City of Ontario

BUILDING DEPARTMENT

303 EAST "B' STREET, CIVIC CENTER, ONTARIO, CA 91764

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Submittal Requirements Standard – Solar Photovoltaic Installations 10 kW or Less for One- and Two-Family Dwellings

The plan must include the following *minimum* requirements:

- Must submit a minimum of two sets of plans.
- General information about the project, such as property address, licensed design professional and property owner's information; systems power size; maximum distributed weight of the solar PV system in psf, (including modules, rails, attachments, and all components); & calculations of percentages of covered roof areas to be included.
- Systems that cover more than 50% of the roof area are beyond the scope of this standard; must be submitted for fire department plan review.
- Supply side connections, de-rating of main circuit breakers, power storage batteries, stand-alone systems, & panelboards connected in series, (panelboards with load circuits of premises wiring), are beyond the scope of this standard; these systems must be submitted for plan review.
- Plans with structural engineering are required to be submitted for plan review.
- This standard is limited to flush mounted type, (installed parallel to the roof), with a gap between 2" to 10" to the roof surface, and to roof pitches from ¼:12 to 6:12, (0° to 26° Slope), only; others are beyond the scope of this standard and must be submitted for plan review.
- Tilted type systems are beyond the scope of this standard; these require plan submittal with structural engineering design.
- The roof mounted PV arrays systems are limited to a maximum of 4psf, higher loads are beyond the scope of this standard and must be submitted for plan review.
- This standard is limited for roofing materials of tile without other roofing materials below, two layers maximum of asphalt shingles, & one layer of built-up roofs.
- Roofs with metal standing seam, and wooden shingle or shake materials are beyond the scope this standard; these require plan submittal with structural engineering design.
- The horizontal connections and attachments spacing shall not exceed 4' and must be staggered in adjacent horizontal rows, and the maximum length of the rails' cantilever is limited to 18"; spans that exceed these spacings and lengths are beyond the scope of this standard and must be submitted for plan review.
- Submittals must include copies of the specifications of the manufactured racking system; modules, combiner boxes, optimizers, and inverters.
- A site plan showing all of the existing improvements in the property, location of the electrical service equipment and all of the solar PV wall mounted equipment, required working clearances in front of the electrical equipment, property lines, and north orientation.
- An electrical roof/roof framing plan showing the layout of the arrays and their supporting structure, fire department roof access and clearances, roof pitch and slope, microinverters, optimizers, combiner boxes, junction boxes, electrical raceways' layout/routing, DWV vent terminations, gas flue/B-Vents, attic air vents, skylights, exhaust vents terminations, chimneys, antennas, satellite dishes, rooftop HVAC equipment, and other existing items on the roof.
- A structural mounting detail for the connections and attachments of the proposed supports, rails systems, flashing, and roof structure. It must indicate the amount of lag screws per connection. The lag screws must be 5/16" diameter, corrosive resistant type, and be embedded not less than 2½" into the roof rafter/truss top chord.
- The electrical single line diagram shall include:
  - A diagram showing the number of photovoltaic modules with Voltage and Ampacity output.
  - Show all disconnects, combiners, inverters with input and output ratings, the ampere rating of the main electrical panel bus, the size of the main service disconnect, PV circuit breaker in amperes, in addition to the size and the type of all raceways and conductors, and the Amp rating of existing electrical service that are proposed to be removed must be stated.
  - Show and identify in the inverter reference the required DC ground-fault, GFI, protection; DC arc-fault circuit interrupter, AFCI, protection; and DC disconnect; 690.5, 690.11, & 690.13.
  - Must follow the PV electrical design worksheet that is included within this standard as minimum requirements.
- Rooftop-mounted PV panels/modules shall have a minimum class C fire rating, CBC 1509.7.2 & CRC R908.1.2.
- For design build plans, the contractor's license classification, license number, and signature must be included on each sheet.
- Plans shall be signed and stamped by the licensed design professional as required by the California Business and Professions Code

Fire safety requirements:

- Conduit, wiring systems and raceways for photovoltaic circuits shall be located as close as possible to the ridge, hip or valley and from the hip or valley as directly as possible to an outside wall to reduce trip hazards and maximize ventilation opportunities, CFC 605.11.2 & CRC R331.3.
- Conduit runs between sub arrays and to DC combiner boxes shall be installed in a manner that minimizes total amount of conduit on the roof by taking the shortest path from the array to the DC combiner box, CFC 605.11.2 & CRC R331.3.
- DC Combiner Boxes shall be located so that conduit runs are minimized in the pathways between arrays, CFC 605.11.2 & CRC R331.3.
- DC wiring in enclosed spaces in buildings shall be installed in metallic conduit or raceways. Conduit runs along the bottom of load bearing members, CFC 605.11.2, CEC 690.4(F,) & CRC R331.3.
- All roofs shall have an access point that does not place ground ladders over openings such as windows or doors, shall be located at strong points of building construction, and in locations where the access point does not conflict with overhead obstructions such as tree limbs, wires, or signs, CFC 605.11.3.1 & CRC R331.3.
- Roofs with slopes greater than 2:12 shall have solar PV layouts with access pathways that comply with the following criteria: (some exceptions apply, see the referenced code sections)
  - Hip Roofs: Panels/modules shall be located so that there is a 3-foot wide clear access pathway from the eave to the ridge on each roof slope where panels/modules are located, CFC 605.11.3.2.1 & CRC R331.4.2.1.
  - Hips and Valleys: If panels/modules are placed on both sides of a hip or valley they shall be located no closer than 18 inches to a hip or valley. If the panels are located on only one side of a hip or valley that is of equal length, then the panels can be placed directly adjacent to the hip or valley, CFC 605.11.3.2.3 & CRC R331.4.2.3.
  - Single Ridges: Panels/modules shall be located so that there are two 3-foot wide access pathways from the eave to the ridge on each roof slope where there are panels/modules installed, CFC 605.11.3.2.2 & CRC R331.4.2.2.
  - Ridges: Panels/modules shall be located no higher than 3 feet from the top of the ridge in order to allow for fire department smoke ventilation operations, CFC605.11.3.2.4 & CRC R331.4.2.4.
- Access pathways shall be located at a structurally sound location capable of supporting the load of fire fighters accessing the roof, CFC 605.11.3.2.1 & CRC R331.4.2.1.
- Must follow the markings and warning labels diagram that is included within this standard as minimum requirements.

This plan standard may be used as a general guideline to prepare the minimum requirements of solar PV installations 10 kW or less in one- and two-family dwellings' plans. The sample electrical single line diagram provided in this standard is for *reference purposes only*. Plans *shall be prepared/modified* to reflect the actual project-specific details.

The following notes must be included in the plans:

- All materials, equipment, installation and work shall comply with the following applicable codes:
  - 2013 CRC / 2012 IRC
  - 2013 CEC / 2011 NEC
  - 2013 CMC / 2012 UMC
  - 2013 CPC / 2012 UPC
  - 2013 CFC / 2012 IFC
  - 2013 Building Energy Efficiency Standards
- Existing plumbing vents, skylights, exhaust outlets, & ventilations intake air openings shall not be covered or blocked by the solar photovoltaic system.
- All equipment shall be listed and labeled by a recognized electrical testing laboratory and installed per the listing requirements and the manufacturer's instructions. [NEC 690.4(D)]
- All outdoor equipment shall be NEMA 3R rated, including all roof mounted transition boxes and switches.
- All equipment shall be properly grounded and bonded in accordance with NEC article 250.
- All circuits connected to more than one source shall have overcurrent devices located so as to provide overcurrent protection from all sources. [NEC 690.9(A)]
- Additional equipment of the PV system shall be located outside the building near the main electrical services. [NEC 690.14(C)]
- The utility-interactive inverters shall automatically de-energize its output to the connected electrical production and distribution network upon loss of voltage in the system and shall remain in that state until the electrical production and distribution network voltage has been restored.[NEC 690.61 & 705.40]
- Due to the fact that PV modules are energized whenever exposed to light, PV contractor shall disable the array during installation and service by short circuiting, open circuiting, or covering the array with opaque covering. [NEC 690.18]
- All conductor exposed to weather shall be listed and identified for use in direct sunlight. [NEC 690.31(B), 310.8(D)]
- The module conductors must be type USE-2 or listed for photovoltaic (PV) wire. [NEC 690.31(B)]
- All conductors shall be marked on each end for unique identification. [NEC 690.4 (B)]
- All grounded conductor shall be properly color identified as white. [NEC 200.6]
- PV system connected on the load side of the service disconnecting means of the other source(s) at any distribution equipment on the premises shall meet the following [NEC 705.12(D)]:
  - Each source connection shall be made at a dedicated circuit breaker or fusible disconnecting means. [NEC 705.12(D)(1)]
  - The sum of the ampere rating of the overcurrent devices in circuits supplying power to the busbar or conductor shall not exceed 120% of the rating of busbar or conductor. [NEC 705.12(D)(2)]
  - The interconnection point shall be on the line side of all ground-fault protection equipment. [NEC 705.12(D)(3)]
  - Equipment containing overcurrent devices in circuits supplying power to a bus bar or conductor shall be marked to indicate the presence of all sources. [NEC 705.12(D)(4)]
  - Circuit breaker, if backfed, shall be suitable for such operation. [NEC 705.12(D)(5)]
- To minimize overheating of the busbar in panelboard, the panelboard main circuit breaker and the PV power source circuit breaker shall be physically located at the opposite end of the busbar.[NEC 705.12(D)(7)]
- All the NEC required warning signs, markings, and labels shall be posted on equipment and disconnects prior to any inspections to be performed by the Building Department inspector.
- Metallic raceways or metallic enclosures are required wiring method for inside a building for PV system. [NEC 690.31(E)]
- Flexible, fine-stranded cables shall be terminated only with terminals, lugs, devices or connector that are identified and listed for such use. [NEC 690.31(F) & 110.14(A)]
- Connectors shall be of latching or locking type. Connectors that are readily accessible and operating at over 30 volts shall require tool to open and marked "Do Not Disconnect Under Load" or "Not For Current Interrupting". [NEC 690.33(C) & (E)(2)]
- Equipment grounding conductor for PV modules smaller than 6AWG shall be protected from physical damage by a raceway or cable armor. [NEC 690.46 & 250.120(C)]
- Equipment grounding conductor for PV systems without Ground Fault Protection (GFP) and installed on non-dwelling unit must have ampacity of at least 2 times the temperature and conduit fill corrected circuit conductor ampacity. [NEC 690.45(B)]
- Fine-stranded cables used for battery terminals, devices, and connections require lugs and terminals listed and marked for the use. [NEC 690.74 (A)]
- Insulation of exposed conductors under the modules shall be USE-2 or PV-Wire type for grounded DC systems, 690.31(B); and PV-Wire type for ungrounded DC systems, (as in transformerless inverters or microinverters with isolated grounds), 690.35(F)
- All conductors to be of copper material and their insulations to be rated to not less than 90°C.
- DC conductors in the attic or inside the building must be in metallic raceways, 690.31(E).
- The location of DC raceways beneath the roof, must be not closer than, and must run perpendicular to, 10" of the roof deck as required by CEC 690.31(D)(1)
- Existing B-vent terminations, for fuel burning appliances, where adjacent to the proposed modules, must be extended 12" above the modules' top surface to comply with CMC 802.6.2(1) & CPC 509.6.2(1)
- Cables/wires that are not under the modules must be protected from physical damage per CEC 300.4
- Center-fed and off-set switchboards & panelboards are ***not*** recognized to meet the requirements of 120% rule of CEC 705.12(D)(7)
- The markings, "WARNING: PHOTOVOLTAIC POWER SOURCE", for DC raceways and cable assemblies must be @ 10' o.c.; within 1' of turns or bends, above or below penetrations of roof and ceilings, & walls or barriers per CEC 690.31(E)(4), CFC 605.11.1.4 & CRC R331.2.4
- Existing DWV plumbing vent terminations that are located closer than 12" horizontally from the proposed modules, must be rerouted or extended 6" minimum above the top surface of the modules to comply with CPC 906.1
- For electrical service replacements, provide bonding to the metal pipes of natural gas, hot water, and cold water per CEC 250.104
- The proposed location of electrical service replacement to be approved by the electrical utility company.
- All exterior conduits shall be painted to match the color of the surrounding area (roof, siding, and stucco).

PV electrical design worksheet:

PROJECT ADDRESS: _____ PLAN REVIEW # _____

Module's Model number _____, Voc _____, & Isc _____.

Optimizer, (converter), maximum output current/Amps rating _____.

Inverter(s)/microinverter Model Number(s) _____ & maximum output Amp rating _____.

The lowest expected temperature is 13°F for Ontario; must use Voltage correction factor of 1.12 or greater per Table 690.7.

The average ambient temperature of conductors in raceways or cable assemblies located outdoors and **NOT** on roof-tops is 98°F for Ontario; must use correction factor of 0.91 or less per table 310.15(B)(2)(a).

The average ambient temperature of exposed conductors or conductors in raceways on roofs is 138°F for Ontario; must use correction factor of 0.71 or less, Tables 310.15(B)(2)(a) & 310.15(B)(3)(c). Must be located more than ½" above roofs.

An adjustment factor of 0.8 must be use for 4-6 current carrying conductors in a conduit or cable assembly per table 310.15(B)(3)(a); must use an adjustment factor of 1.0 for 3 or less conductors.

Overcurrent protection & Ampacity for **copper** conductors; 110.14(C), 240.4(B) & (D), 240.6, & Table 310.15(B)(16):

Size of **copper** conductor in American Wire Gauge, (AWG):	14	12	10	8	6	4	2
Circuit breaker maximum Ampere rating:	15	20	30	50	70	90	125
Ampacity only for adjustments/corrections:	25	30	40	55	75	95	130
Adjusted/corrected Ampacity not to exceed that of 75°C: terminals' temperature rating.	20	25	35	50	65	85	115
Equipment Grounding Conductors, (EGC), AWG, Table 250.122: must use #6 AWG minimum where exposed/**NOT** in a raceway, 690.45 & 250.120(C).	14	12	10	10	8	8	6

Inverters Grounding Electrode Conductor, (GEC), Table 250.66; 8-AWG minimum where in a raceway; 6-AWG minimum where exposed/NOT in a raceway, 690.45 & 250.64(B); or 6-AWG minimum where single conductor is used for combined EGC & GEC for 100, 110, & 125-Amp circuit breaker, 690.45(C).

1. **MAXIMUM PV VOLTAGE AND CURRENT CALCULATIONS:**
   a. Maximum PV system Voltage (total to be 600 Volts or less per 690.7(C):
      1.12 x Voc x # of modules connected in series = total Volts.
      1.12 x _____ x _____ = _____ total Volts.
      Maximum PV current/Amps, (1.25 x 1.25 = 1.56 per 690.8(B)(1)(a) & 690.8(B)(2)(a)):
   b. For modules connections made in series, **NO** optimizers:
      1.56 x Isc = Amps.
      1.56 x _____**=**_____ Amps.
   c. For modules connections made in parallel, **NO** optimizers:
      1.56 x Isc x # of connections made in parallel = Amps.
      1.56 x _____x _____ **=**_____ Amps.
   d. For optimizers connections made in series:
      1.56 x Isc = Amps.
      1.56 x _____**=**_____ Amps.
   e. For optimizers connections made in parallel:
      1.56 x Isc x # of connections made in parallel = Amps.
      1.56 x _____x _____ **=**_____ Amps.

2. **DC CONDUCTOR AMPACITY CALCULATIONS:** ***(modules/optimizers to junction/combiner box)***
   a. Conductor size: _____ AWG & its allowed Ampacity for adjustments/corrections: _____Amps.
      Conductors' adjusted Ampacity:
      Temperature correction factor of 0.71 x more than 3 current carrying conductors adjustment factor x conductor allowed Ampacity for adjustments/corrections = Amps.
      0.71 x 0.80 or 1.0 x _____ = _____ Amps; Ampacity not to exceed that of 75°C terminals' temperature rating.

3. **DC CONDUCTOR AMPACITY CALCULATIONS** ***(from junction/combiner box to inverter)***
   a. Conductor size: _____ AWG & its allowed Ampacity for adjustments/corrections: _____Amps.
      Conductors' adjusted Ampacity:
      Temperature correction factor of 0.71 x more than 3 current carrying conductors adjustment factor x conductor allowed Ampacity for adjustments/corrections = Amps.
      0.71 x 0.80 or 1.0 x _____ = _____Amps; Ampacity not to exceed that of 75°C terminals' temperature rating.

4. **CENTRAL INVERTERS AC CONDUCTOR AMPACITY CALCULATION:** ***(inverter(s) to panelboard/electrical service equipment)***
   a. Inverter #1 output AC calculations:
      1.25 x Inverter output maximum current per = Amps.
      1.25 x _____ = _____ Amps
   b. Conductor size: _____ AWG & its allowed Ampacity for adjustments/corrections: _____ Amps.
      Conductors' corrected Ampacity:
      Temperature correction factor of 0.91 x conductor allowed Ampacity for adjustments/corrections = Amps.
      0.91 x _____ = _____ Amps; Ampacity not to exceed that of 75°C terminals' temperature rating.
   c. Inverter #2 output AC calculations, (applicable if another inverter of different output ratings is proposed:
      1.25 x Inverter output maximum current = Amps.
      1.25 x _____ = _____ Amps.
      Conductor size: _____ AWG & its allowed Ampacity for adjustments/corrections: _____ Amps.
   d. Conductors' corrected Ampacity:
      Temperature correction factor of 0.91 x conductor allowed Ampacity for adjustments/corrections = Amps. 0.91 x _____ = _____ Amps; Ampacity not to exceed that of 75°C terminals' temperature rating.

5. ***MICROINVERTERS AC CONDUCTOR AMPACITY CALCULATION: (inverter(s) to panelboard/electrical service equipment)***
   a. Microinverter output AC calculations, for **single** circuit:
      1.25 x largest number of microinverters in parallel in single circuit x microinverter output maximum current = Amps.
      1.25 x _____ x _____= _____ Amps.
   b. Conductor size: _____ AWG & its allowed Ampacity for adjustments/corrections: _____ Amps.
      Conductors' corrected Ampacity:
      Temperature correction factor of 0.71 x conductor allowed Ampacity for adjustments/corrections = Amps. 0.71 x _____ = _____ Amps; Ampacity not to exceed that of 75°C terminals' temperature rating.
   c. Microinverter output AC calculations, for **multiple** circuits:
      1.25 x total number of microinverters in parallel x microinverter output maximum current = Amps.
      1.25 x _____ x _____= _____ Amps.
   d. Conductor size: _____ AWG & its allowed Ampacity for adjustments/corrections: _____ Amps.
      Conductors' corrected Ampacity:
      Temperature correction factor of 0.71 or 0.91 x conductor allowed Ampacity for adjustments/corrections = Amps.
      0.71 or 0.91 x _____ = _____ Amps; Ampacity not to exceed that of 75°C terminals' temperature rating.

6. **PV COMBINER PANELBOARD AC CONDUCTOR AMPACITY CALCULATION:** ***(inverters to combiner panelboard)***
   a. Combiner panelboard busbar rating _____ Amps.
   b. 1.25 x (inverter #1 + inverter #2 + inverter #3 output maximum currents = Amps
      1.25 x (_____ + _____ + _____) = _____ Amps
   c. Conductor size: _____ AWG & its allowed Ampacity for adjustments/corrections: _____ Amps.
      Conductors' corrected Ampacity:
      Temperature correction factor of 0.91 x conductor allowed Ampacity for adjustments/corrections = Amps
      0.91 x _____ = _____ Amps; Ampacity not to exceed that of 75°C terminals' temperature rating

7. CALCULATION OF 120% or 100% RULE FOR BUSBAR AND CONDUCTOR/FEEDER:

Note: Supply side connections, de-rating of main circuit breakers, & panelboards connected in series, (panelboards with load circuits of premises wiring), are beyond the scope of this standard.

   a. For end-fed busbar the 120% rule is applicable:
      1.2 x busbar Ampere rating – main circuit breaker Ampere rating = Maximum Ampere rating allowed of back-fed PV circuit breaker; **the Ampere ratings of the six circuit breakers, as allowed to act as a main circuit breaker per 230.71(A), must be added together**.
      1.2 x _____ - _____ = _____ Amps.
   b. For center-fed or offset-fed busbar the 100% rule is applicable:
      1.0 x busbar Ampere rating – main circuit breaker Ampere rating = Maximum Ampere rating allowed of back-fed PV circuit breaker.
      1.0 x _____ - _____ = _____ Amps.
   c. Conductor/feeder size: _____ AWG & its allowed Ampacity for adjustments/corrections: _____ Amps.
      Conductors' corrected Ampacity:
      Temperature correction factor of 0.91 x conductor allowed Ampacity for adjustments/corrections = Amps
      0.91 x _____ = _____ Amps; Ampacity not to exceed that of 75°C terminals' temperature rating.

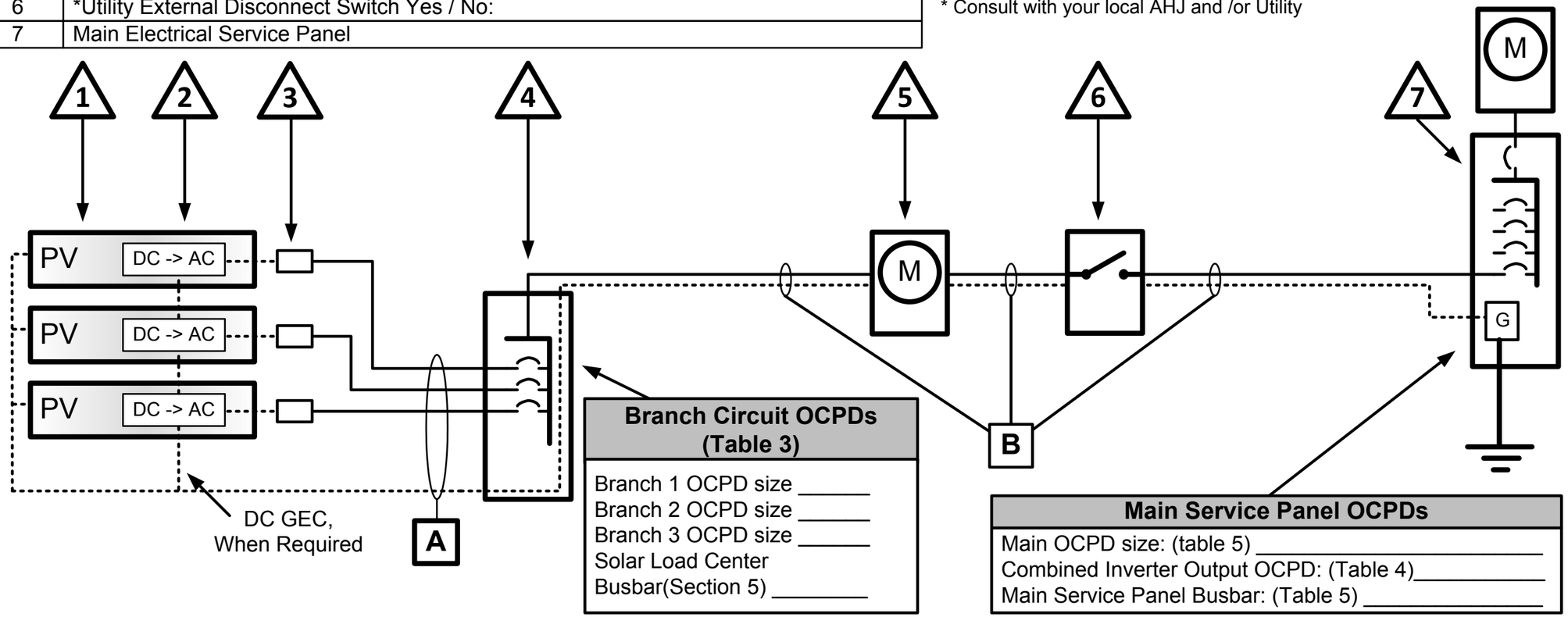
Sample **of Electrical Single Line Diagram**

Equipment Schedule	
△ TAG	DESCRIPTION: (Provide model # if provided)
1	Solar PV Module or ACM:
2	Microinverter (if not ACM):
3	Junction Box (es):
4	Solar Load Center, Yes / No:
5	Performance Meter Yes / No:
6	*Utility External Disconnect Switch Yes / No:
7	Main Electrical Service Panel

Single-Line Diagram for Microinverters or ACMs

Check a box for dc system grounding: ☐ Grounded, ☐ Ungrounded
For ungrounded dc power systems, EGC is required
For grounded dc power systems, GEC & EGC are required
Refer to CEC 250.120 for EGC installation & Table 250.122 for sizing

* Consult with your local AHJ and /or Utility



Branch Circuit OCPDs (Table 3)

Branch 1 OCPD size _____
Branch 2 OCPD size _____
Branch 3 OCPD size _____
Solar Load Center
Busbar(Section 5) _____

Main Service Panel OCPDs

Main OCPD size: (table 5) _____
Combined Inverter Output OCPD: (Table 4)_____
Main Service Panel Busbar: (Table 5) _____

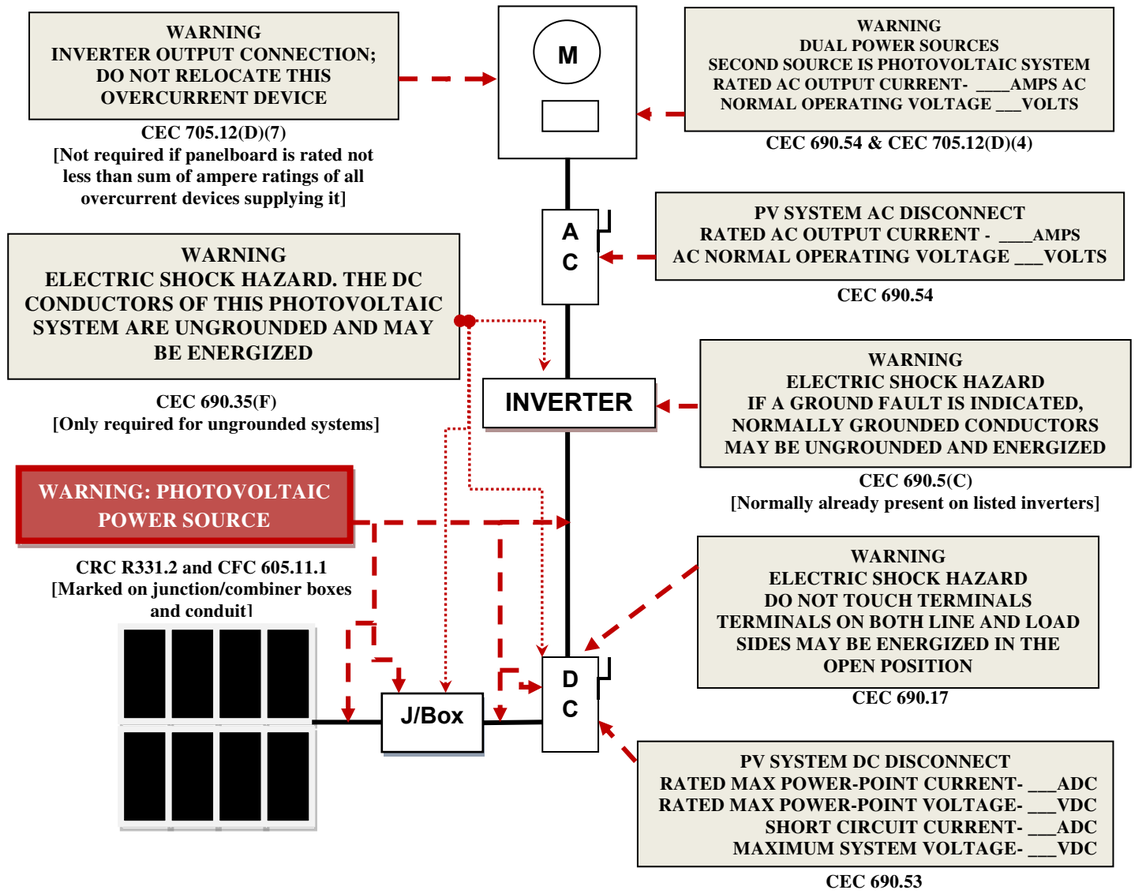
Conductor, Cable and Conduit Schedule

☐ TAG	Description and Conductor Type: (Table 3)	Conductor Size	Number of Conductors	Conduit/ Conductor/ Cable Type	Conduit Size
A	Current-Carrying Conductors: (for each branch circuit)				
	EGC:				
	GEC (when required):				
B	Current-Carrying Conductors:				
	EGC:				
	GEC (when required):				

Markings and warning labels

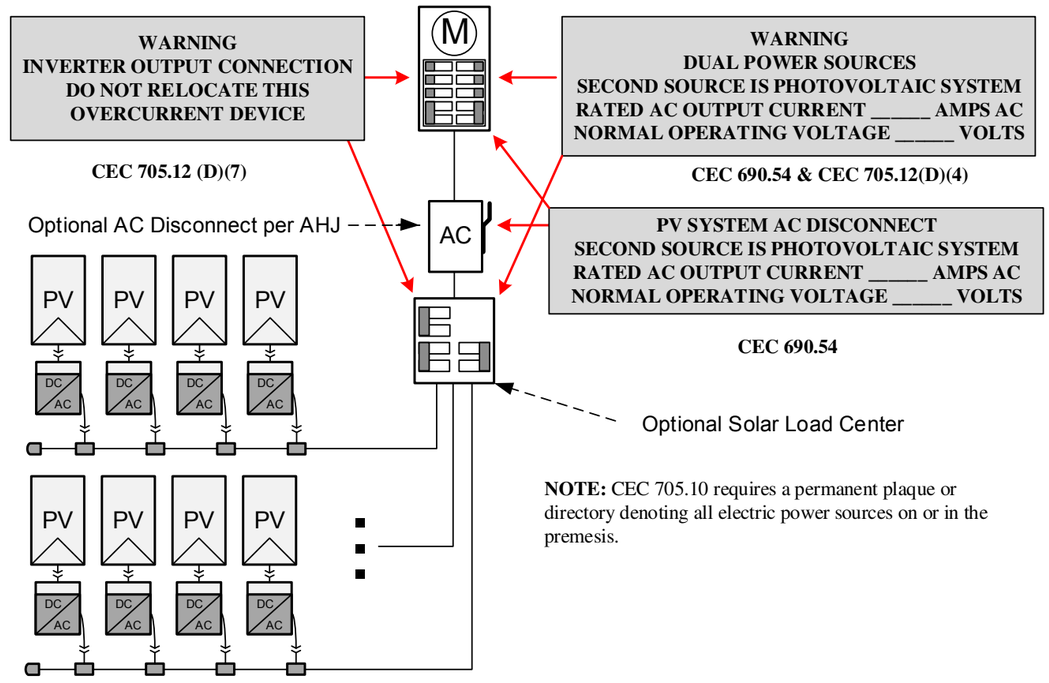
ANSI Z535.4 provides guidelines for the design of safety signs and labels for application to products. A phenolic plaque with contrasting colors between the text and background would meet the intent of the code for permanency. No type size is specified, but 20 point (3/8”) should be considered the minimum

Central/String Inverter Systems Markings



CEC 690.4(H), 690.56(B), & 705.10 requires a permanent plaque or directory denoting all electric power sources on or in the premises.

Microinverter Systems Markings



NOTE: CEC 705.10 requires a permanent plaque or directory denoting all electric power sources on or in the premesis.