. Array Panels constructed of combustible materials shall not be located on or adjacent to construction required to be of non-combustible materials or in special fire areas unless approved by the Authority Having Jurisdiction.

Controls:
Required electrical, mechanical, safety, and operating controls shall be of such design and construction as to be suitable for installation in the environment in which they are located.

Protection:
Any portion of the solar system installed where it may be subjected to mechanical damage shall be guarded against such damage by being installed behind barriers such as bollards, fences, or other approve means or when located within a garage be elevated a minimum of 48" above finished garage floor or located out of the normal path of a vehicle.

Fire Safety Requirements/Fire Fighter Access:
Solar arrays which function as building components shall comply with the Building Code, and shall not reduce the required fire-resistance or fire classification of the structure. Examples include but are not limited to: curtain walls, membrane roofing, sky lights and solar windows.

On residential structures, solar arrays shall maintain a minimum clearance of 36" from all edges, peaks, valleys, roof access points, skylights. In addition, a minimum 36" wide pathway shall be maintained to access skylights, roof hatches, HVAC equipment or other equipment requiring maintenance. On commercial structures a 48" wide pathway shall be maintained from all edges, peaks, valleys, roof access points, skylights. In addition, a minimum 48" wide pathway shall be maintained to access skylights, roof hatches, HVAC equipment or other equipment requiring maintenance, this pathway shall be directly over roof structural members. (See attached examples for best design practices).

Installation of conductors, conduits, combiner boxes, disconnects shall be made in such a manner as to not create a tripping hazard or impede fire-fighter access nor cross through the required pathway.

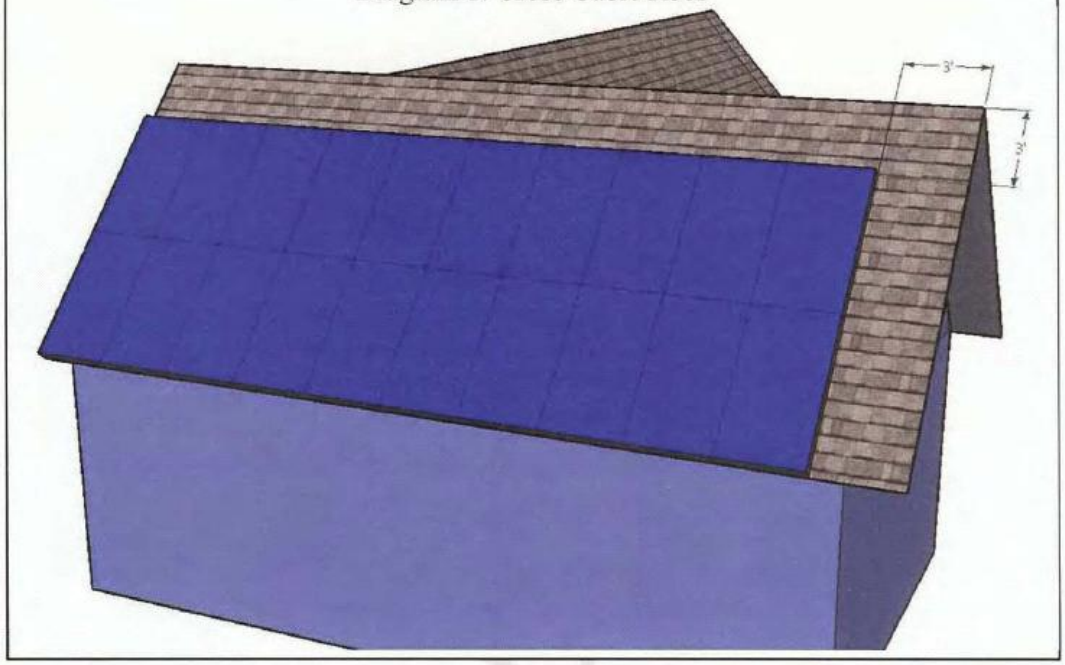
Each solar array string shall be installed with a visible D/C disconnect. This disconnect shall be marked "Array # __ D/C disconnect". Letters shall be a minimum of 1" in height, suitable for the environment and red in color.

This space reserved for examples of "best practice" installations relating to fire fighter access.

Examples of "best practice" installations relating to fire fighter access

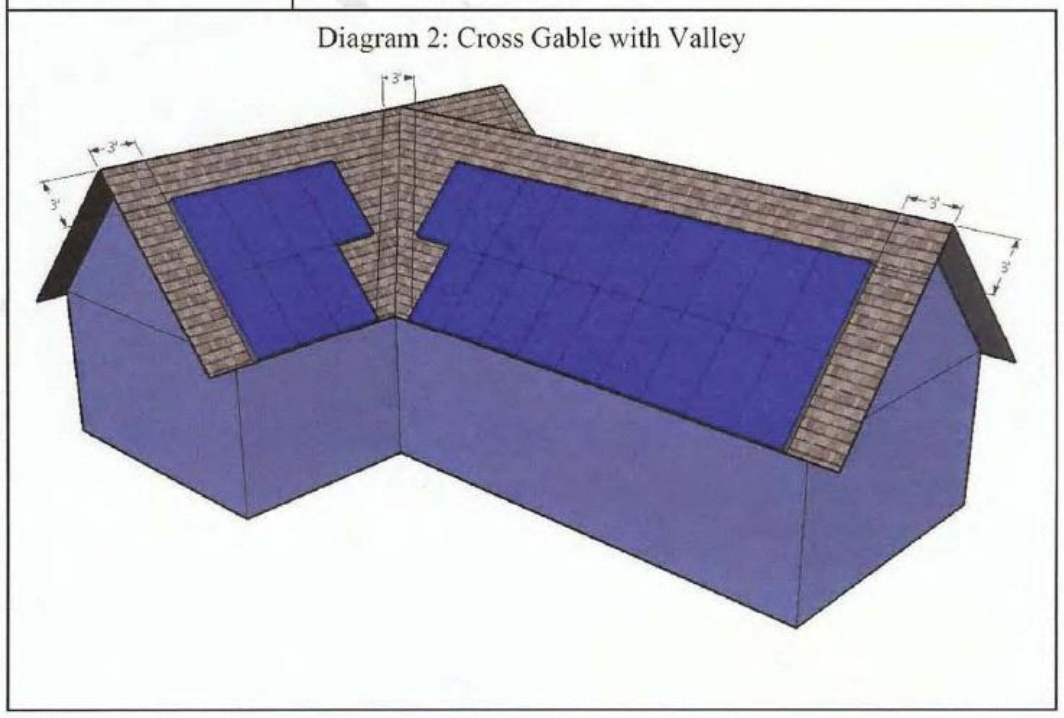
EXAMPLE 1

Diagram 1: Cross Gable Roof



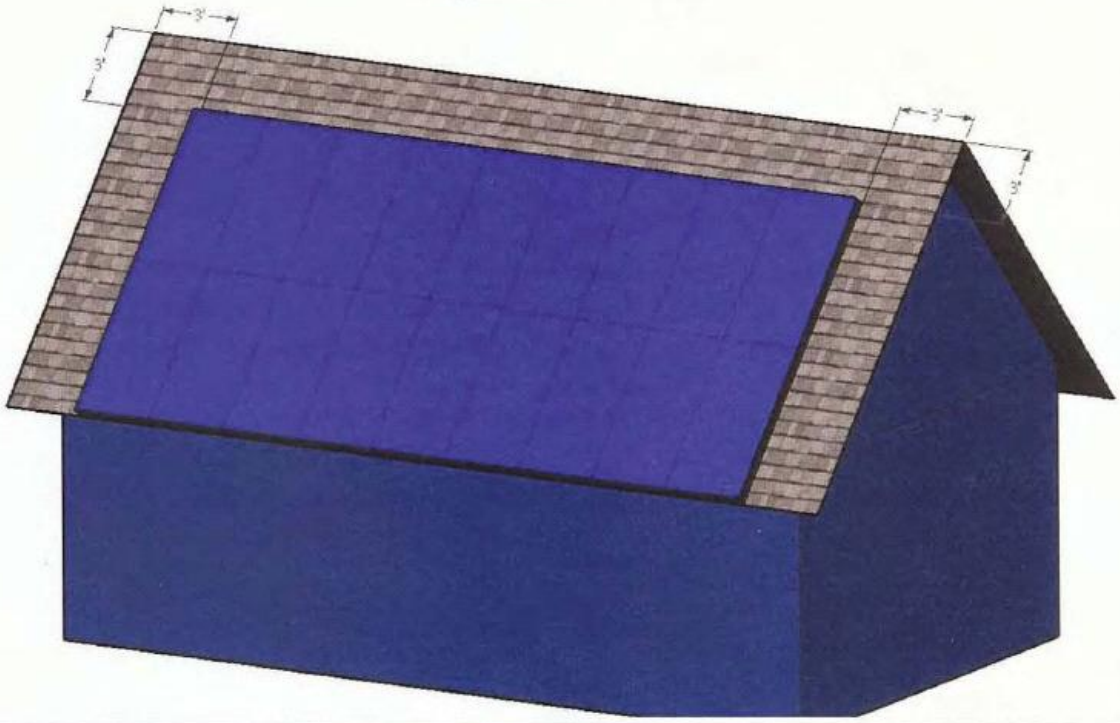
EXAMPLE 2

Diagram 2: Cross Gable with Valley



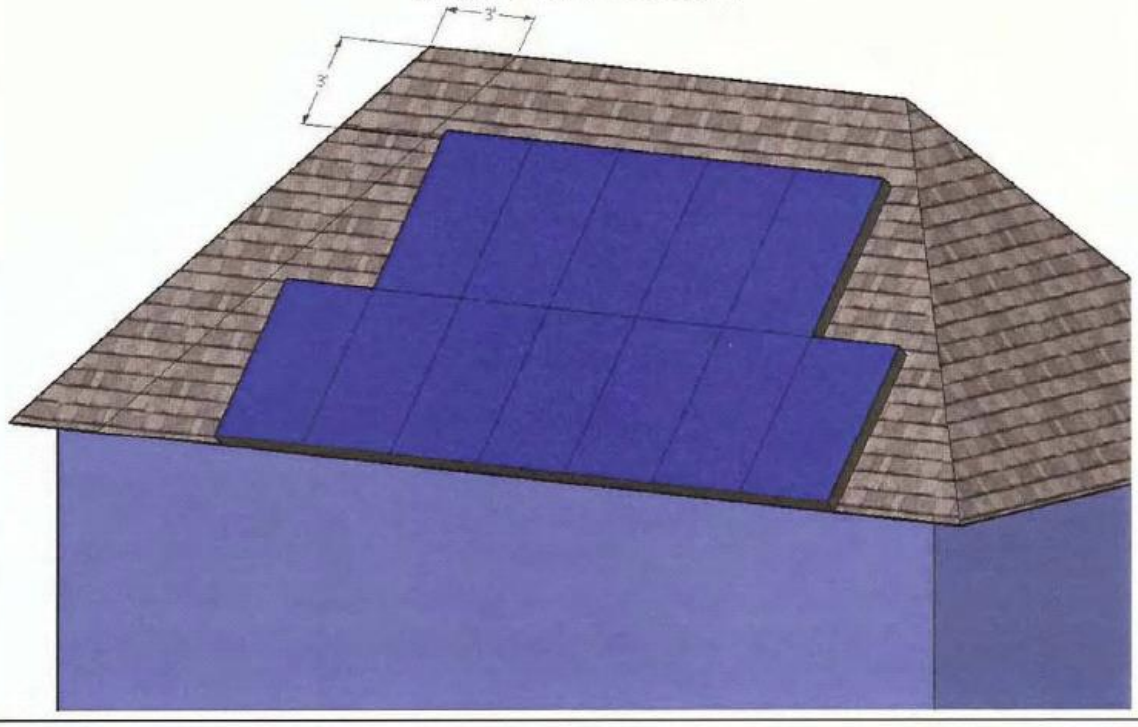
EXAMPLE 3

Diagram 3: Full Gable

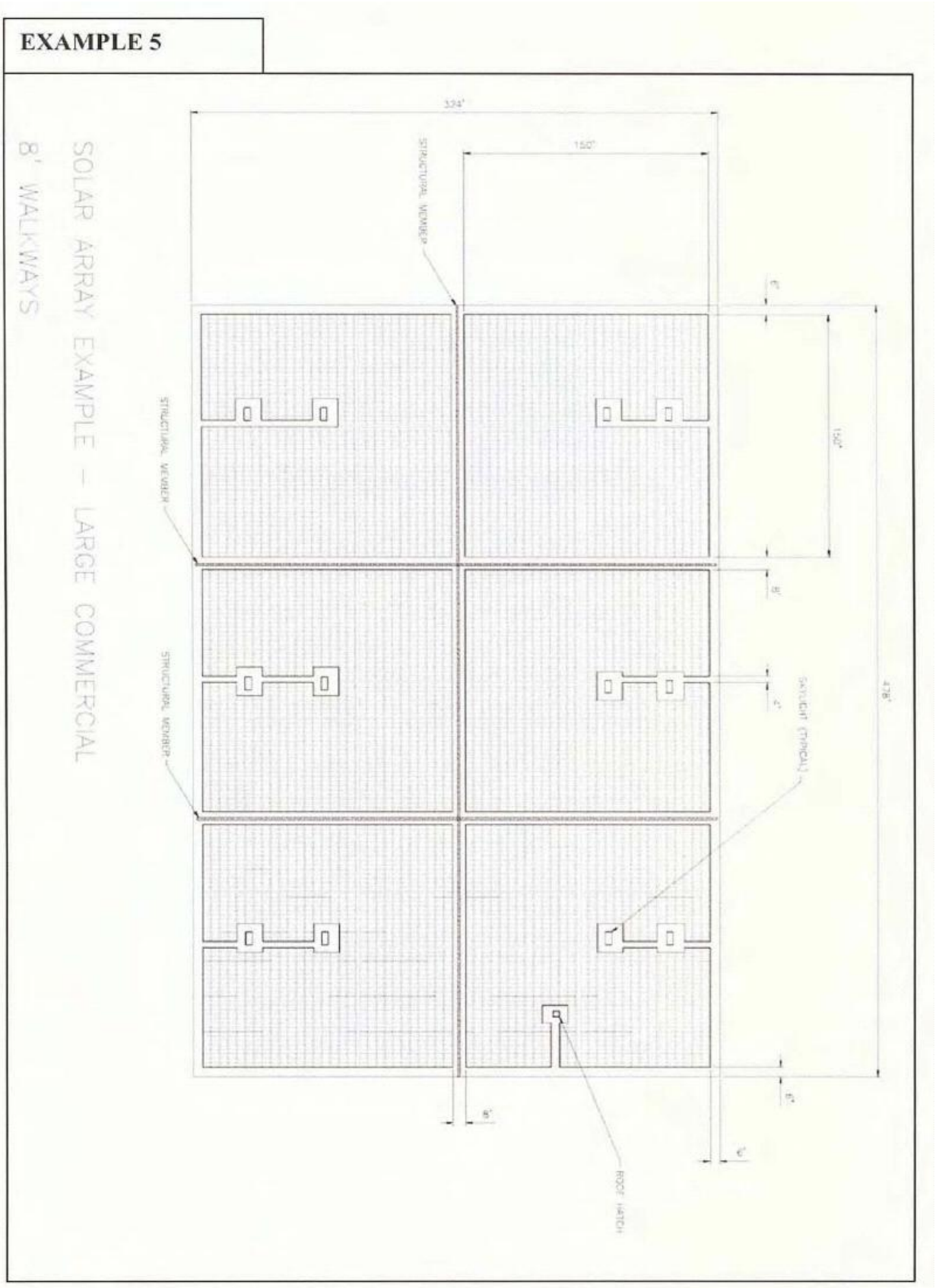


EXAMPLE 4

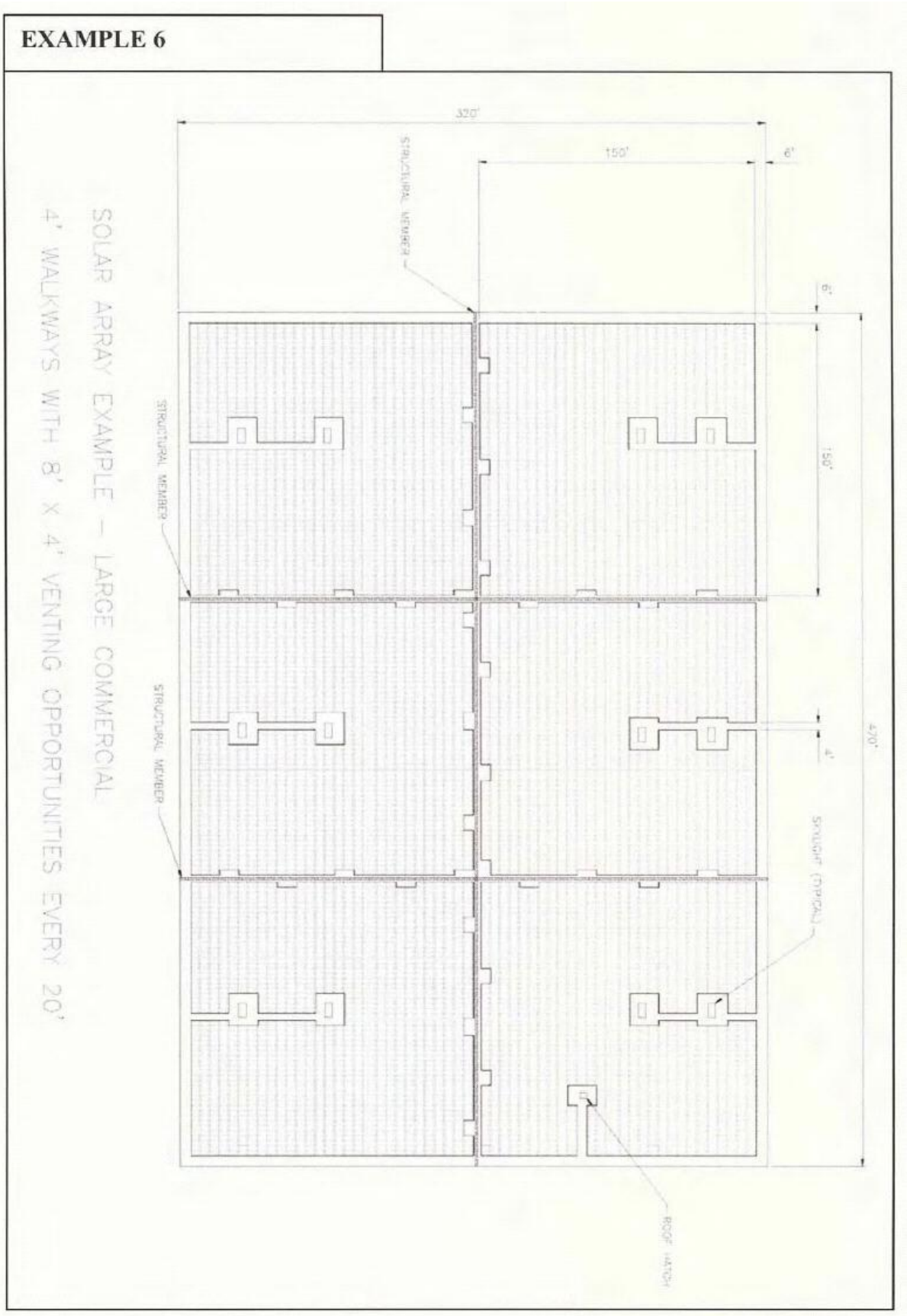
Example 4: Full Hip Roof



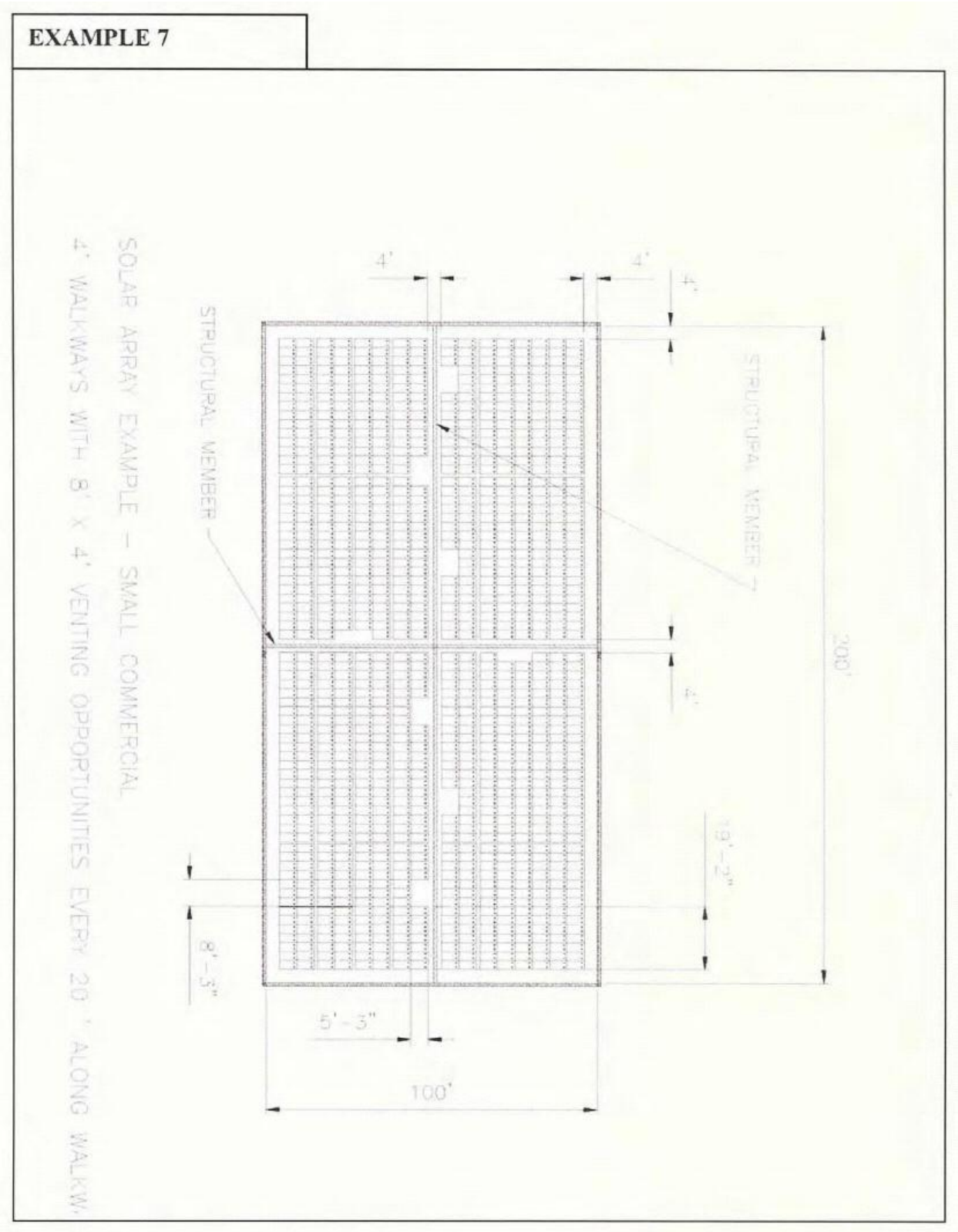
EXAMPLE 5


SOLAR ARRAY EXAMPLE – LARGE COMMERCIAL
8' WALKWAYS
334'
150'
STRUCTURAL MEMBER
STRUCTURAL MEMBER
STRUCTURAL MEMBER
150'
478'
SKYLIGHT (TYPICAL)
ROOF HATCH
8'
8'
8'
8'
4'
4'

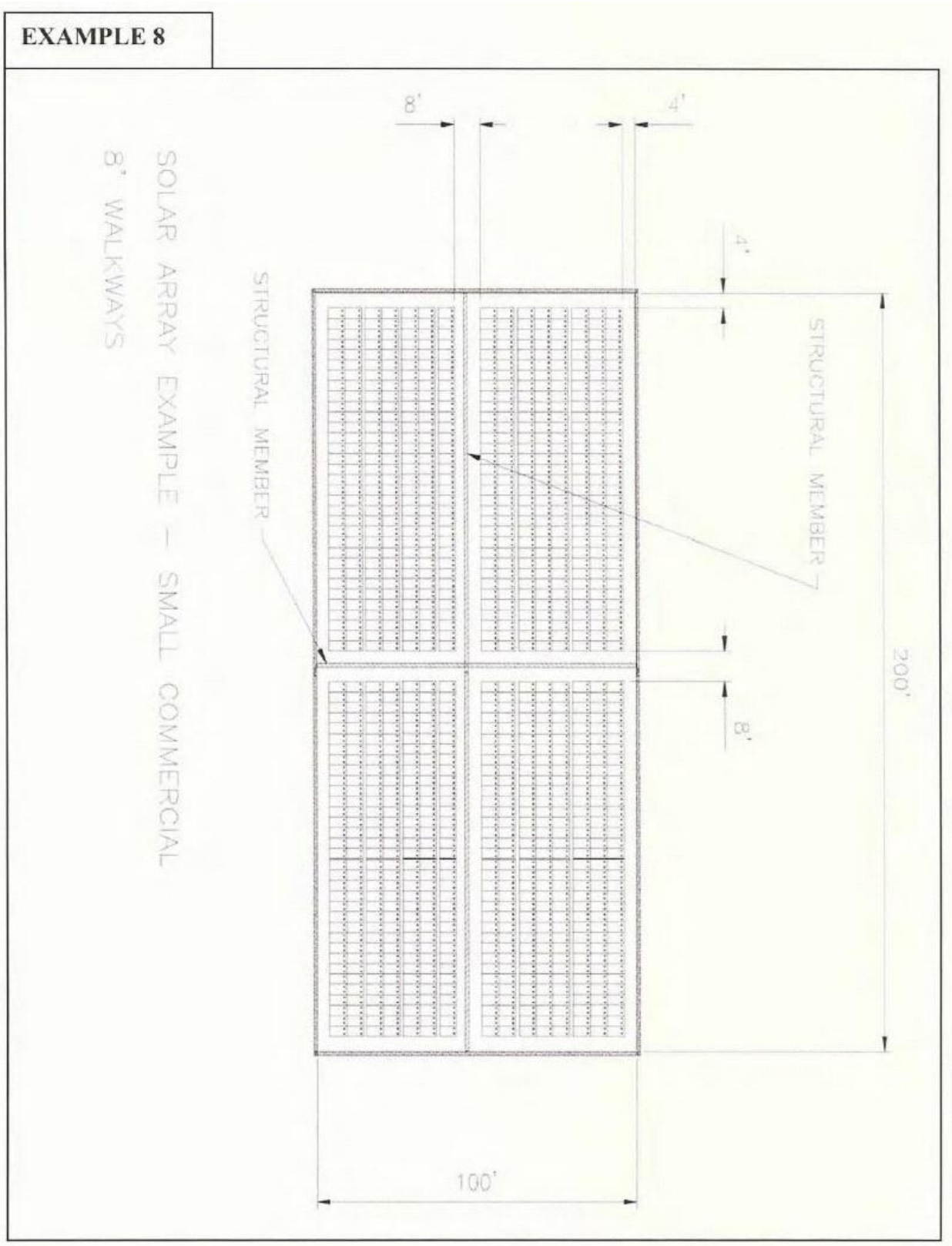
EXAMPLE 6

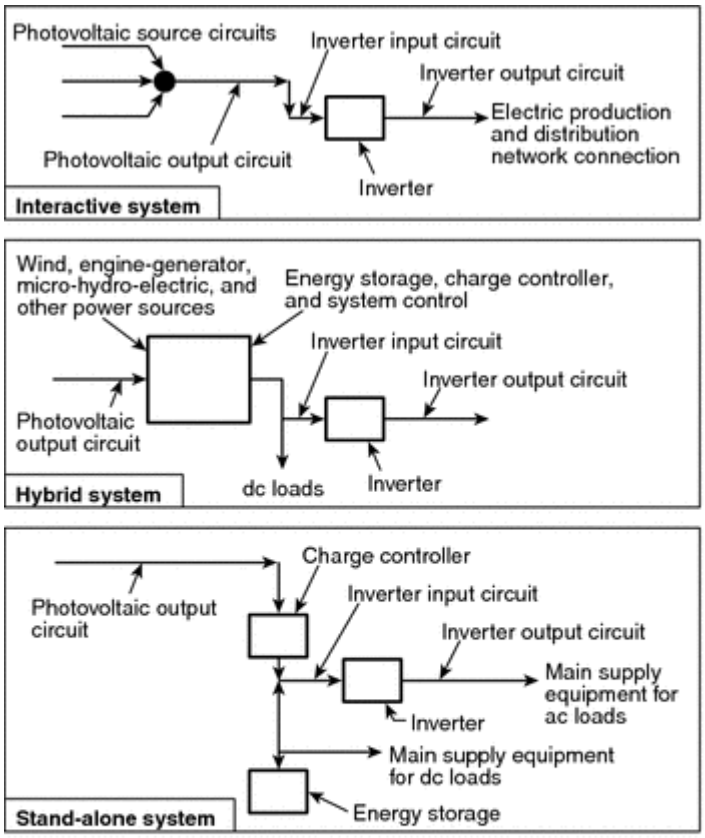

320'
150'
6'
STRUCTURAL MEMBER
6'
150'
470'
4'
SKYLIGHT (TYP.)
ROOF HATCH
SOLAR ARRAY EXAMPLE – LARGE COMMERCIAL
4' WALKWAYS WITH 8' X 4' VENTING OPPORTUNITIES EVERY 20'

EXAMPLE 7


SOLAR ARRAY EXAMPLE – SMALL COMMERCIAL
4' WALKWAYS WITH 8' X 4' VENTING OPPORTUNITIES EVERY 20 ' ALONG WALKW
STRUCTURAL MEMBER
STRUCTURAL MEMBER
4'
4'
4'
4'
200'
19'-2"
8'-3"
5'-3"
100'

EXAMPLE 8


SOLAR ARRAY EXAMPLE – SMALL COMMERCIAL
8' WALKWAYS
8'
4'
4'
STRUCTURAL MEMBER
STRUCTURAL MEMBER
200'
8'
100'



Notes:
1. These diagrams are intended to be a means of identification for photovoltaic system components, circuits, and connections.
2. Disconnecting means and overcurrent protection required by Article 690 are not shown.
3. System grounding and equipment grounding are not shown. See Article 690, Part V.
4. Custom designs occur in each configuration, and some components are optional.

Identification of Solar Photovoltaic System Components in Common System Configurations.

Chapter 4: Electrical Requirements

Electrical:

Electrical wiring and equipment shall comply with the requirements of the Oregon Electrical Specialty Code as modified by this document. In the event of conflict, the requirements found in this document shall prevail.

General:

OSEC 690.1 Scope:

The provisions of this article apply to solar photovoltaic (PV), electrical energy systems, including the array circuit(s), inverter(s), and controller(s) for such systems. ~~**[See Figure 690.1(A) and Figure 690.1(B).]**~~ PV systems covered by this article may be interactive with other electrical power production sources or stand-alone, with or without electrical energy storage such as batteries. These systems may have ac or dc output for utilization.

OSEC 690.3 Other Codes:

If the PV system is operated in parallel with a primary source(s) of electricity, such as utility supply or on-site electric power sources, the requirements in 705.14, 705.16, 705.32, and 705.143 **of the adopted Oregon Electrical Specialty Code** shall apply.

The installation of conduits or other raceway systems shall comply with the appropriate requirements of the adopted Oregon Electrical Specialty Code. Raceways and conduit systems shall be installed with special attention to ambient temperature, expansion characteristics of the conduit or raceway system and any required ambient temperature adjustment from Table 310.15(B)(2)(c).

~~*Exception:*~~ *PV systems, equipment, or wiring installed in a hazardous (classified) location shall also comply with the applicable portions of Articles 500 through 516* ***of the adopted Oregon Electrical Specialty Code.***

OSEC 690.4 Installation:

(A) PV System. A PV system shall be permitted to supply a building or other structure in addition to any service(s) of another electricity supply system(s).

(B) Conductors of Different Systems. PV source circuits and PV output circuits shall not be contained in the same raceway, cable tray, cable, outlet box, junction box, or similar fitting as feeders or branch circuits of other systems, unless the conductors of the different systems are separated by a partition or are connected together.

(C) Module Connection Arrangement. The connections to a module or panel shall be arranged so that removal of a module or panel from a PV source circuit does not interrupt a grounded conductor to another PV source circuit. Sets of modules interconnected as systems rated at 50 volts or less, with or without blocking diodes, and having a single over-current device shall be considered as a single-source circuit. Supplementary over-current devices used for the exclusive protection of the PV modules are not considered as over-current devices for the purpose of this section.

(D) Equipment. Inverters, motor generators, PV modules, PV panels, ac PV modules, source-circuit combiners, and charge controllers intended for use in PV power systems shall be identified and **certified** for the application.

OSEC 690.5 Ground-Fault Protection:
Grounded dc PV arrays shall be provided with dc ground-fault protection meeting the requirements of **OSEC** 690.5 (A) through (C) to reduce fire hazards. Ungrounded dc PV arrays shall comply with **OSEC** 690.35.

Exception No. 1: Ground-mounted or pole-mounted PV arrays with not more than two paralleled source circuits and with all dc source and dc output circuits isolated from buildings shall be permitted without ground-fault protection.

*Exception No. 2: PV arrays installed at other than dwelling units shall be permitted without ground-fault protection where the equipment grounding conductors are sized in accordance with **OSEC** 690.45.*

(A) Ground-Fault Detection and Interruption:
The ground-fault protection device or system shall be capable of detecting a ground-fault current, interrupting the flow of fault current, and providing an indication of the fault. Automatically opening the grounded conductor of the faulted circuit to interrupt the ground-fault current path shall be permitted. If a grounded conductor is opened to interrupt the ground-fault current path, all conductors of the faulted circuit shall be automatically and simultaneously opened. Manual operation of the main PV dc disconnect shall not activate the ground-fault protection device or result in grounded conductors becoming ungrounded.

(B) Isolating Faulted Circuits:
The faulted circuits shall be isolated by one of the two following methods:
(1) The ungrounded conductors of the faulted circuit shall be automatically disconnected.
(2) The inverter or charge controller fed by the faulted circuit shall automatically cease to supply power to output circuits.

(C) Labels and Markings:
A warning label shall appear on the utility-interactive inverter or be applied by the installer near the ground-fault indicator at a visible location, stating the following:

WARNING
ELECTRIC SHOCK HAZARD IF A GROUND FAULT IS INDICATED, NORMALLY GROUNDED CONDUCTORS MAY BE UNGROUNDED AND ENERGIZED

When the PV system also has batteries, the same warning shall also be applied by the installer in a visible location at the batteries.

OSEC 690.6 Alternating-Current (ac) Modules:
(A) PV Source Circuits- The requirements of ~~Article~~ **OSEC Section** 690 pertaining to PV source circuits shall not apply to ac modules. The PV source circuit, conductors, and inverters shall be considered as internal wiring of an ac module.

(B) Inverter Output Circuit- The output of an ac module shall be considered an inverter output circuit.

(C) Disconnecting Means- A single disconnecting means, in accordance with **OSEC** 690.15 and **OSEC** 690.17, shall be permitted for the combined ac output of one or more ac modules. Additionally, each ac module in a multiple ac module system shall be provided with a connector, bolted, or terminal-type disconnecting means.
(D) Ground-Fault Detection- Alternating-current module systems shall be permitted to use a single detection device to detect only ac ground faults and to disable the array by removing ac power to the ac module(s).

(E) Overcurrent Protection- The output circuits of ac modules shall be permitted to have overcurrent protection and conductors sized in accordance with 240.5(B)(2) **of the adopted Oregon Electrical Specialty Code**.

II. Circuit Requirements

OSEC 690.7 Maximum Voltage:
(A) Maximum PV System Voltage- In a dc PV source circuit or output circuit, the maximum PV system voltage for that circuit shall be calculated as the sum of the rated open-circuit voltage of the series-connected PV modules corrected for the lowest expected ambient temperature. For crystalline and multicrystalline silicon modules, the rated open-circuit voltage shall be multiplied by the correction factor provided in **OSEC** Table 690.7. This voltage shall be used to determine the voltage rating of cables, disconnects, overcurrent devices, and other equipment. Where the lowest expected ambient temperature is below -40°C (-40°F), or where other than crystalline or multicrystalline silicon PV modules are used, the system voltage adjustment shall be made in accordance with the manufacturer's instructions.

When open-circuit voltage temperature coefficients are supplied in the instructions for ~~listed~~certified PV modules, they shall be used to calculate the maximum PV system voltage as required by **manufacturer's instructions** instead of using **OSEC** Table 690.7, OESC 110.3(B).

OSEC Table 690.7 Voltage Correction Factors for Crystalline and Multicrystalline Silicon Modules

Correction Factors for Ambient Temperatures below 25°C (77°F).
(Multiply the rated open circuit voltage by the appropriate correction factor shown below.)

Ambient Temperature (°C)	Factor	Ambient Temperature (°F)
24 to 20	1.02	76 to 68
19 to 15	1.04	67 to 59
14 to 10	1.06	58 to 50
9 to 5	1.08	49 to 41
4 to 0	1.10	40 to 32
-1 to -5	1.12	31 to 23
-6 to -10	1.14	22 to 14
-11 to -15	1.16	13 to 5
-16 to -20	1.18	4 to -4
-21 to -25	1.20	-5 to -13
-26 to -30	1.21	-14 to -22
-31 to -35	1.23	-23 to -31
-36 to -40	1.25	-32 to -40

(B) Direct-Current Utilization Circuits- The voltage of dc utilization circuits shall conform to 210.6 **of the adopted Oregon Electrical Specialty Code.**

(C) PV Source and Output Circuits- In one- and two-family dwellings, PV source circuits and PV output circuits that do not include lampholders, fixtures, or receptacles shall be permitted to have a maximum PV system voltage up to 600 volts. Other installations with a maximum PV system voltage over 600 volts shall comply with **OSEC** Article 690, Part IX. ~~PV dc circuits in buildings are permanently connected using wiring systems recognized by this Code. Requirements for protecting unqualified persons from contact with these circuits are included in OSEC 690.7(B) and (D). Unqualified persons are not likely to service equipment in these circuits due to its complexity. A significant difference exists between the rated open-circuit voltage and the operating voltage in PV dc circuits. For the PV system to perform its intended function, rated dc open-circuit voltages of up to 600 volts may be present.~~

(D) Circuits over 150 Volts to Ground. In one- and two-family dwellings, live parts in PV source circuits and PV output circuits over 150 volts to ground shall not be accessible to other than qualified persons while energized.

FPN: See 110.27 ***of the adopted Oregon Electrical Specialty Code*** *for guarding of live parts, and 210.6 of the adopted Oregon Electrical Specialty Code for voltage to ground and between conductors.* ~~*Where dc circuitry over 150 volts to ground is present in one- and two-family dwellings, additional protection for unqualified persons may be needed. Protection may be in the form of conduit, a closed cabinet, or an enclosure that requires the use of tools to open it and that permits entry only by qualified persons.*~~

(E) Bipolar Source and Output Circuits. For 2-wire circuits connected to bipolar systems, the maximum system voltage shall be the highest voltage between the conductors of the 2-wire circuit if all of the following conditions apply:

(1) One conductor of each circuit is solidly grounded.
(2) Each circuit is connected to a separate sub-array.
(3) The equipment is clearly marked with a label as follows:

WARNING
BIPOLAR PHOTOVOLTAIC ARRAY. DISCONNECTION
OF NEUTRAL OR GROUNDED CONDUCTORS MAY RESULT IN
OVERVOLTAGE ON ARRAY OR INVERTER

OSEC 690.8 Circuit Sizing and Current:
(A) Calculation of Maximum Circuit Current- The maximum current for the specific circuit shall be calculated in accordance with **OSEC** 690.8(A)(1) through (A)(4).

FPN: Where the requirements of ***OSEC*** *690.8(A)(1) and (B)(1) are both applied, the resulting multiplication factor is 156 percent.*

(1) PV Source Circuit Currents- The maximum current shall be the sum of parallel module rated short-circuit currents multiplied by 125 percent.

(2) PV Output Circuit Currents- The maximum current shall be the sum of parallel source circuit maximum currents as calculated in OSEC 690.8(A)(1).

(3) Inverter Output Circuit Current- The maximum current shall be the inverter continuous output current rating.

(4) Stand-Alone Inverter Input Circuit Current. The maximum current shall be the stand-alone continuous inverter input current rating when the inverter is producing rated power at the lowest input voltage.

(B) Ampacity and Overcurrent Device Ratings- PV system currents shall be considered to be continuous.

(1) Sizing of Conductors and Overcurrent Devices- The circuit conductors and overcurrent devices shall be sized to carry not less than 125 percent of the maximum currents as calculated in **OSEC** 690.8(A). The rating or setting of overcurrent devices shall be permitted in accordance with 240.4(B) and (C) **of the adopted Oregon Electrical Specialty Code.**

Exception: Circuits containing an assembly, together with its overcurrent device(s), that is listed for continuous operation at 100 percent of its rating shall be permitted to be utilized at 100 percent of its rating.

(2) Internal Current Limitation- Overcurrent protection for PV output circuits with devices that internally limit the current from the PV output circuit shall be permitted to be rated at less than the value calculated in **OSEC** 690.8(B)(1). This reduced rating shall be at least 125 percent of the limited current value. PV output circuit conductors shall be sized in accordance with **OSEC** 690.8(B)(1).

Exception: An overcurrent device in an assembly listed for continuous operation at 100 percent of its rating shall be permitted to be utilized at 100 percent of its rating.

(C) Systems with Multiple Direct-Current Voltages- For a PV power source that has multiple output circuit voltages and employs a common-return conductor, the ampacity of the common-return conductor shall not be less than the sum of the ampere ratings of the overcurrent devices of the individual output circuits.

(D) Sizing of Module Interconnection Conductors- Where a single overcurrent device is used to protect a set of two or more parallel-connected module circuits, the ampacity of each of the module interconnection conductors shall not be less than the sum of the rating of the single fuse plus 125 percent of the short-circuit current from the other parallel-connected modules**.**

(E) DC Current-Carrying Conductors-Conductors used for PV source and output circuits shall be considered current-carrying conductors. The provisions of Table 310.15(B)(2)(a) of the adopted Oregon Electrical Specialty Code shall apply to PV circuits contained in raceways and appropriate de-rating of conductors as required by T310.15(B)(2)(a) of the adopted Oregon Electrical Specialty Code shall be part of any design or installation of PV conductors.

OSEC 690.9 Overcurrent Protection:
(A) Circuits and Equipment- PV source circuit, PV output circuit, inverter output circuit, and storage battery circuit conductors and equipment shall be protected in accordance with the requirements of Article 240 **of the adopted Oregon Electrical Specialty Code.** Circuits connected to more than one electrical source shall have overcurrent devices located so as to provide overcurrent protection from all sources.

*Exception: An overcurrent device shall not be required for circuit conductors sized in accordance with **OSEC** 690.8(B) and located where one of the following apply:*
(a) There are no external sources such as parallel-connected source circuits, batteries, or back-feed from inverters.
(b) The short-circuit currents from all sources do not exceed the ampacity of the conductors.

FPN: Possible back-feed of current from any source of supply, including a supply through an inverter into the PV output circuit and PV source circuits, is a consideration in determining whether adequate overcurrent protection from all sources is provided for conductors and modules.

(B) Power Transformers- Overcurrent protection for a transformer with a source(s) on each side shall be provided in accordance with 450.3 **of the adopted Oregon Electrical Specialty Code**, by considering first one side of the transformer, then the other side of the transformer, as the primary.

Exception: A power transformer with a current rating on the side connected toward the PV power source, not less than the short-circuit output current rating of the inverter, shall be permitted without overcurrent protection from that source.

(C) PV Source Circuits- Branch-circuit or supplementary-type overcurrent devices shall be permitted to provide overcurrent protection in PV source circuits. The overcurrent devices shall be accessible but shall not be required to be readily accessible. Standard values of supplementary overcurrent devices allowed by this section shall be in one ampere size increments, starting at one ampere up to and including 15 amperes. Higher standard values above 15 amperes for supplementary overcurrent devices shall be based on the standard sizes provided in 240.6(A) **of the adopted Oregon Electrical Specialty Code.**

(D) Direct-Current Rating- Overcurrent devices, either fuses or circuit breakers, used in any dc portion of a PV power system shall be listed for use in dc circuits and shall have the appropriate voltage, current, and interrupt ratings.

(E) Series Overcurrent Protection- In series-connected strings of two or more modules, a single overcurrent protection device shall be permitted.

OSEC 690.10 Stand-Alone Systems:
The premises wiring system shall be adequate to meet the requirements of this Code for a similar installation connected to a service. The wiring on the supply side of the building or structure

disconnecting means shall comply with this Code except as modified by **OSEC** 690.10(A) through (D).

(A) Inverter Output- The ac output from a stand-alone inverter(s) shall be permitted to supply ac power to the building or structure disconnecting means at current levels less than the calculated load connected to that disconnect. The inverter output rating or the rating of an alternate energy source shall be equal to or greater than the load posed by the largest single utilization equipment connected to the system. Calculated general lighting loads shall not be considered as a single load.

(B) Sizing and Protection- The circuit conductors between the inverter output and the building or structure disconnecting means shall be sized based on the output rating of the inverter. These conductors shall be protected from overcurrents in accordance with Article 240 **of the adopted Oregon Electrical Specialty Code**. The overcurrent protection shall be located at the output of the inverter.

(C) Single 120-Volt Supply- The inverter output of a stand-alone solar PV system shall be permitted to supply 120 volts to single-phase, 3-wire, 120/240-volt service equipment or distribution panels where there are no 240-volt outlets and where there are no multiwire branch circuits. In all installations, the rating of the overcurrent device connected to the output of the inverter shall be less than the rating of the neutral bus in the service equipment. This equipment shall be marked with the following words or equivalent:

WARNING
SINGLE 120-VOLT SUPPLY. DO NOT CONNECT
MULTIWIRE BRANCH CIRCUITS!

(D) Energy Storage or Backup Power System Requirements- Energy storage or backup power supplies are not required.

III. Disconnecting Means

OSEC 690.13 All Conductors:

Means shall be provided to disconnect all current-carrying conductors of a PV power source from all other conductors in a building or other structure. A switch, circuit breaker, or other device, either ac or dc, shall not be installed in a grounded conductor if operation of that switch, circuit breaker, or other device leaves the marked, grounded conductor in an ungrounded and energized state.

*Exception: A switch or circuit breaker that is part of a ground-fault detection system required by **OSEC** 690.5 shall be permitted to open the grounded conductor when that switch or circuit breaker is automatically opened as a normal function of the device in responding to ground faults. The switch or circuit breaker shall indicate the presence of a ground fault.*

FPN: The grounded conductor may have a bolted or terminal disconnecting means to allow maintenance or troubleshooting by qualified personnel.

(A) Fire Fighting Disconnect- A D/C disconnect shall be installed in all PV array strings to aid in fire-fighting efforts.

(B) Utility Disconnect- An A/C disconnect shall be located adjacent to the point where the inverter back-feeds the utility service. This disconnect shall be unlocked and visible to utility workers to prevent a PV system from inadvertently energizing the utility distribution system in the event of primary power loss.

OSEC 690.14 Additional Provisions:
PV disconnecting means shall comply with **OSEC** 690.14(A) through (D).

(A) Disconnecting Means- The disconnecting means shall not be required to be suitable as service equipment and shall comply with OSEC 690.17. ~~A disconnecting means rated in accordance with OSEC 690.17 may be used, but it is not required to be marked as suitable for use as service equipment.~~

(B) Equipment- Equipment such as PV source circuit isolating switches, overcurrent devices, and blocking diodes shall be permitted on the PV side of the PV disconnecting means.

(C) Requirements for Disconnecting Means- Means shall be provided to disconnect all conductors in a building or other structure from the PV system conductors.

(1) Location- The PV disconnecting means shall be installed at a readily accessible location either on the outside of a building or structure or inside nearest the point of entrance of the system conductors.

*Exception: Installations that comply with **OSEC** 690.31(E) shall be permitted to have the disconnecting means located remote from the point of entry of the system conductors.*

The PV system disconnecting means shall not be installed in bathrooms.

(2) Marking- Each PV system disconnecting means shall be permanently marked to identify it as a PV system disconnect.

(3) Suitable for Use- Each PV system disconnecting means shall be suitable for the prevailing conditions. Equipment installed in hazardous (classified) locations shall comply with the requirements of Articles 500 through 517 **of the adopted Oregon Electrical Specialty Code.**

(4) Maximum Number of Disconnects- The PV system disconnecting means shall consist of not more than six switches or six circuit breakers mounted in a single enclosure, in a group of separate enclosures, or in or on a switchboard.

(5) Grouping- The PV system disconnecting means shall be grouped with other disconnecting means for the system to comply with **OSEC** 690.14(C)(4). A PV disconnecting means shall not be required at the PV module or array location.

(D) Utility-Interactive Inverters Mounted in Not-Readily-Accessible Locations- Utility-interactive inverters shall be permitted to be mounted on roofs or other exterior areas that are not readily accessible. These installations shall comply with (1) through (4):

(1) A direct-current PV disconnecting means shall be mounted within sight of or in the inverter.

(2) An alternating-current disconnecting means shall be mounted within sight of or in the inverter.

(3) The alternating-current output conductors from the inverter and an additional alternating-current disconnecting means for the inverter shall comply with **OSEC** 690.14(C)(1).

(4) A plaque shall be installed in accordance with 705.10 **of the adopted Oregon Electrical Specialty Code.**

OSEC 690.15 Disconnection of PV Equipment:

Means shall be provided to disconnect equipment, such as inverters, batteries, charge controllers, and the like, from all ungrounded conductors of all sources. If the equipment is energized from more than one source, the disconnecting means shall be grouped and identified. A single disconnecting means in accordance with **OSEC** 690.17 shall be permitted for the combined ac output of one or more inverters or ac modules in an interactive system.

OSEC 690.16 Fuses:

Disconnecting means shall be provided to disconnect a fuse from all sources of supply if the fuse is energized from both directions and is accessible to other than qualified persons. Such a fuse in a PV source circuit shall be capable of being disconnected independently of fuses in other PV source circuits.

OSEC 690.17 Switch or Circuit Breaker:

The disconnecting means for ungrounded conductors shall consist of a manually operable switch(es) or circuit breaker(s) complying with all of the following requirements:

(1) Located where readily accessible

(2) Externally operable without exposing the operator to contact with live parts

(3) Plainly indicating whether in the open or closed position

(4) Having an interrupting rating sufficient for the nominal circuit voltage and the current that is available at the line terminals of the equipment

Where all terminals of the disconnecting means may be energized in the open position, a warning sign shall be mounted on or adjacent to the disconnecting means. The sign shall be clearly legible and have the following words or equivalent:

WARNING
ELECTRIC SHOCK HAZARD. DO NOT TOUCH TERMINALS.
TERMINALS ON BOTH THE LINE AND LOAD SIDES MAY BE ENERGIZED
IN THE OPEN POSITION.

*Exception: A connector shall be permitted to be used as an ac or a dc disconnecting means, provided that it complies with the requirements of **OSEC** 690.33 and is listed and identified for the use.*

OSEC 690.18 Installation and Service of an Array:
Open circuiting, short circuiting, or opaque covering shall be used to disable an array or portions of an array for installation and service.

FPN: PV modules are energized while exposed to light. Installation, replacement, or servicing of array components while a module(s) is irradiated may expose persons to electric shock.

IV. Wiring Methods

OSEC 690.31 Methods Permitted:
(A) Wiring Systems- All raceway and cable wiring methods included in this Code and other wiring systems and fittings specifically intended and identified for use on PV arrays shall be permitted. Where wiring devices with integral enclosures are used, sufficient length of cable shall be provided to facilitate replacement.

Where PV source and output circuits operating at maximum system voltages greater than 30 volts are installed in readily accessible locations, circuit conductors shall be installed in a raceway.

*FPN: PV modules operate at elevated temperatures when exposed to high ambient temperatures and to bright sunlight. These temperatures may routinely exceed 70°C (158°F) in many locations. Module interconnection conductors are available with insulation rated for wet locations and a temperature rating of 90°C (194°F) or greater***.**

(B) Single-Conductor Cable- Single-conductor cable type USE-2, and single-conductor cable **certified** as PV wire shall be permitted in exposed outdoor locations in PV source circuits for PV module interconnections within the PV array.

*Exception: Raceways shall be used when required by **OSEC** 690.31(A).*

(C) Flexible Cords and Cables- Flexible cords and cables, where used to connect the moving parts of tracking PV modules, shall comply with Article 400 **of the adopted Oregon Electrical Specialty Code** and shall be of a type identified as a hard service cord or portable power cable; they shall be suitable for extra-hard usage, **certified** for outdoor use, water resistant, and sunlight resistant. Allowable ampacities shall be in accordance with 400.5 **of the adopted Oregon Electrical Specialty Code**. For ambient temperatures exceeding 30°C (86°F), the ampacities shall be de-rated by the appropriate factors given in **OSEC** Table 690.31(C).

OSEC Table 690.31(C) Correction Factors

Temperature Rating of Conductor

Ambient Temperature (°C)	60°C (140°F)	75°C (167°F)	90°C (194°F)	105°C (221°F)	Ambient Temperature (°F)
30	1.00	1.00	1.00	1.00	86
31–35	0.91	0.94	0.96	0.97	87–95
36–40	0.82	0.88	0.91	0.93	96–104
41–45	0.71	0.82	0.87	0.89	105–113
46–50	0.58	0.75	0.82	0.86	114–122
51–55	0.41	0.67	0.76	0.82	123–131
56–60	—	0.58	0.71	0.77	132–140
61–70	—	0.33	0.58	0.68	141–158
71–80	—	—	0.41	0.58	159–176

(D) Small-Conductor Cables- Single-conductor cables listed for outdoor use that are sunlight resistant and moisture resistant in sizes 16 AWG and 18 AWG shall be permitted for module interconnections where such cables meet the ampacity requirements of **OSEC** 690.8. Section 310.15 **of the adopted Oregon Electrical Specialty Code** shall be used to determine the cable ampacity and temperature de-rating factors.

(E) Direct-Current Photovoltaic Source and Output Circuits Inside a Building- Where direct-current PV source or output circuits of a utility-interactive inverter from a building-integrated or other PV system are run inside a building or structure, they shall be contained in metal raceways, or metal enclosures, from the point of penetration of the surface of the building or structure to the first readily accessible disconnecting means. The disconnecting means shall comply with **OSEC** 690.14(A) through (D).

(F) Flexible, Fine-Stranded Cables- Flexible, fine-stranded cables shall be terminated only with terminals, lugs, devices, or connectors that are **certified** for such use.

OSEC 690.32 Component Interconnections:
Fittings and connectors that are intended to be concealed at the time of on-site assembly, where **certified** for such use, shall be permitted for on-site interconnection of modules or other array components. Such fittings and connectors shall be equal to the wiring method employed in insulation, temperature rise, and fault-current withstand, and shall be capable of resisting the effects of the environment in which they are used.

OSEC 690.33 Connectors:
The connectors permitted by **OSEC** Article 690 shall comply with **OSEC** 690.33(A) through (E).
(A) Configuration. The connectors shall be polarized and shall have a configuration that is non-interchangeable with receptacles in other electrical systems on the premises.
(B) Guarding. The connectors shall be constructed and installed so as to guard against inadvertent contact with live parts by persons.
(C) Type. The connectors shall be of the latching or locking type. Connectors that are readily accessible and that are used in circuits operating at over 30 volts, nominal, maximum system voltage for dc circuits, or 30 volts for ac circuits, shall require a tool for opening.

(D) Grounding Member. The grounding member shall be the first to make and the last to break contact with the mating connector.
(E) Interruption of Circuit. Connectors shall be either (1) or (2):

~~***Note: See May 2008 Chief Electrical Inspector Notice on applicability of this requirement.***~~

(1) Be rated for interrupting current without hazard to the operator.
(2) Be a type that requires the use of a tool to open and marked "Do Not Disconnect Under Load" or "Not for Current Interrupting."

OSEC 690.34 Access to Boxes:
Junction, pull, and outlet boxes located behind modules or panels shall be so installed that the wiring contained in them can be rendered accessible directly or by displacement of a module(s) or panel(s) secured by removable fasteners and connected by a flexible wiring system.

OSEC 690.35 Ungrounded PV Power Systems:
PV power systems shall be permitted to operate with ungrounded PV source and output circuits where the system complies with **OSEC** 690.35(A) through (G), and OSEC 690.47(A) through (D).

(A) Disconnects- All PV source and output circuit conductors shall have disconnects complying with **OSEC** 690, Part III.

(B) Overcurrent Protection- All PV source and output circuit conductors shall have overcurrent protection complying with **OSEC** 690.9.

(C) Ground-Fault Protection- All PV source and output circuits shall be provided with a ground-fault protection device or system that complies with (1) through (3):
(1) Detects a ground fault.
(2) Indicates that a ground fault has occurred
(3) Automatically disconnects all conductors or causes the inverter or charge controller connected to the faulted circuit to automatically cease supplying power to output circuits.

(D) The PV source conductors shall consist of the following**:**
(1) Nonmetallic jacketed multi-conductor cables
(2) Conductors installed in raceways, or
(3) Conductors certified as PV Wire installed as exposed, single conductors.

(E) The PV power system direct-current circuits shall be permitted to be used with ungrounded battery systems complying with **OSEC** 690.71(G).

(F) The PV power source shall be labeled with the following warning at each junction box, combiner box, disconnect, and device where energized, ungrounded circuits may be exposed during service:

WARNING
ELECTRIC SHOCK HAZARD. THE DC CONDUCTORS
OF THIS PHOTOVOLTAIC SYSTEM ARE
UNGROUNDED AND MAY BE ENERGIZED

(G) The inverters or charge controllers used in systems with ungrounded PV source and output circuits shall be certified for the purpose.

V. Grounding

OSEC 690.41 System Grounding:
For a PV power source, one conductor of a 2-wire system with a PV system voltage over 50 volts and the reference (center tap) conductor of a bipolar system shall be solidly grounded or shall use other methods that accomplish equivalent system protection in accordance with 250.4(A) **of the adopted Oregon Electrical Specialty Code**, and that utilize equipment **certified** for the use.

*Exception: Systems complying with **OSEC** 690.35.*

OSEC 690.42 Point of System Grounding Connection:
The dc circuit grounding connection shall be made at any single point on the PV output circuit.

FPN: Locating the grounding connection point as close as practicable to the PV source better protects the system from voltage surges due to lightning.

*Exception: Systems with a **OSEC** 690.5 required ground-fault protection device shall be permitted to have the required grounded conductor-to-ground bond made by the ground-fault protection device. This bond, where internal to the ground-fault equipment, shall not be duplicated with an external connection.*

OSEC 690.43 Equipment Grounding:
Exposed non–current-carrying metal parts of module frames, equipment, and conductor enclosures shall be grounded in accordance with 250.134 or 250.136(A) **of the adopted Oregon Electrical Specialty Code** regardless of voltage. An equipment grounding conductor between a PV array and other equipment shall be required in accordance with 250.110 **of the adopted Oregon Electrical Specialty Code.**
Devices **certified** for grounding the metallic frames of PV modules shall be permitted to bond the exposed metallic frames of PV modules to grounded mounting structures. Devices **certified** for bonding the metallic frames of PV modules shall be permitted to bond the exposed metallic frames of PV modules to the metallic frames of adjacent PV modules.
Equipment grounding conductors for the PV array and structure (where installed) shall be contained within the same raceway or cable, or otherwise run with the PV array circuit conductors when those circuit conductors leave the vicinity of the PV array.

OSEC 690.45 Size of Equipment Grounding Conductors:
Equipment grounding conductors for PV source and PV output circuits shall be sized in accordance with **OSEC** 690.45(A) or (B).

(A) General. Equipment grounding conductors in PV source and PV output circuits shall be sized in accordance with **OESC Table 690.45**. Where no overcurrent protective device is used in the circuit, an assumed overcurrent device rated at the PV rated short-circuit current shall be used in **OSEC Table 690.45**. Increases in equipment grounding conductor size to address voltage drop considerations shall not be required. The equipment grounding conductors shall be no smaller than 14 AWG.

OSEC Table 690.45 Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment

Rating or Setting of Overcurrent Device on individual strings or combined ampacity of combiner box.

Not Exceeding (Amperes)	Size (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum*
15	14	12
20	12	10
30	10	8
40	10	8
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0
800	1/0	3/0
1000	2/0	4/0
1200	3/0	250
1600	4/0	350
2000	250	400
2500	350	600
3000	400	600
4000	500	800
5000	700	1200
6000	800	1200

~~Note: Where ungrounded conductors are increased in size, equipment grounding conductors, where installed, shall be increased in size proportionately according to the circular mil area of the ungrounded conductors.~~

(B) Ground-Fault Protection Not Provided- For other than dwelling units where ground-fault protection is not provided in accordance with **OSEC** 690.5(A) through (C), each equipment grounding conductor shall have an ampacity of at least two (2) times the temperature and conduit fill corrected circuit conductor ampacity.

FPN: The short-circuit current of PV modules and PV sources is just slightly above the full-load normal output rating. In ground-fault conditions, these sources are not able to supply the high levels of short-circuit or ground-fault currents necessary to quickly activate overcurrent devices as in typical ac systems. Protection for equipment grounding conductors in PV systems that are not provided with ground-fault protection is related to size and withstand capability of the equipment grounding conductor, rather than overcurrent device operation.

OSEC 690.46 Array Equipment Grounding Conductors: Equipment grounding conductors for PV modules smaller than 6 AWG **shall be provided with physical protection.**

OSEC 690.47 Grounding Electrode System:

(A) Alternating-Current Systems ~~- If installing an ac system~~, a grounding electrode system shall be provided in accordance with 250.50 through 250.60 **of the adopted Oregon Electrical Specialty Code**. The grounding electrode conductor shall be installed in accordance with 250.64 **of the adopted Oregon Electrical Specialty Code**.

(B) Direct-Current Systems ~~- If installing a dc system~~**, a grounding electrode system shall be provided in accordance with** ~~OESC~~ OSEC **690.47(B)(1) – (B)(5), for grounded systems or ungrounded systems. The grounding electrode conductor shall be installed in accordance with 250.64 of the adopted Oregon Electrical Specialty Code.**

(1) Not Smaller Than the Neutral Conductor- Where the dc system consists of a 3-wire balancer set or a balancer winding with overcurrent protection as provided in 445.12(D) of the adopted Oregon Electrical Specialty Code**, the grounding electrode conductor shall not be smaller than the neutral conductor and not smaller than** ~~8~~ 6 **AWG copper or** ~~6~~ 4 **AWG aluminum.**

(2) Not Smaller Than the Largest Conductor- Where the dc system is other than as in ~~250.166(A)~~OSEC 690.47(B)(1)**, the grounding electrode conductor shall not be smaller than the largest conductor supplied by the system, and not smaller than** ~~8~~ 6 **AWG copper or** ~~6~~ 4 **AWG aluminum.**

(3) Connected to Rod, Pipe, or Plate Electrodes- Where connected to rod, pipe, or plate electrodes as in 250.52(A)(5) or (A)(7) of the adopted Oregon Electrical Specialty Code**, that portion of the grounding electrode conductor that is the sole connection to the grounding electrode shall not be required to be larger than 6 AWG copper wire or 4 AWG aluminum wire.**

(4) Connected to a Concrete-Encased Electrode- Where connected to a concrete-encased electrode as in 250.52(A)(3) of the adopted Oregon Electrical Specialty Code**, that portion of the grounding electrode conductor that is the sole connection to the grounding electrode shall not be required to be larger than 4 AWG copper wire.**

(5) Connected to a Ground Ring- Where connected to a ground ring as in 250.52(A)(4) of the adopted Oregon Electrical Specialty Code**, that portion of the grounding electrode conductor that is the sole connection to the grounding electrode shall not be required to be larger than the conductor used for the ground ring.**

(C) Systems with Alternating-Current and Direct-Current Grounding Requirements- Systems with alternating-current and direct-current grounding requirements shall comply with items (C)(1) through (C)(8):

(1) Where PV power systems have both alternating-current (ac) and direct-current (dc) grounding requirements, the dc grounding system shall be bonded to the ac grounding system.

(2) A bonding conductor between these systems shall be sized as the larger of the dc requirement in accordance with **OSEC** 690.45, the ac requirements based on the inverter alternating current overcurrent device rating and **OSEC Table 690.45**, **and shall not be smaller than # 6 AWG**

(3) **A conductor that serves as both an equipment grounding conductor and as part of the bond between ac and dc systems for an inverter incorporating dc ground-fault protection shall meet the requirements for equipment bonding jumpers in accordance with ~~OESC~~ OSEC Table 690.47. A single conductor shall be permitted to be used to perform the multiple functions of dc grounding, ac grounding, and bonding between ac and dc systems.**

(4) A bonding conductor or equipment grounding conductor that serves multiple inverters shall be sized based on the sum of applicable maximum currents used in item (2).

(5) A common ground bus shall be permitted to be used for both systems.

(6) A common grounding electrode shall be permitted to be used for both systems, in which case the grounding electrode conductor shall be connected to the ac ground system bonding point.

(7) Grounding electrode conductor(s) shall be sized to meet the requirements of 250.66 **of the adopted Oregon Electrical specialty Code** (ac system) and **OSEC 690.47(B)** (dc system).

(8) For systems with utility-interactive inverters, the premises grounding system serves as the ac grounding system.

OSEC Table 690.47 Grounding Electrode Conductor for Direct-Current Systems

Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		Size of Grounding Electrode Conductor (AWG/kcmil)	
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum
~~2 or smaller~~	~~1/0 or smaller~~	~~8~~ 6	~~6~~ 4
~~1 or~~ 1/0 or smaller	~~2/0 or~~ 3/0 or smaller	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0
Over 1100	Over 1750	3/0	250

Notes:

1. Where multiple sets of conductors are used the equivalent size of the largest conductor shall be determined by the largest sum of the areas of the corresponding conductors of each set.

~~**2. Where there are no service-entrance conductors, the grounding electrode conductor size shall be determined by the equivalent size of the largest service-entrance conductor required for the load to be served.**~~

~~**This table also applies to the derived conductors of separately derived ac systems.**~~

(D) Additional Electrodes for Array Grounding- Grounding electrodes shall be installed at the location of all ground- and pole-mounted PV arrays and as close as practicable to the location of roof-mounted photovoltaic arrays. The electrodes shall be connected directly to the array

frame(s) or structure. The dc grounding electrode conductor shall be sized according to **OSEC 690.47(B).** Additional electrodes are not permitted to be used as a substitute for equipment bonding or equipment grounding conductor requirements.

The structure of a ground- or pole-mounted PV array shall be permitted to be considered a grounding electrode if it ~~extends a minimum of 10ft into native soil and is inspected prior to cover.~~meets the requirements of 250.52 of the adopted Oregon Electrical Specialty Code. Roof-mounted PV arrays shall be permitted to use the metal frame of a building or structure if the ~~metal frame has been inspected and approved as a grounding electrode.~~requirements of 250.52(A)(2) of the adopted Oregon Electrical Specialty Code are met.

Exception No. 1: Array grounding electrode(s) shall not be required where the load served by the array is integral with the array.

Exception No. 2: Additional array grounding electrode(s) shall not be required if located within 6 ft of the premises wiring electrode.

OSEC 690.48 Continuity of Equipment Grounding Systems:
Where the removal of equipment disconnects the bonding connection between the grounding electrode conductor and exposed conducting surfaces in the PV source or output circuit equipment, a bonding jumper shall be installed while the equipment is removed.

OSEC 690.49 Continuity of PV Source and Output Circuit Grounded Conductors:
Where the removal of the utility-interactive inverter or other equipment disconnects the bonding connection between the grounding electrode conductor and the PV source and/or PV output circuit grounded conductor, a bonding jumper shall be installed to maintain the system grounding while the inverter or other equipment is removed.

OSEC 690.50 Equipment Bonding Jumpers:
Equipment bonding jumpers, if used, **smaller than # 6 AWG**, shall be provided with physical protection.

VI. Marking

OSEC 690.51 Modules:
Modules shall be marked with identification of terminals or leads as to polarity, maximum overcurrent device rating for module protection, and with the following ratings:

(1) Open-circuit voltage
(2) Operating voltage
(3) Maximum permissible system voltage
(4) Operating current
(5) Short-circuit current
(6) Maximum power

OSEC 690.52 Alternating-Current Photovoltaic Modules:
Alternating-current modules shall be marked with identification of terminals or leads and with identification of the following ratings:

(1) Nominal operating ac voltage
(2) Nominal operating ac frequency
(3) Maximum ac power
(4) Maximum ac current
(5) Maximum overcurrent device rating for ac module protection

OSEC 690.53 Direct-Current PV Power Source:
A permanent label for the direct-current photovoltaic power source indicating items (1) through (5) shall be provided by the installer at the PV disconnecting means:

(1) Rated maximum power-point current
(2) Rated maximum power-point voltage
(3) Maximum system voltage

*FPN to (3): See **OSEC** 690.7(A) for maximum PV system voltage.*

(4) Short-circuit current

*FPN to (4): See **OSEC** 690.8(A) for calculation of maximum circuit current.*

(5) Maximum rated output current of the charge controller (if installed)

FPN: Reflecting systems used for irradiance enhancement may result in increased levels of output current and power.

OSEC 690.54 Interactive System Point of Interconnection:
All interactive system(s) points of interconnection with other sources shall be marked at an accessible location at the disconnecting means as a power source and with the rated ac output current and the nominal operating ac voltage.

OSEC 690.55 PV Power Systems Employing Energy Storage:
PV power systems employing energy storage shall also be marked with the maximum operating voltage, including any equalization voltage and the polarity of the grounded circuit conductor.

OSEC 690.56 Identification of Power Sources:
(A) Facilities with Stand-Alone Systems- Any structure or building with a PV power system that is not connected to a utility service source and is a stand-alone system shall have a permanent plaque or directory installed on the exterior of the building or structure at a readily visible location acceptable to the authority having jurisdiction. The plaque or directory shall indicate the location of system disconnecting means and that the structure contains a stand-alone electrical power system.

(B) Facilities with Utility Services and PV Systems- Buildings or structures with both utility service and a PV system shall have a permanent plaque or directory providing the location of the service disconnecting means and the PV system disconnecting means if not located at the same location.

VII. Connection to Other Sources:

OSEC 690.57 Load Disconnect:
A load disconnect that has multiple sources of power shall disconnect all sources when in the off position.

OSEC 690.60 Identified Interactive Equipment:
Only inverters and ac modules **certified** as interactive shall be permitted in interactive systems.

OSEC 690.61 Loss of Interactive System Power:
An inverter or an ac module in an interactive PV system shall automatically de-energize its output to the connected electrical production and distribution network upon loss of voltage in that system and shall remain in that state until the electrical production and distribution network voltage has been restored.

A normally interactive PV system shall be permitted to operate as a stand-alone system to supply loads that have been disconnected from electrical production and distribution network sources.

OSEC 690.62 Ampacity of Neutral Conductor:
If a single-phase, 2-wire inverter output is connected to the neutral conductor and one ungrounded conductor (only) of a 3-wire system or of a 3-phase, 4-wire, wye-connected system, the maximum load connected between the neutral conductor and any one ungrounded conductor plus the inverter output rating shall not exceed the ampacity of the neutral conductor. A conductor used solely for instrumentation, voltage detection, or phase detection, and connected to a single-phase or 3-phase utility-interactive inverter, shall be permitted to be sized at less than the ampacity of the other current-carrying conductors and shall be sized equal to or larger than the equipment grounding conductor.

OSEC 690.63 Unbalanced Interconnections:
(A) Single-Phase- Single-phase inverters for PV systems and ac modules in interactive PV systems shall not be connected to 3-phase power systems unless the interconnected system is designed so that significant unbalanced voltages cannot result.

(B) Three-Phase- Three-phase inverters and 3-phase ac modules in interactive systems shall have all phases automatically de-energized upon loss of, or unbalanced, voltage in one or more phases unless the interconnected system is designed so that significant unbalanced voltages will not result.

OSEC 690.64 Point of Connection:
The output of a utility-interactive inverter shall be connected as specified in **OSEC** 690.64(A) or (B).

(A) Supply Side- The output of a utility-interactive inverter shall be permitted to be connected to the supply side of the service disconnecting means.

(B) Load Side- The output of a utility-interactive inverter shall be permitted to be connected to the load side of the service disconnecting means of the other source(s) at any distribution equipment on the premises. Where distribution equipment, including switchboards and panelboards, is fed simultaneously by a primary source(s) of electricity and one or more utility-interactive inverters, and where this distribution equipment is capable of supplying multiple branch circuits or feeders, or both, the interconnecting provisions for the utility-interactive inverter(s) shall comply with (B)(1) through (B)(7).

(1) Dedicated Overcurrent and Disconnect. Each source interconnection shall be made at a dedicated circuit breaker or fusible disconnecting means.

(2) Bus or Conductor Rating. ~~In lieu of **OSEC** 690.64(B)(7), the~~ The sum of the ampere ratings of overcurrent devices in circuits supplying power to a busbar or conductor shall not exceed 120 percent of the rating of the busbar or conductor. In systems with panelboards connected in series, the rating of the first overcurrent device directly connected to the output of a utility-interactive inverter(s) shall be used in the calculations for all busbars and conductors.

(3) Ground-Fault Protection. The interconnection point shall be on the line side of all ground-fault protection equipment.

Exception: Connection shall be permitted to be made to the load side of ground-fault protection, provided that there is ground-fault protection for equipment from all ground-fault current sources. Ground-fault protection devices used with supplies connected to the load-side terminals shall be identified and listed as suitable for back-feeding.

(4) Marking. Equipment containing overcurrent devices in circuits supplying power to a busbar or conductor supplied from multiple sources shall be marked to indicate the presence of all sources.

(5) Suitable for Back-feed. Circuit breakers, if back-fed, shall be suitable for such operation.

FPN: Circuit breakers that are marked “Line” and “Load” have been evaluated only in the direction marked. Circuit breakers without “Line” and “Load” have been evaluated in both directions.

Circuit breakers not marked Line and Load are considered to be identified as suitable for back-feeding.

(6) Fastening. Listed plug-in-type circuit breakers back-fed from utility-interactive inverters complying with **OSEC** 690.60 shall be permitted to omit the additional fastener normally required for service equipment.

(7) Inverter Output Connection. Unless the panelboard is rated not less than the sum of the ampere ratings of all overcurrent devices supplying it, a connection in a panelboard shall be positioned at the opposite (load) end from the input feeder location or main circuit location. The bus or conductor rating shall be sized for the loads connected in

accordance with Article 220 **of the adopted Oregon Electrical Specialty Code**. A permanent warning label shall be applied to the distribution equipment with the following or equivalent marking:

WARNING
INVERTER OUTPUT CONNECTION
DO NOT RELOCATE THIS OVERCURRENT DEVICE

VIII. Storage Batteries:

OSEC 690.71 Installation:

(A) General- Storage batteries in a PV system shall be installed in accordance with the provisions of Article 480 **of the adopted Oregon Electrical Specialty Code**. The interconnected battery cells shall be considered grounded where the PV power source is installed in accordance with **OSEC** 690.41.

(B) Dwellings-

(1) Operating Voltage. Storage batteries for dwellings shall have the cells connected so as to operate at less than 50 volts nominal. Lead-acid storage batteries for dwellings shall have no more than twenty-four 2-volt cells connected in series (48-volts nominal).

*Exception: Where live parts are not accessible during routine battery maintenance, a battery system voltage in accordance with **OSEC** 690.7 shall be permitted.*

(2) Guarding of Live Parts- Live parts of battery systems for dwellings shall be guarded to prevent accidental contact by persons or objects, regardless of voltage or battery type.

FPN: Batteries in PV systems are subject to extensive charge–discharge cycles and typically require frequent maintenance, such as checking electrolyte and cleaning connections.

(C) Current Limiting- A **certified**, current-limiting, overcurrent device shall be installed in each circuit adjacent to the batteries where the available short-circuit current from a battery or battery bank exceeds the interrupting or withstand ratings of other equipment in that circuit. The installation of current-limiting fuses shall comply with **OSEC** 690.16.

(D) Battery Nonconductive Cases and Conductive Racks- Flooded, vented, lead-acid batteries with more than twenty-four 2-volt cells connected in series (48 volts, nominal) shall not use conductive cases or shall not be installed in conductive cases. Conductive racks used to support the nonconductive cases shall be permitted where no rack material is located within 150 mm (6 in.) of the tops of the nonconductive cases. This requirement shall not apply to any type of valve-regulated lead-acid (VRLA) battery or any other types of sealed batteries that may require steel cases for proper operation.

(E) Disconnection of Series Battery Circuits: Battery circuits subject to field servicing, where more than twenty-four 2-volt cells are connected in series (48 volts, nominal), shall have provisions to disconnect the series-connected strings into segments of 24 cells or less for maintenance by qualified persons. Non–load-break bolted or plug-in disconnects shall be permitted.

(F) Battery Maintenance Disconnecting Means- Battery installations, where there are more than twenty-four 2-volt cells connected in series (48 volts, nominal), shall have a disconnecting means, accessible only to qualified persons, that disconnects the grounded circuit conductor(s) in the battery electrical system for maintenance. This disconnecting means shall not disconnect the grounded circuit conductor(s) for the remainder of the PV electrical system. A non–load-break-rated switch shall be permitted to be used as the disconnecting means.

(G) Battery Systems of More Than 48 Volts- On photovoltaic systems where the battery system consists of more than twenty-four 2-volt cells connected in series (more than 48 volts, nominal), the battery system shall be permitted to operate with ungrounded conductors, provided the following conditions are met:

(1) The PV array source and output circuits shall comply with **OSEC** 690.41.

(2) The dc and ac load circuits shall be solidly grounded.

(3) All main ungrounded battery input/output circuit conductors shall be provided with switched disconnects and overcurrent protection.

(4) A ground-fault detector and indicator shall be installed to monitor for ground faults in the battery bank.

OSEC 690.72 Charge Control:
(A) General- Equipment shall be provided to control the charging process of the battery. Charge control shall not be required where the design of the PV source circuit is matched to the voltage rating and charge current requirements of the interconnected battery cells and the maximum charging current multiplied by 1 hour is less than 3 percent of the rated battery capacity expressed in ampere-hours or as recommended by the battery manufacturer. All adjusting means for control of the charging process shall be accessible only to qualified persons.

FPN: Certain battery types such as valve-regulated lead acid or nickel cadmium can experience thermal failure when overcharged.

(B) Diversion Charge Controller-
(1) Sole Means of Regulating Charging- A PV power system employing a diversion charge controller as the sole means of regulating the charging of a battery shall be equipped with a second independent means to prevent overcharging of the battery.

(2) Circuits with Direct-Current Diversion Charge Controller and Diversion Load. Circuits containing a dc diversion charge controller and a dc diversion load shall comply with the following:

(~~A~~1) The current rating of the diversion load shall be less than or equal to the current rating of the diversion load charge controller. The voltage rating of the diversion load shall be greater than the maximum battery voltage. The power rating of the diversion load shall be at least 150 percent of the power rating of the PV array.

(~~B~~2) The conductor ampacity and the rating of the overcurrent device for this circuit shall be at least 150 percent of the maximum current rating of the diversion charge controller.

(3) PV Systems Using Utility-Interactive Inverters- PV power systems using utility-interactive inverters to control battery state-of-charge by diverting excess power into the utility system shall comply with (A) and (B):

(~~A~~1) These systems shall not be required to comply with **OSEC** 690.72(B)(2). The charge regulation circuits used shall comply with the requirements of **OSEC** 690.8.

(~~B~~2) These systems shall have a second, independent means of controlling the battery charging process for use when the utility is not present or when the primary charge controller fails or is disabled.

OSEC 690.74 Battery Interconnections:
Flexible cables in sizes 2/0 AWG and larger shall be permitted within the battery enclosure from battery terminals to a nearby junction box where they shall be connected to an approved wiring method. Flexible battery cables shall also be permitted between batteries and cells within the battery enclosure. Such cables shall be listed for hard-service use and identified as moisture resistant. Flexible, fine-stranded cables shall only be used with terminals, lugs, devices, and connectors that are listed and marked for such use.

IX. Systems over 600 Volts:

OSEC 690.80 General:
PV systems with a maximum system voltage over 600 volts dc shall comply with Article 490 **of the adopted Oregon Electrical Specialty Code** and other requirements applicable to installations rated over 600 volts.

OSEC 690.85 Definitions:
For the purposes of Part IX of this article, the voltages used to determine cable and equipment ratings are as follows:

Battery Circuits: In battery circuits, the highest voltage experienced under charging or equalizing conditions.
PV Circuits: In dc photovoltaic source circuits and PV output circuits, the maximum system voltage.