CITY OF SONOMA - TOOLKIT DOCUMENT #1

Submittal Requirements for Solar Photovoltaic Installations 10 kW or Less in One- and Two-Family (Duplex) Dwellings

Revised 1/28/2020

This information bulletin is published to guide applicants through a streamlined permitting process for solar photovoltaic (PV) projects 10 kilowatts (kW) in size or smaller. This bulletin provides information about submittal requirements for plan review, required fees and inspections.

1. Approval Requirements

a) A completed City of Sonoma Building Permit application (available at Sonoma City Hall or on the City's web site at https://www.sonomacity.org/building-forms/) is required for all solar system installations.

b) Planning Department and Fire Department plan review and inspection is not required for solar PV installations for one- and two-family dwellings of 10 kW or less.

2. Submittal Requirements

a) NOTE: All information, forms and checklists described below are available on the City's web page for Expedited Solar Permitting for One- & Two-Family Dwellings located at https://www.sonomacity.org/expedited-solar-permitting-one-two-family-dwellings/ .

b) A completed building permit application form must be submitted.

c) Demonstrate compliance with the Eligibility Checklist for Expedited Permitting (Toolkit Document #2).

d) A completed electrical plan and single line electrical diagram must be provided. Standard Electrical Plan templates (Toolkit Documents #3 or #4 as applicable) may be used for proposed solar installations 10 kW in size or smaller.

If standard electrical plans are not provided for use, an electrical plan must be submitted that includes the following.

- *Locations of main service or utility disconnect.*
- *Total number of modules, number of modules per string and the total number of strings.*
- *Make and model of inverter(s) and/or combiner box if used.*
- *One-line diagram of system.*
- *Specify grounding/bonding, conductor type and size, conduit type and size and number of conductors in each section of conduit.*
- *If batteries are to be installed, include them in the diagram and show their locations and venting. See* Expedited Permitting for (Battery) Energy Storage Systems (ESS) at https://www.sonomacity.org/expedited-permitting-for-battery-energy-storage-systems-ess/ for submittal information for ESS.
- *Equipment cut sheets including inverters, modules, AC and DC disconnects, combiners and wind generators.*
- *Location and wording for permanent labeling of equipment as required by CA Electrical Code, Sections 690 and 705.*

e) *Site diagram showing the arrangement of panels on the roof or ground, north arrow, lot dimensions and the distance from property lines to adjacent buildings/structures (existing and proposed)*

f) A roof plan showing roof layout (i.e. hips, ridges valleys, eaves, etc.), PV panels and the following fire safety items:

- approximate location of roof access point;
- location and dimensions of code-compliant access pathways;
- PV system fire classification (i.e. Class A, B or C) and the locations of all required labels and markings.
- A satellite image of the roof with solar panels overlaid is not an acceptable roof plan.

g) A completed Structural Criteria for Expedited Solar PV Permitting form (Toolkit Document #5) along with required documentation.

For non-qualifying systems, provide structural drawings and calculations stamped and signed by a California-licensed Civil or Structural Engineer, along with the following information.

- The type of roof covering and the number of roof coverings installed
- Type of roof framing, size of members, spacing and maximum rafter spans.
- Weight of panels, support locations and method of attachment
- Framing plan and details for any work necessary to strengthen the existing roof structure
- Site-specific structural calculations
- Where an approved racking system is used, provide documentation showing manufacture of the rack system, maximum allowable weight the system can support, attachment method to the roof or ground and product evaluation information or structural design for the rack system

h) A completed Smoke Alarm & Carbon Monoxide Alarm Declaration form available on the City's web site. The California Residential Code requires that smoke and carbon monoxide alarms be provided in all residential buildings where a building permit is issued for additions, alterations or repairs with a valuation exceeding $1,000.

3. Plan Review

Permit applications can be submitted to the City of Sonoma Building Department in person at City Hall, #1 The Plaza, Sonoma, CA and electronically through e-mail. E-mail addresses are available under the Contact Numbers expandable box at http://www.sonomacity.org/Government/Departmental-Offices/Building.aspx .

Permit applications utilizing fully completed standard plan templates are eligible for the expedited permitting process for small residential rooftop solar energy systems.

Permit applications eligible for the expedited permitting process will receive a high review priority and be reviewed as early as practical with a processing goal of one to three business days following receipt of the submittal.

4. Fees

An initial building permit deposit of $100.00 must accompany all solar PV building permit applications at the time of submittal. The deposit will be applied towards the total cost of the building permit and is used to help cover initial processing, plan review and other applicable fees for service. The total cost for building permits for expedited small residential rooftop solar energy systems is dependent on a number of factors but generally is in the range of $300 - $400.

5. Inspections

Once all permits to construct the solar installation have been issued and the system has been installed, it must be inspected before final approval is granted for the solar system. On-site inspections can be scheduled by contacting the City of Sonoma Building Department by telephone at 707-938-3681. Inspection requests received during City Hall business hours can typically be scheduled for the next business day.

Permit holders must provide the inspector with the Building Department Approved Job Plans, the Building Permit Inspection Record Card and access to the location of the work. The permittee must be prepared to show conformance with all technical requirements in the field at the time of inspection. The inspector will verify that the installation is in conformance with applicable code requirements and the approved plans.

The inspection checklist (Toolkit Document #7) provides an overview of common points of inspection, and the applicant should be prepared to show compliance with these points.

6. Departmental Contact Information

For additional information regarding this permit process, please consult our departmental website at http://www.sonomacity.org/Government/Departmental-Offices/Building.aspx or contact the Building Department at 707-938-3681.

CITY OF SONOMA - TOOLKIT DOCUMENT #2

Eligibility Checklist for Expedited Solar Photovoltaic Permitting for One- and Two-Family (Duplex) Dwellings

Revised 1/28/2020

PROJECT ADDRESS: _____

GENERAL REQUIREMENTS

A.	System size is specified and is 10 kilowatts (kW) AC CEC rating or less.	☐ Y	☐ N
B.	The solar array is roof-mounted on one- or two-family dwelling or an accessory structure.	☐ Y	☐ N
C.	The solar panel/module arrays will not exceed 30 feet in height.	☐ Y	☐ N
D.	Solar system is utility interactive and without battery storage.	☐ Y	☐ N
E.	A permit application is completed and attached.	☐ Y	☐ N
F.	All items listed in the Submittal Requirements for Solar PV Installations are provided.	☐ Y	☐ N
G.	All permit documentation as printed is fully legible, accurate and complete.	☐ Y	☐ N

ELECTRICAL REQUIREMENTS

A.	For central/string inverter systems, strings are not combined prior to the inverter	☐ Y	☐ N
B.	PV module short circuit current (ISC) is less than 13 Amps	☐ Y	☐ N
C.	System does not utilize storage batteries, charge controllers, or trackers	☐ Y	☐ N
D.	PV system is not a hybrid or bipolar system	☐ Y	☐ N
E.	For central inverter systems: No more than two inverters are utilized.	☐ Y	☐ N
F.	The PV system is interconnected to a single-phase AC service panel of nominal 120/220 Vac with a bus bar rating of 225 A or less.	☐ Y	☐ N
G.	A Solar PV Standard Plan and supporting documentation is fully completed and attached.	☐ Y	☐ N

STRUCTURAL REQUIREMENTS

A.	A completed Structural Criteria for Expedited Solar PV Permitting form and supporting documentation is attached.	☐ Y	☐ N

FIRE SAFETY REQUIREMENTS

A.	Clear access pathways are shown and provided as prescribed by CA Residential Code – R324	☐ Y	☐ N
B.	The fire classification (per UL 1703) for the solar system (i.e. Class A, B or C) is provided.	☐ Y	☐ N
C.	All required system and component markings and labels are shown and provided.	☐ Y	☐ N
D.	A diagram of the roof layout of all panels, modules, dimensioned clear access pathways and approximate locations of electrical disconnecting means and roof access points is provided.	☐ Y	☐ N

Note:

These criteria are intended for the expedited solar permitting process. If any items are checked NO, revise the design to fit within Eligibility Checklist, otherwise the permit application will go through the City's standard plan review process.

CITY OF SONOMA - TOOLKIT DOCUMENT #3

Solar PV Standard Plan – Simplified Central/String Inverter Systems for One- and Two-Family (Duplex) Dwellings

Revised 1/28/2020

SCOPE: Use this plan ONLY for utility-interactive central/string inverter systems not exceeding a system AC inverter output rating of 10kW on the roof of a one- or two-family dwelling or accessory structure. The photovoltaic system must interconnect to the load side of a single-phase AC service panel of nominal 120/240Vac with a bus bar rating of 225A or less. This standard plan is not intended for bipolar systems, hybrid systems or systems that utilize storage batteries, charge controllers, trackers, more than two inverters or more than one DC combiner (noninverter-integrated) per inverter. Systems must be in compliance with current California Building Standards Codes and local amendments of the City of Sonoma.

MANUFACTURER'S SPECIFICATION SHEETS MUST BE PROVIDED for proposed inverter, modules, combiner/junction boxes and racking systems. Installation instructions for bonding and grounding equipment shall be provided. Listed and labeled equipment shall be installed and used in accordance with any instructions included in the listing or labeling (CEC 110.3). Equipment intended for use with PV system shall be identified and listed for the application (CEC 690.4[B]).

Applicant and Site Information

Job Address: _____

Contractor/ Engineer Name: _____ License # and Class: _____

Signature: _____ Date: _____ Phone Number: _____

General Requirements and System Information

Total # of Inverters installed: _____ (If more than one inverter, complete and attach the "Supplemental Calculation Sheets" and the "Load Center Calculations" if a new load center is to be used.)

Inverter 1 AC Output Power Rating: _____ Watts

Inverter 2 AC Output Power Rating (if applicable): _____ Watts

Combined Inverter Output Power Rating: _____ ≤ 10,000 Watts

Location Ambient Temperatures (Check box next to which lowest expected temperature is used):

1) ❑ If T_L is greater than or equal to -5°C, **C_F = 1.12**

❑ If T_L is between -6°C and -10°C, **C_F = 1.14**

Average ambient high temperature (T_H) for this plan = 47 °C

Note: For a lower T_L or a higher T_H, this plan is not applicable - submit design calculations.

DC Information:

Module Manufacturer: _____ Model: _____

2) Module V_{oc} (from module nameplate): _____Volts

3) Module I_{SC} (from module nameplate): Amps

Is Module I_{SC} less than 13 Amps? ❑ Yes ❑ No (If No, this plan is not applicable.)

4) Module DC output power under standard test conditions (STC) = _____ Watts (STC)

5) DC Module Layout

Identify each source circuit (string) for inverter 1 shown on the roof plan with a Tag (e.g., A, B, C …)	Number of modules per source circuit for inverter 1

Total number of source circuits for inverter 1:

) Are DC/DC Converters used? ❑ Yes ❑ No If No, skip to STEP 7. If Yes, enter info below.

DC/DC Converter Model #: _____

Max DC Output Current: _____ Amps

Max # of DC/DC Converters in an Input Circuit: _____

DC/DC Converter Max DC Input Voltage: _____Volts

Max DC Output Voltage: _____Volts

DC/DC Converter Max DC Input Power: __ _____ Watts

7) Max. System DC Voltage –

Only use for systems without DC/DC converters.

A. Module VOC (Step 2) _____x # of modules in series (Step 5)_____ x CF (Step 1) _____= _____V

Table 1. Maximum Number of PV Modules in Series Based on Module Rated VOC for 600 Vdc Rated Equipment (CEC 690.7)

Max. Rated Module VOC (*1.12)(Volts)	29.76	31.51	33.48	35.71	38.27	41.21	44.64	48.70	53.57	59.52	66.96	76.53	89.29
Max. Rated Module VOC (*1.14)(Volts)	29.24	30.96	32.89	35.09	37.59	40.49	43.86	47.85	52.63	58.48	65.79	75.19	87.72
Max # of Modules for 600 Vdc	18	17	16	15	14	13	12	11	10	9	8	7	6

Only use for systems with DC/DC converters. The value calculated below must be less than DC/DC converter max DC input voltage (Step 6).

B. Module VOC (Step 2) _____x # of modules per converter (Step 6) _____x CF (Step 1) _____= _____V

Table 2. Largest Module VOC for Single-Module DC/DC Converter Configurations (With 80V AFCI Cap) (CEC 690.7 and 690.11)

Max. Rated Module VOC (*1.12) (Volts)	30.4	33.0	35.7	38.4	41.1	43.8	46.4	49.1	51.8	54.5	57.1	59.8	62.5	65.2	67.9	70.5
Max. Rated Module VOC (*1.14) (Volts)	29.8	32.5	35.1	37.7	40.4	43.0	45.6	48.2	50.9	53.5	56.1	58.8	61.4	64.0	66.7	69.3
DC/DC Converter Max DC Input (STEP #6) (Volts)	34	37	40	43	46	49	52	55	58	61	64	67	70	73	76	79

8) Maximum System DC Voltage from DC/DC Converters to Inverter – Only required if Yes in STEP 6

Maximum System DC Voltage = _____ Volts

9) Sizing Source Circuit Conductors

Source Circuit Conductor Size = Min. #10 AWG copper conductor, 90°C wet (USE-2, PV Wire, XHHW-2, THWN-2, RHW-2)

For up to 8 conductors in roof-mounted conduit exposed to sunlight at least ½" from the roof covering (CEC 310)

Note: For over 8 conductors in the conduit or mounting height of lower than ½" from the roof, use Comprehensive Plan.

10) Inverter DC Disconnect

Does the inverter have an integrated DC disconnect? ❑ Yes ❑ No If Yes, skip to Step 11.

If No, the external DC disconnect to be installed is rated for _____Amps (DC) and _____ Volts (DC)

11) Inverter information

Manufacturer: _____ Model: _____

Max. Continuous AC Output Current Rating: _____Amps

Max. Short Circuit Current Per Input: _____ Amps

Does PV Module I_{SC} (Step 3) exceed value above? ❑ Yes ❑ No (If No, this plan is not applicable.)

Integrated DC Arc-Fault Circuit Protection? ❑ Yes ❑ No (If No is selected, this plan is not applicable.)

Grounded or Underground System? ❑ Grounded ❑ Ungrounded

AC Information:

12) Sizing Inverter Output Circuit Conductors and OCPD

Inverter Output OCPD rating = _____ Amps (Table 3)

Inverter Output Circuit Conductor Size = _____ AWG (Table 3)

Table 3. Minimum Inverter Output OCPD and Circuit Conductor Size									
Inverter Continuous Output Current Rating (Amps) (STEP#11)	12	16	20	24	28	32	36	40	48
Minimum OCPD Size (Amps)	15	20	25	30	35	40	45	50	60
Minimum Conductor Size (AWG, 75°C, Copper)	14	12	10	10	8	8	6	6	6

13) Point of Connection to Utility -

Inverter(s) must be connected to either load or supply side of service disconnecting means. Only one of the sub-sections below and either Single Line Diagram #1 or Single Line Diagram #2 should be filled out.

Only use this section for connections on the load side of the service disconnecting means.

Is the PV OCPD positioned at the opposite end from input feeder location or main OCPD location?

❑ Yes ❑ No (If No, then use 100% row in Table 4)

Table 4. Maximum Combined Supply OCPDs Based on Bus Bar Rating (Amps) per CEC 705.12(D)(2)(3)(b)									
Bus bar Rating	100	125	125	200	200	200	225	225	225
Main OCPD	100	100	125	150	175	200	175	200	225
Max Combined PV System OCPD(s) at **120%** of bus bar Rating	20	50	25	60*	60*	40	60*	60*	45
Max Combined PV System OCPD(s) at **100%** of bus bar Rating	0	25	0	50	25	0	50	25	0

*This value has been lowered to 60 A from the calculated value to reflect 10kW AC size maximum.

Reduction of the main breaker is not permitted with this plan. Otherwise, provide code complying design.

Only use this section for connections on the supply side of the service disconnecting means (between the utility meter and the service disconnecting means). Select one:

❑ Utility- and AHJ-approved meter socket adapter.

Adapter name/model: _____

❑ Service equipment listed for the purpose of PV interconnection.

Description / model number(s): _____

14) Rapid Shutdown

The rapid shutdown initiation device shall be labeled according to CEC 690.56(C), and its location shall be shown on the site plan drawing. The rapid shutdown initiation device may be the inverter output or input circuits' disconnecting means, the service main disconnect, or a separate device as approved by the AHJ. The disconnecting means shall be identified for the purpose, suitable for their environment, and listed as a disconnecting means. A single rapid shutdown initiation device shall operate all disconnecting means necessary to control conductors in compliance with CEC 690.12.

Note: Check with the City Building Department regarding approval where field verification of reduction of voltage within the time required by CEC 690.12 is performed.

Rapid shutdown shall be provided as required by CEC 690.12 with one of the following methods **(Select one):**

- ❑ The inverter(s) is within 10 feet of the array, and the location of the inverter is such that uncontrolled PV system conductors are no greater than 5 feet of length within the building. A remotely-controlled AC disconnecting means is required immediately adjacent to or as close as practicable to the inverters, and located within 10 feet of the array.
- ❑ The inverter(s) is within 10 feet of the array, and the location of the inverter is such that uncontrolled PV system conductors are no greater than 5 feet of length within the building. Reduction of the voltage for the inverter output within the time required by CEC 690.12 shall be verified in the field, or the inverter output is listed to UL 1741 with rapid shutdown capability.
- ❑ Reduction of the voltage for the inverter output within the time required by CEC 690.12 shall be verified in the field, or the inverter output is listed to UL 1741 with rapid shutdown capability.
- ❑ Remotely-controlled DC disconnecting means is located within 10 feet of the array at the DC input of inverter(s) connected to a module level DC-DC converter circuit where the DC-DC converter circuit meets the requirements for controlled conductors when disconnected from the inverter. Reduction of the voltage for the DC-DC converter output and the inverter output within the time required by CEC 690.12 shall be verified in the field, or the DC-DC converter output and the inverter output are listed to UL 1741 with rapid shutdown capability.
- ❑ A UL 1741-listed and identified inverter(s) with input and output rapid shutdown capability supplying module level DC-DC converter circuit where the DC-DC converter circuit meets the requirements for controlled conductors when disconnected from the inverter.
- ❑ A UL 1741-listed rapid shutdown system:

  Manufacturer: _____

  Testing Agency Name: _____

  System Model Number: _____

  System Components: _____

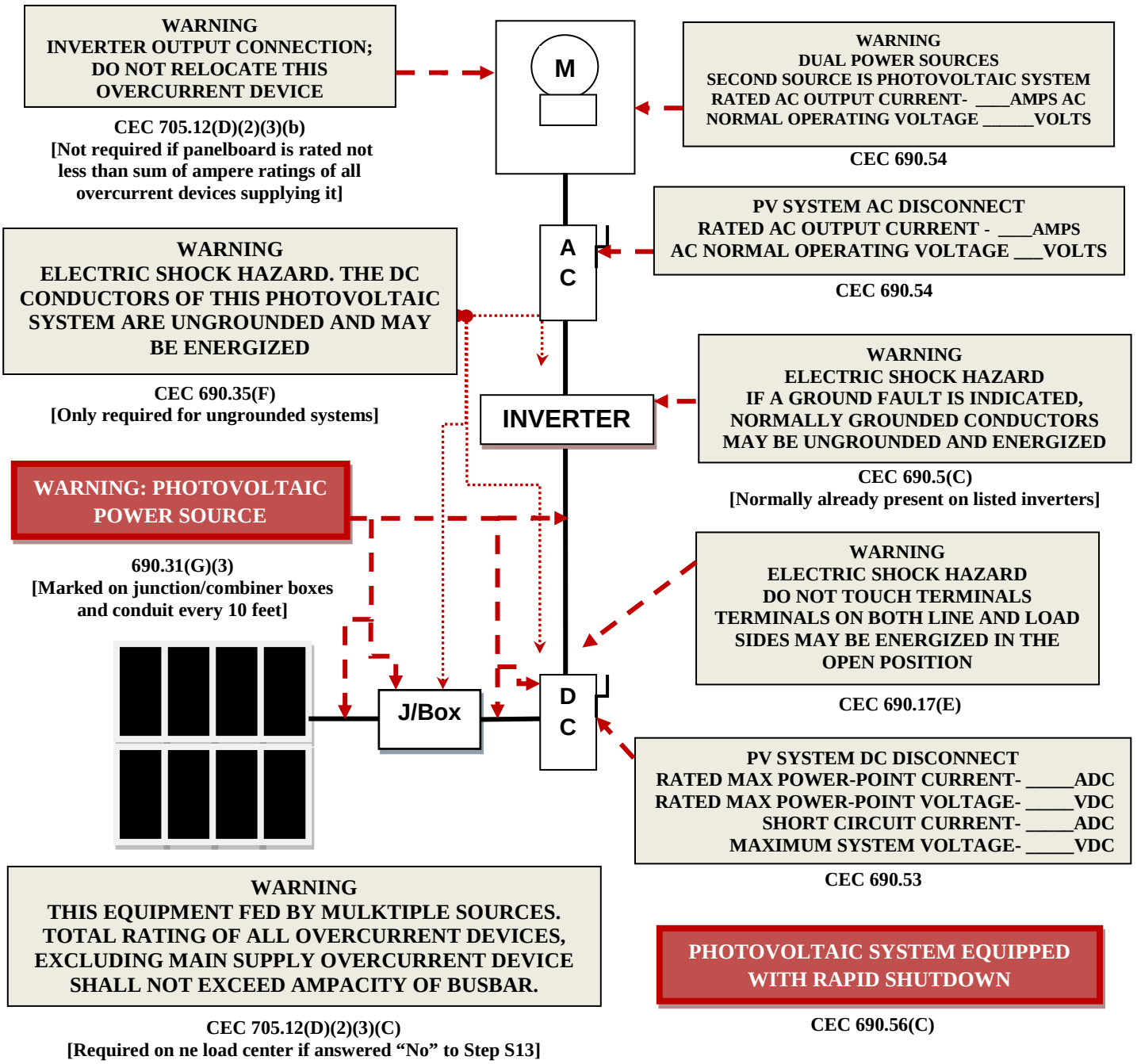
15) Grounding and Bonding of Modules and Racking System

- ❑ Racking system listed to UL 2703 using modules identified in the listing.
- ❑ Other method subject to City approval.

Solar PV Standard Plan – Simplified
Central/String Inverter Systems for One- and Two-Family Dwellings

Labeling

CEC Articles 690 and 705 require the following labels or markings be installed at these components of the photovoltaic system:



Code Abbreviations:
California Electrical Code (CEC)

Informational note: ANSI Z535.40-2011 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.

CEC 705.12 requires a permanent plaque or directory denoting all electric power sources on or in the premises.

Solar PV Standard Plan – Simplified
Central/String Inverter System for One- and Two-Family Dwellings

(Print on 11 x 17" paper)

TAG	DESCRIPTION
1	SOLAR PV MODULE / STRING
2	DC/DC CONVERTERS INSTALLED? YES / NO (IF YES, STEPS 6 & 8 REQUIRED)
3	SOURCE CIRCUIT JUNCTION BOX INSTALLED?: YES / NO
4	SEPARATE DC DISCONNECT INSTALLED?: YES / NO
5	INTERNAL INVERTER DC DISCONNECT: YES / NO
6	CENTRAL INVERTER
7	LOAD CENTER INSTALLED?: YES / NO
8	PV PRODUCTION METER INSTALLED?: YES / NO
9	*SEPARATE AC DISCONNECT INSTALLED?: YES / NO
10	CONNECT TO INVERTER #2 (USE LINE DIAGRAM 3)

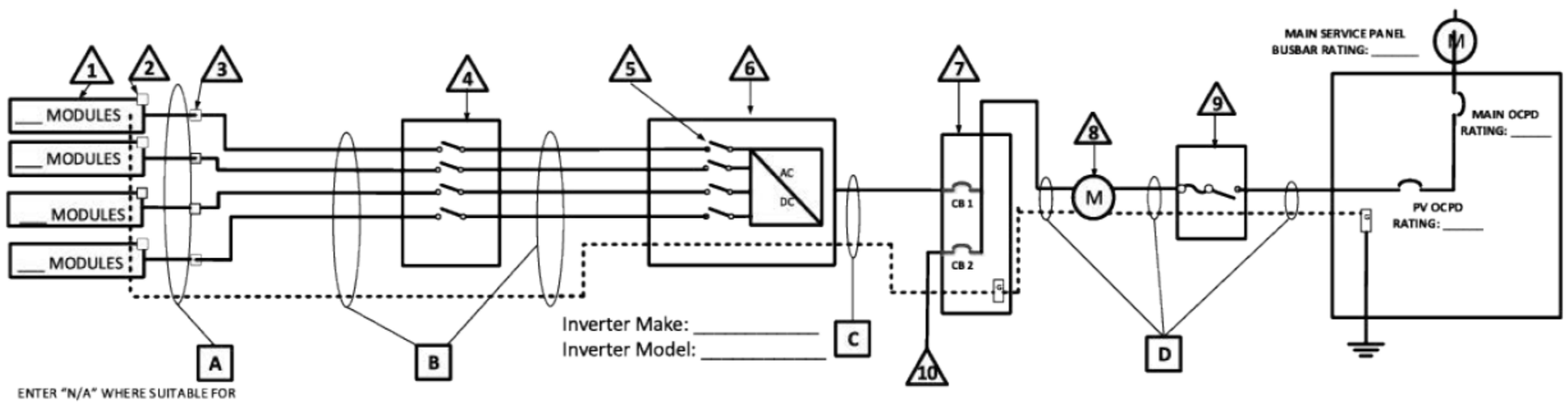
* Consult with your local AHJ and /or Utility

SINGLE-LINE DIAGRAM #1 – LOAD SIDE CONNECTION

CHECK A BOX FOR WHETHER SYSTEM IS GROUNDED OR UNGROUNDED: ☐ GROUNDED (INCLUDE GEC)

REFER TO STEP 14 FOR RAPID SHUTDOWN DETAILS ☐ UNGROUNDED

FOR UNGROUNDED SYSTEMS:
- DC OCPD MUST DISCONNECT BOTH CONDUCTORS OF EACH SOURCE CIRCUIT
- UNGROUNDED CONDUCTORS MUST BE IDENTIFIED PER 210.5(C). WHITE-FINISHED CONDUCTORS ARE NOT PERMITTED.



☐

CONDUCTOR/CONDUIT SCHEDULE					
TAG	DESCRIPTION AND CONDUCTOR TYPE	CONDUCTOR SIZE	NUMBER OF CONDUCTORS	CONDUIT/CABLE TYPE	CONDUIT SIZE
A	USE-2 ☐ OR PV-WIRE ☐				
	EGC/GEC:				
B					
	EGC/GEC:				
C					
	EGC/GEC:				
D					
	EGC/GEC:				

Solar PV Standard Plan – Simplified
Central/String Inverter System for One- and Two-Family Dwellings

(Print on 11 x 17" paper)

TAG	DESCRIPTION
1	SOLAR PV MODULE / STRING
2	DC/DC CONVERTERS INSTALLED? YES / NO (IF YES, STEPS 6 & 8 REQUIRED)
3	SOURCE CIRCUIT JUNCTION BOX INSTALLED?: YES / NO
4	SEPARATE DC DISCONNECT INSTALLED?: YES / NO
5	INTERNAL INVERTER DC DISCONNECT: YES / NO
6	CENTRAL INVERTER
7	LOAD CENTER INSTALLED?: YES / NO
8	PV PRODUCTION METER INSTALLED?: YES / NO
9	*SEPARATE AC DISCONNECT INSTALLED?: YES / NO
10	CONNECT TO INVERTER #2 (USE LINE DIAGRAM 3)

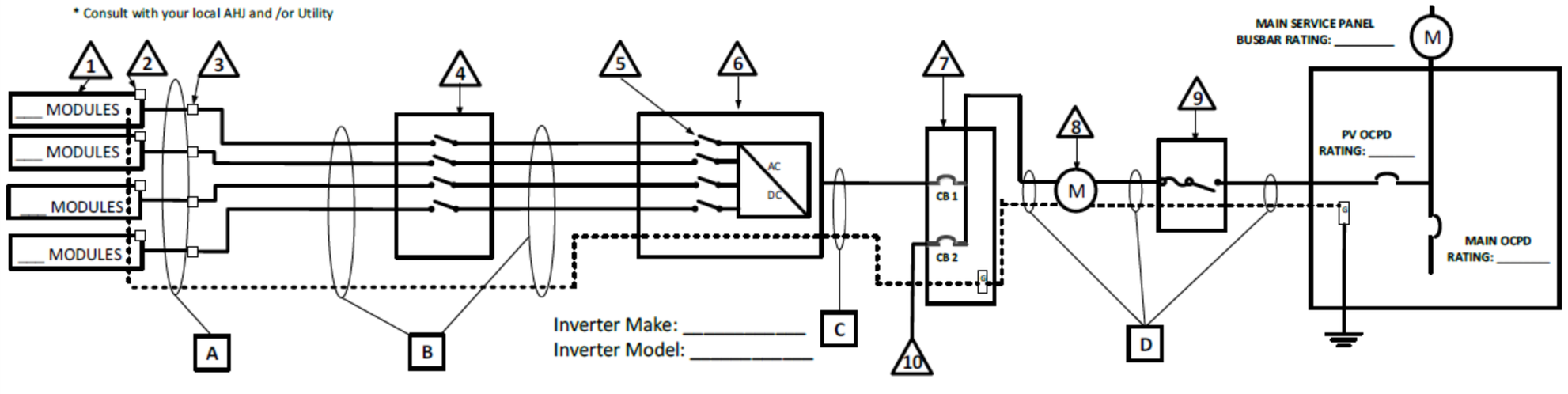
SINGLE-LINE DIAGRAM #2 – SUPPLY SIDE CONNECTION

CHECK A BOX FOR WHETHER SYSTEM IS GROUNDED OR UNGROUNDED: ☐ **GROUNDED (INCLUDE GEC)**

REFER TO STEP 14 FOR RAPID SHUTDOWN DETAILS ☐ **UNGROUNDED**

FOR UNGROUNDED SYSTEMS:
- **DC OCPD MUST DISCONNECT BOTH CONDUCTORS OF EACH SOURCE CIRCUIT**
- **UNGROUNDED CONDUCTORS MUST BE IDENTIFIED PER 210.5(C). WHITE-FINISHED CONDUCTORS ARE NOT PERMITTED.**

* Consult with your local AHJ and /or Utility



ENTER "N/A" WHERE SUITABLE FOR WHEN NOT USING CONDUIT OR CABLE AS PERMITTED BY CODE

CONDUCTOR/CONDUIT SCHEDULE					
☐ TAG	DESCRIPTION AND CONDUCTOR TYPE	CONDUCTOR SIZE	NUMBER OF CONDUCTORS	CONDUIT/CABLE TYPE	CONDUIT SIZE
A	USE-2 ☐ OR PV-WIRE ☐				
	EGC/GEC:				
B					
	EGC/GEC:				
C					
	EGC/GEC:				
D					
	EGC/GEC:				

Select one interconnection method:

☐ Utility- and AHJ-approved meter socket adapter.
Adapter name/model: _____

☐ Service equipment listed for purpose of PV interconnection.
Description / model number: _____

Solar PV Standard Plan — Simplified
Central/String Inverter Systems for One- and Two-Family Dwellings

Supplemental Calculation Sheets for Inverter #2
(Only include if second inverter is used)

DC Information:

Module Manufacturer: _____ Model: _____

S2) Module V_{oc} (from module nameplate): _____Volts

S3) Module I_{SC} (from module nameplate): Amps
Is Module I_{SC} less than 13 Amps? ❑ Yes ❑ No (If No, this plan is not applicable.)

S4) Module DC output power under standard test conditions (STC) = _____ Watts (STC)

S5) DC Module Layout

Identify each source circuit (string) for inverter 1 shown on the roof plan with a Tag (e.g., A, B, C …)	Number of modules per source circuit for inverter 1

Total number of source circuits for inverter 1:

S6) Are DC/DC Converters used? ❑ Yes ❑ No If No, skip to STEP #S7. If Yes, enter info below.

DC/DC Converter Model #: _____
Max DC Output Current: _____ Amps
Max # of DC/DC Converters in a source circuit: _____

DC/DC Converter Max DC Input Voltage: _____Volts
Max DC Output Voltage: _____Volts
DC/DC Converter Max DC Input Power: _____Watts

S7) Max. System DC Voltage –
Only use for systems without DC/DC converters.

A. Module V_{OC} (STEP S2) = _____ x # in series (STEP S5)_____x C_F (STEP S1) _____= _____ V

Table 1. Maximum Number of PV Modules in Series Based on Module Rated VOC for 600 Vdc Rated Equipment (CEC 690.7)													
Max. Rated Module V_{OC} C_F =1.12 (Volts)	29.76	31.51	33.48	35.71	38.27	41.21	44.64	48.70	53.57	59.52	66.96	76.53	89.29
Max. Rated Module V_{OC} C_F =1.14 (Volts)	29.24	30.96	32.89	35.09	37.59	40.49	43.86	47.85	52.63	58.48	65.79	75.19	87.72
Max # of Modules for 600 Vdc	18	17	16	15	14	13	12	11	10	9	8	7	6

Only use for systems with DC/DC converters. The value calculated below must be less than DC/DC converter max DC input voltage (Step S6).

B. Module V_{OC} (STEP S2) = _____ x # per converter (STEP S6)_____x C_F (STEP S1) _____= _____ V

Table 2. Largest Module VOC for Single-Module DC/DC Converter Configurations (With 80V AFCI Cap) (CEC 690.7 and 690.11)																
Max. Rated Module V_{OC} C_F =1.12 (Volts))	30.4	33.0	35.7	38.4	41.1	43.8	46.4	49.1	51.8	54.5	57.1	59.8	62.5	65.2	67.9	70.5
Max. Rated Module V_{OC} C_F =1.14 (Volts)	29.8	32.5	35.1	37.7	40.4	43.0	45.6	48.2	50.9	53.5	56.1	58.8	61.4	64.0	66.7	69.3
DC/DC Converter Max DC Input (STEP #6) (Volts)	34	37	40	43	46	49	52	55	58	61	64	67	70	73	76	79

S8) Maximum System DC Voltage from DC/DC Converters to Inverter – Only required if Yes in STEP S6
Maximum System DC Voltage = _____ Volts

S9) Sizing Source Circuit Conductors:
Source Circuit Conductor Size = Min. #10 AWG copper conductor, 90°C wet (USE-2, PV Wire, XHHW-2, THWN-2, RHW-2)
For up to 8 conductors in roof-mounted conduit exposed to sunlight at least ½" from the roof covering (CEC 310)
Note: For over 8 conductors in the conduit or mounting height of lower than ½"from the roof, this plan is not applicable.

S10) Inverter DC Disconnect
Does the inverter have an integrated DC disconnect? ❑ Yes ❑ No If yes, proceed to STEP S14.
If No, the external DC disconnect to be installed is rated for _____ Amps (DC) and _____Volts (DC)

S11) Inverter information:
Manufacturer: _____ Model: _____

Does PV Module I_{SC} (Step S3) exceed value above? ❑ Yes ❑ No (If No, this plan is not applicable.)

Integrated DC Arc-Fault Circuit Protection? ❑ Yes ❑ No (If No is selected, Comprehensive Standard Plan)
Grounded or Ungrounded System: ❑ GROUNDED ❑ UNGROUNDED

AC Information:

S12) Sizing Inverter Output Circuit Conductors and OCPD:

Inverter Output OCPD rating = _____ Amps (Table S3)

Inverter Output Circuit Conductor Size = _____ AWG (Table S3)

Table S3. Minimum Inverter Output OCPD and Circuit Conductor Size									
Inverter Continuous Output Current Rating (Amps) (STEP S13)	12	16	20	24	28	32	36	40	48
Minimum OCPD Size (Amps)	15	20	25	30	35	40	45	50	60
Minimum Conductor Size (AWG, 75°C, Copper)	14	12	10	10	8	8	6	6	6

Load Center Calculations
(Omit if a load center will not be installed for PV Overcurrent Protection Devices)

S13) Load Center Output:

Calculate the sum of the maximum AC outputs from each inverter.

Inverter #1 Max Continuous AC Output Current Rating[STEP 11] _____ × 1.25 = _____ Amps

Inverter #2 Max Continuous AC Output Current Rating[STEP S11] _____ × 1.25 = _____ Amps

Total inverter currents connected to load center (sum of above) = _____ Amps

Conductor Size: _____ AWG

Overcurrent Protection Device: _____ Amps

Load center bus bar rating: _____ Amps

The sum of the ampere ratings of overcurrent devices in circuits supplying power to a bus bar or conductor shall not exceed 120 percent of the rating of the bus bar or conductor.

Solar PV Standard Plan – Simplified
Central/String Inverter System for One- and Two-Family Dwellings

(Print on 11 x 17" paper)

TAG	DESCRIPTION
1	SOLAR PV MODULE / STRING
2	DC/DC CONVERTERS INSTALLED? YES / NO (IF YES, STEPS 6 & 8 REQUIRED)
3	SOURCE CIRCUIT JUNCTION BOX INSTALLED?: YES / NO
4	SEPARATE DC DISCONNECT INSTALLED?: YES / NO
5	INTERNAL INVERTER DC DISCONNECT: YES / NO
6	CENTRAL INVERTER
7	*SEPARATE AC DISCONNECT INSTALLED?: YES / NO
8	TO LOAD CENTER ON LINE DIAGRAM 1

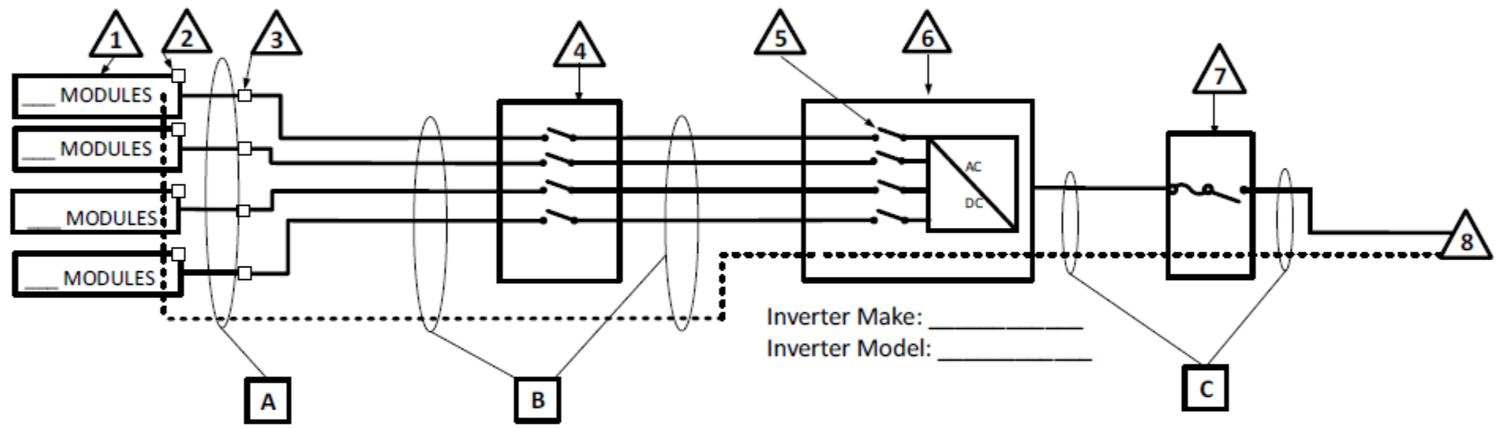
* Consult with your local AHJ and /or Utility

SINGLE-LINE DIAGRAM #3 – ADDITIONAL INVERTER

INVERTER # 2

CHECK A BOX FOR WHETHER SYSTEM IS GROUNDED OR UNGROUNDED: ☐ **GROUNDED (INCLUDE GEC)**
REFER TO STEP 14 FOR RAPID SHUTDOWN DETAILS ☐ **UNGROUNDED**

FOR UNGROUNDED SYSTEMS:
- DC OCPD MUST DISCONNECT BOTH CONDUCTORS OF EACH SOURCE CIRCUIT
- UNGROUNDED CONDUCTORS MUST BE IDENTIFIED PER 210.5(C). WHITE-FINISHED CONDUCTORS ARE NOT PERMITTED.



Inverter Make: _____
Inverter Model: _____

CONDUCTOR/CONDUIT SCHEDULE					
☐ TAG	DESCRIPTION AND CONDUCTOR TYPE	CONDUCTOR SIZE	NUMBER OF CONDUCTORS	CONDUIT/CABLE TYPE	CONDUIT SIZE
A	USE-2 ☐ OR PV-WIRE ☐				
	EGC/GEC:				
B					
	EGC/GEC:				
C					
	EGC/GEC:				

ENTER "N/A" WHERE SUITABLE FOR WHEN NOT USING CONDUIT OR CABLE AS PERMITTED BY CODE

Solar PV Standard Plan – Simplified
Central/String Inverter System for One- and Two-Family Dwellings

(Print on 11 x 17” paper)

Items required: Illustrate the roof layout (hips, valleys ridges and edges) . Show the layout of all panels, modules and approximate locations of electrical disconnecting means, service panel location and roof access points. Specify the roof slope for each roof plane and dimension the clear access pathways required by the CA Fire Code.

Solar PV Roof Layout Diagram for One- and Two-Family Dwellings

(Print on 11 x 17” paper)

CITY OF SONOMA - TOOLKIT DOCUMENT #4

Solar PV Standard Plan – Simplified Microinverter and AC Module (ACM) Systems for One- and Two-Family Dwellings

Revised 1/28/2020

SCOPE: Use this plan ONLY for systems using utility-interactive Microinverters or AC Modules (ACM) not exceeding a combined system AC inverter output rating of 10 kW, with a maximum of 3 branch circuits, one PV module per inverter and with PV module ISC maximum of 10-A DC, installed on a roof of a one- or two-family dwelling or accessory structure. The photovoltaic system must interconnect to a single-phase AC service panel of 120/240 Vac with service panel bus bar rating of 225 A or less. This plan is not intended for bipolar systems, hybrid systems or systems that utilize storage batteries, charge controllers or trackers. Systems must be in compliance with current California Building Standards Codes and local amendments of the City of Sonoma. Other articles of the California Electrical Code (CEC) shall apply as specified in section 690.3.

MANUFACTURER'S SPECIFICATION SHEETS MUST BE PROVIDED for proposed inverters, modules, combiner/junction boxes and racking systems. Installation instructions for bonding and grounding equipment shall be provided. Listed and labeled equipment shall be installed and used in accordance with any instructions included in the listing or labeling (CEC 110.3). Equipment intended for use with PV system shall be identified and listed for the application CEC 690.4(D).

Applicant and Site Information

Job Address: _____

Contractor /Engineer Name: _____ License # and Class: _____

Signature: _____ Date: _____ Phone Number: _____

1. General Requirements and System Information

☐ Microinverter
Number of PV modules installed: _____

Number of Microinverters installed: _____

☐ AC Module (ACM)
Number of ACMs installed: _____

*Note: Listed Alternating-Current Module (ACM) is defined in **CEC 690.2** and installed per **CEC 690.6***

1.1 Number of Branch Circuits, 1, 2 or 3: _____

1.2 Actual number of Microinverters or ACMs per branch circuit: 1 _____ 2._____ 3._____

1.3 Total AC system power rating = (Total Number of Microinverters or ACMs) * (AC inverter power output)

= _____ Watts

1.4 Lowest expected ambient temperature for this plan in Table 1: For -1 to -5°C use 1.12 or for -6 to -10°C use 1.14 correction factor.

1.5 **Average ambient high temperature for this plan: = +47°C**
(Note: For lower expected ambient or higher average ambient high temperatures, submit design calculations.)

2. Microinverter or AC Module (ACM) Information and Ratings

Microinverters with ungrounded DC inputs shall be installed in accordance with CEC 690.35.

Microinverter or ACM Manufacturer: _____

Model: _____

2.1 Rated (continuous) AC output power: _____ Watts

2.2 Nominal AC voltage rating: _____ Volts

2.3 Rated (continuous) AC output current: _____ Amps

If installing AC Modules (ACMs), skip STEP 2.4

2.4 Maximum DC input voltage rating: _____ Volts (limited to 79 V, otherwise use the Comprehensive Standard Plan)

2.5 Maximum input short circuit current: _____Amps

2.6 Maximum AC output overcurrent protection device (OCPD) _____ Amps

2.7 Maximum number of Microinverters or ACMs per branch circuit: _____

3. PV Module Information

(If installing AC Modules, skip to STEP 4)

PV Module Manufacturer: _____

Model: _____

Module DC output power under standard test conditions (STC) = _____ Watts

3.1 Module V_{OC} at STC (from module nameplate): _____ Volts

Module I_{SC} at STC (from module nameplate): _____ Amps [cannot exceed Step 2.5]

3.2

3.3 Adjusted PV Module DC voltage at minimum temperature = [Table 1] _____ [cannot exceed Step 2.4]

Table 1. Module VOC at STC Based on Inverter Maximum DC Input Voltage Derived from CEC 690.7

Microinverter Max. DC Input [STEP 2.4] (Volts)	34	37	40	43	46	49	52	55	58	61	64	67	70	73	76	79
Max. Module VOC @ STC, 1.12 (-1 to -5°C) Correction Factor (Volts)	30.4	33.0	35.7	38.4	41.1	43.8	46.4	49.1	51.8	54.5	57.1	59.8	62.5	65.2	67.9	70.5
Max. Module VOC @ STC, 1.14 (-6 to -10°C) Correction Factor (Volts)	29.8	32.5	35.1	37.7	40.4	43.0	45.6	48.2	50.9	53.5	56.1	58.8	61.4	64.0	66.7	69.3

4. Branch Circuit Output Information

Fill in [Table 3] to describe the branch circuit inverter output conductor and OCPD size. Use [Table 2] for determining the overcurrent protection device (OCPD) and Minimum Conductor size.

Table 2. Branch Circuit Overcurrent Protection Device (OCPD) and Minimum Conductor Size*				
Circuit Current (Amps)	Circuit Power (Watts)	OCPD (Amps)	Minimum Conductor Size (AWG)	Minimum Metal Conduit Size for 6 Current Carrying Conductors
12	2880	15	12	¾"
16	3840	20	10	¾"
20	4800	25	8	1"
24	5760	30	8	1"

*CEC 690.8 and 210.19 (A)(1) Factored in Table 2, Conductors are copper, insulation must be 90°C wet-rated. Table 2 values are based on maximum ambient temperature of 69°C, which includes 22°C adder, exposed to direct sunlight, mounted > 0.5 inches above rooftop, ≤ 6 current carrying conductors (3 circuits) in a circular raceway. Otherwise provide code complying design.

Table 3. PV Array Configuration Summary			
	Branch 1	Branch 2	Branch 3
Number of Microinverters or ACMs [STEP 1]			
Selected Conductor Size (AWG)			
Selected Branch and Inverter Output OCPD			

5. Solar Load Center (if used)

5.1 Circuit Power see [Step 1.3] = _____Watts

5.2 Circuit Current = (Circuit Power) / (AC voltage) = _____Amps

5.3 Solar Load Center Bus Bar Rating (use Table 4) = _____Min. Amps

5.4 Solar Load Center Feeder Breaker Rating (use Table 4) = _____Amps

NOTE: If OCPDs of circuits other than for the inverter outputs are present, solar load center bus bar rating must be a minimum of 100 Amps, and the feeder breaker is limited to a maximum of 60 Amps

Table 4. Solar Load Center and Total Inverter Output OCPD and Conductor Size**				
Circuit Current (Amps)	Circuit Power (Watts)	OCPD (Amps)	Minimum Conductor Size (AWG)	Minimum Metal Conduit Size
24	5760	30	10	½"
28	6720	35	8	¾"
32	7680	40	8	¾"
36	8640	45	8	¾"
40	9600	50	8	¾"
41.6	≤ 10000	60	6	¾"

**CEC 690.8 and 210.19 (A)(1) Factored in Table 4, Conductors are copper, insulation must be 90°C wet-rated. Table 4 values are based on maximum ambient temperature of 47°C (no rooftop temperature adder in this calculation), ≤ 3 current carrying conductors in a circular raceway. Otherwise provide code complying design.

6. Point of Connection to Utility:

6.1 Inverter(s) must be connected to either load or supply side of service disconnecting means. Either Step 6.2 or 6.3 below should be filled out, and either Single Line Diagram #1 or Single Line Diagram #2 should be filled out.

6.2 Load side connections only (Per 705.12(D)(2)(3)):

Is the PV OCPD positioned at the opposite end from input feeder location or main OCPD location?

❑ Yes ❑ No (If No, then use 100% row in Table 5)

(Combined inverter output OCPD size + Main OCPD size) ≤ [bus bar size × (100% or 120%)]

6.3 Supply side connections only (Per 705.12(A)):

Only use this section for connections on the supply side of the service disconnecting means. Select one: ❑

❑ Utility- and City-approved meter socket adapter.

Adapter name/model: _____

❑ Service equipment listed for the purpose of PV interconnection.

Description / model number(s): _____

Table 5. Maximum Combined Inverter Output Circuit OCPD									
Bus bar Size (Amps)	100	125	125	200	200	200	225	225	225
Main OCPD (Amps)	100	100	125	150	175	200	175	200	225
Maximum Combined Inverter OCPD with **120%** of bus bar rating (Amps)	20	50	25	60†	60†	40	60†	60†	45
Maximum Combined Inverter OCPD with **100%** of bus bar rating (Amps)	0	25	0	50	25	0	50	25	0

†This plan limits the maximum system size to less than 10 kW, therefore the OCPD size is limited to 60 A. Reduction of Main Breaker is not permitted with this plan.

7. Grounding and Bonding

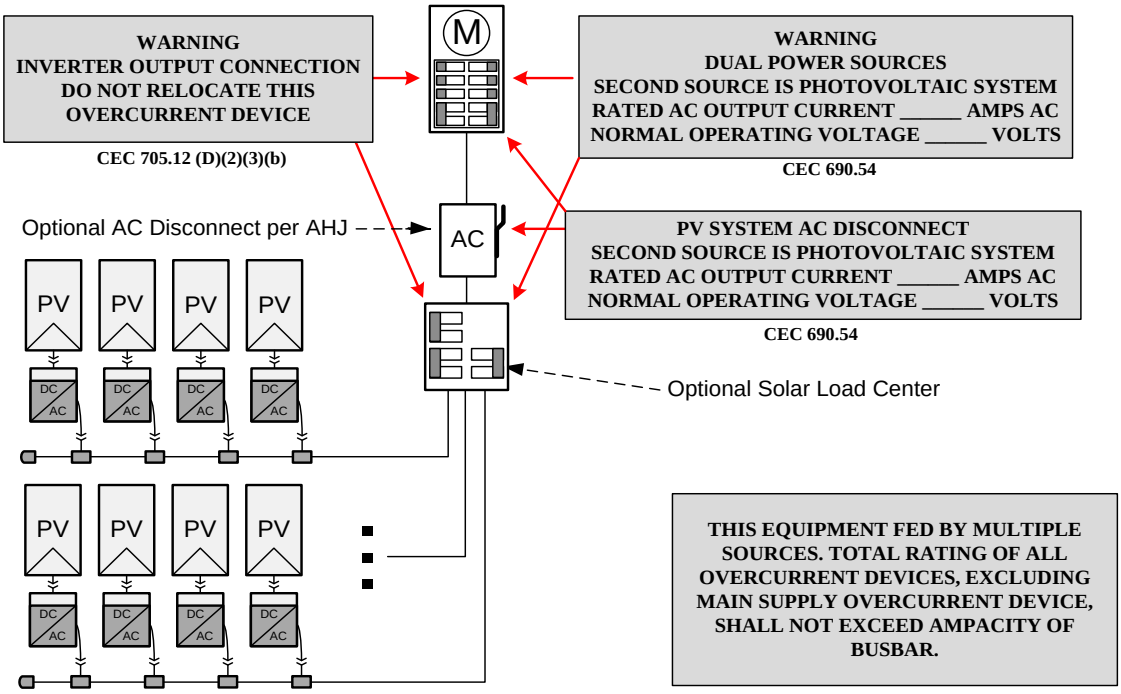
7.1 Check one of the boxes for whether system is grounded or ungrounded: ❑ Grounded ❑ Ungrounded

7.2 For Microinverters with a grounded DC input, systems must follow the requirements of GEC (CEC 690.47) and EGC (CEC 690.43).

7.3 For ACM systems and Microinverters with ungrounded a DC input follow the EGC requirements of (CEC 690.43).

8. Labeling

Informational note: 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.



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

PHOTOVOLTAIC SYSTEM EQUIPPED WITH RAPID SHUTDOWN

CEC 690.56(C)

Solar PV Standard Plan — Simplified
Microinverters and AC Module (ACM) Systems (Load Side Connection) for One- and Two-Family Dwellings

(Print on 11 x 17" paper)

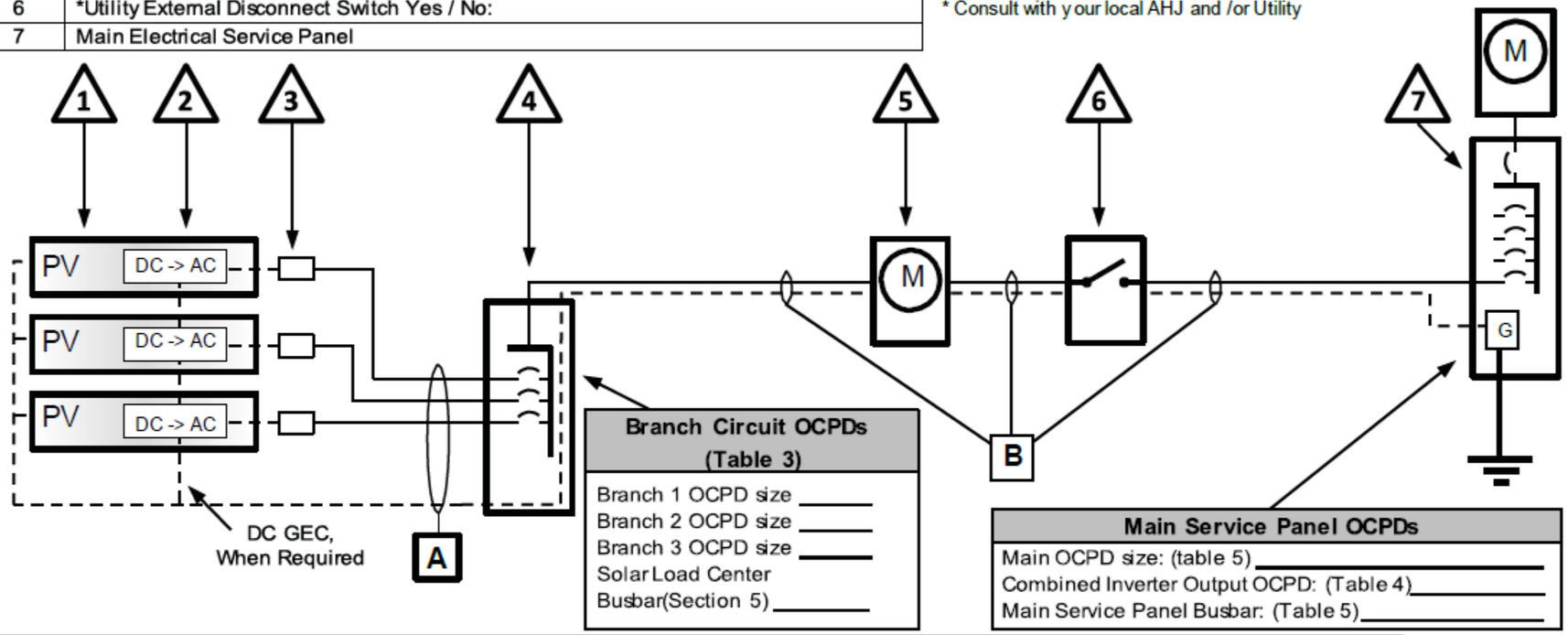
Equipment Schedule

△ TAG	DESCRIPTION: (Provide model # if provided)
1	Solar PV Module or ACM:
2	Microinverter (if not ACM):
3	Junction Box:
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 #1 for Microinverters or ACMs (Load Side Connection)

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



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):				

Single- Line Diagram #1 – Microinverters or ACMs (Load Side Connection)

Solar PV Standard Plan — Simplified

Microinverters and AC Module (ACM) Systems (Supply Side Connection) for One- and Two-Family Dwellings

(Print on 11 x 17" paper)

Equipment Schedule

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

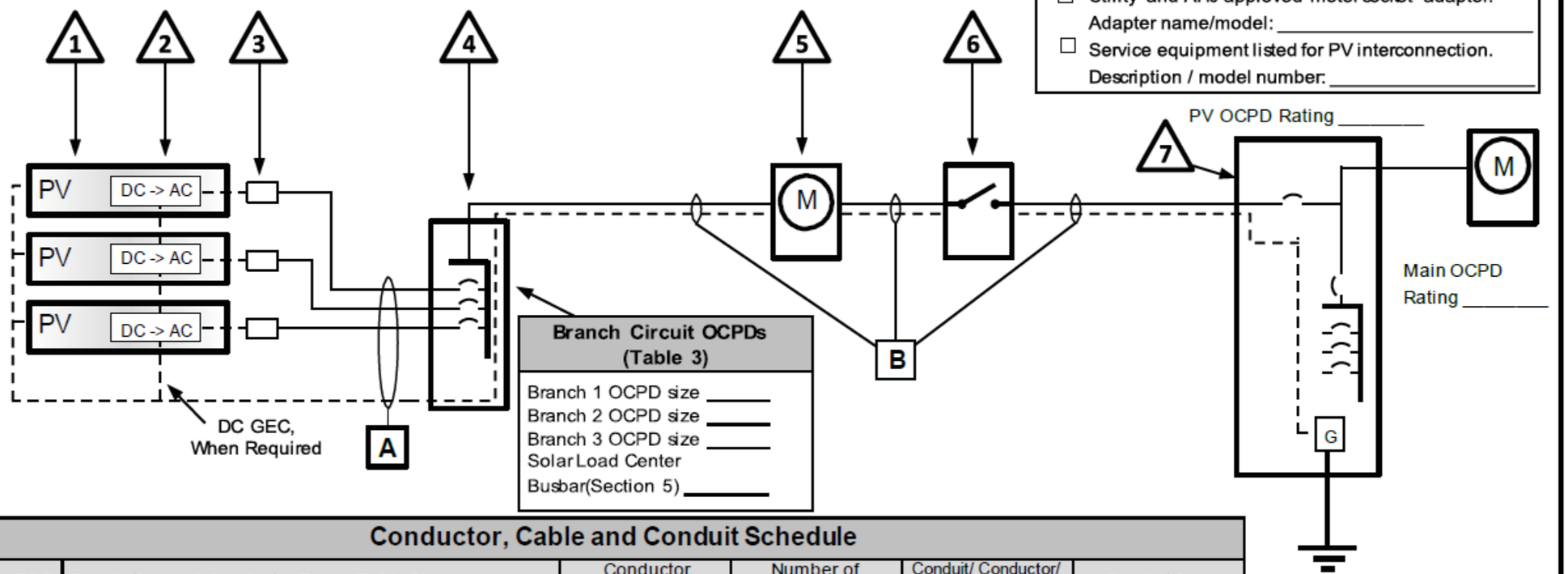
Single-Line Diagram #2 for Microinverters or ACMs (Supply Side Connection)

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

Supply Side Connection (Select One)

☐ Utility- and AHJ-approved meter socket adapter.
Adapter name/model: _____
☐ Service equipment listed for PV interconnection.
Description / model number: _____



Branch Circuit OCPDs (Table 3)

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

Single- Line Diagram #2– Microinverters or ACMs (Supply Side Connection)

Items required: Illustrate the roof layout (hips, valleys ridges and edges) . Show the layout of all panels, modules and approximate locations of electrical disconnecting means, service panel location and roof access points. Specify the roof slope for each roof plane and dimension the clear access pathways required by the CA Fire Code.

Solar PV Roof Layout Diagram for One- and Two-Family Dwellings

(Print on 11 x 17" paper)

CITY OF SONOMA - TOOLKIT DOCUMENT #5

Structural Criteria for Expedited Permitting of Residential Rooftop Solar Energy Installations

Revised 1/28/2020

Use of this document

Applicants for Expedited Permitting of Residential Rooftop Solar Energy Installations must complete and submit this document in its entirety. This document applies to flush-mounted solar arrays installed on the roofs of wood-framed one- and two family dwellings. "Flush-mounted" means the modules are installed parallel to, and relatively close to, the roof surface (see the "Solar Array Check" section of the Structural Criteria for specific qualifying requirements). This list is intended to be a simple pre-installation check to gain reasonable assurance that the design of the solar array complies with the structural provisions of the 2019 California Building Code (CBC) and 2019 California Residential Code (CRC).

Job Address: _____

1. ROOF CHECKS

A. Visual Review/Contractor's Site Audit of Existing Conditions:

1) Is the roof a single roof without a reroof overlay? ☐ Y ☐ N

2) Does the roof structure appear structurally sound, without signs of alterations or significant structural deterioration or sagging, as illustrated in Figure 1? ☐ Y ☐ N

B. Roof Structure Data:

1) Measured roof slope (e.g. 6:12): _____:12

2) Maximum measured rafter or truss spacing (center-to-center): _____ inches o.c.

3) Type of roof framing (rafter or manufactured truss must be verified): ☐ Rafter ☐ Truss

4) Smallest measured rafter size (e.g. 2x4): (Not Applicable if Truss ☐ N/A) ____"x ____" (inches)

5) Longest measured rafter horizontal span (see Figure 4): (if Truss ☐ N/A) ____'-____" (ft-in)

6) Maximum allowed horizontal rafter span per Table 2: (if Truss ☐ N/A) ____'-____" (ft-in)

7) Is the span on line 5) above less than the span on line 6) above? (if Truss ☐ N/A) ☐ Y ☐ N

2. SOLAR ARRAY CHECKS

A. Flush-mounted Solar Array:

1) Is the plane of the modules (panels) parallel to the plane of the roof? ☐ Y ☐ N

2) Is there a 2" to 10" gap between underside of module and the roof surface? ☐ Y ☐ N

3) Modules do not overhang any roof edges (ridges, hops, gable ends, eaves)? ☐ Y ☐ N

B. Do the modules plus support components weigh no more than 4 psf for photovoltaic arrays or 5 psf for solar thermal arrays? ☐ Y ☐ N

C. Does the array cover no more than half of the total roof area (all roof planes)? ☐ Y ☐ N

D. Are solar support component manufacturer's project-specific completed worksheets, tables with relevant cells circled, or web-based calculator results attached? ☐ Y ☐ N

E. Is a roof plan of the module and anchor layout attached? (see Figure 2) ☐ Y ☐ N

F. Downward Load Check (Anchor Layout Check):

1) Proposed anchor horizontal spacing (see Figure 2): ____'-____" (ft-in)

2) Horizontal anchor spacing per Table 1: ____'-____" (ft-in)

3) Is proposed horizontal anchor spacing equal to or less than Table 1 spacing? ☐ Y ☐ N

G. Wind Uplift Check (Anchor Fastener Check):

1) Anchor fastener data (see Figure 3):

a. Are 5/16" diameter lag screws with 2.5" embedment into the rafter used, OR does the anchor fastener meet the manufacturer's guidelines? ☐ Y ☐ N

3. SUMMARY

A. All items above are checked (Y) YES or (N/A). No additional calculations are required. ☐ Y ☐ N

B. One or more items are checked (N) NO. Attach project-specific drawings and calculations stamped and signed by a California-licensed Civil or Structural Engineer. ☐ Y ☐ N

Contractor/Installer that performed Structural Audit: _____
(Please print)

Signature: _____ Date: _____

Tables and Figures:

Table 1. Maximum Horizontal Anchor Spacing

Roof Slope		Rafter Spacing		
		16” o.c.	24” o.c.	32” o.c.
Photovoltaic Arrays (4 psf max)				
Flat to 6:12	0° to 26°	5'-4"	6'-0"	5'-4"
7:12 to 12:12	27° to 45°	1'-4"	2'-0"	2'-8"
13:12 to 24:12	46° to 63°	1'-4"	2'-0"	2'-8"
Solar Thermal Arrays (5 psf max)				
Flat to 6:12	0° to 26°	4'-0"	4'-0"	5'-4"
7:12 to 12:12	27° to 45°	1'-4"	2'-0"	2'-8"
13:12 to 24:12	46° to 63°	Calc. Req'd	Calc. Req'd	Calc. Req'd

Solar support component manufacturer’s guidelines may be relied upon to ensure the array above the roof is properly designed, but manufacturer’s guidelines typically do NOT check to ensure that the roof itself can support the concentrated loads from the solar array. Table 1 assumes that the roof complied with the building code in effect at the time of construction, and places limits on anchor horizontal spacing to ensure that a roof structure is not overloaded under either downward loads or wind uplift loads. Note 4 below lists the basic assumptions upon which this table is based.

Table 1 Notes:

1. Anchors are also known as “stand-offs”, “feet”, “mounts” or “points of attachment”. Horizontal anchor spacing is also known as “cross-slope” or “east-west” anchor spacing (see Figure 2).
2. If anchors are staggered from row-to-row going up the roof, the anchor spacing may be twice that shown above, but no greater than 6’-0”.
3. For manufactured plated wood trusses at slopes of flat to 6:12, the horizontal anchor spacing shall not exceed 4’-0” and anchors in adjacent rows shall be staggered.
4. This table is based on the following assumptions:
   - The roof structure conformed to building code requirements at the time it was built.
   - The attached list of criteria are met.
   - Mean roof height is not greater than 40 feet.
   - Roof sheathing is at least 7/16” thick oriented strand board or plywood. 1x skip sheathing is acceptable.
   - If the dwelling is in Wind Exposure B (typical urban, suburban or wooded areas farther than 500 yards from large open fields), no more than one of the following conditions apply:
     – The dwelling is located in a special wind region with design wind speed between 115 and 130 mph per ASCE 7-10, or
     – The dwelling is located on the top half of a tall hill, provided average slope steeper is less than 15%.
   - If the dwelling is In Wind Exposure C (within 500 yards of large open fields or grasslands), all of the following conditions apply:
     – Design wind speed is 110 mph or less (not in a Special Wind Region), and
     – The dwelling is not located on the top half of a tall hill.
   - The solar array displaces roof live loads (temporary construction loads) that the roof was originally designed to carry.

Table 2. Roof Rafter Maximum Horizontal Span (feet - inches) [1]								
Assumed Vintage	Nominal Size	Actual Size	Non-Tile Roof [2]			Tile Roof [3]		
			Rafter Spacing					
			16" o.c.	24" o.c.	32" o.c.	16" o.c.	24" o.c.	32" o.c.
Post-1960	2x4	1½"x3½"	9'-10"	8'-0"	6'-6"	8'-6"	6'-11"	5'-6"
	2x6	1½"x5½"	14'-4"	11'-9"	9'-6"	12'-5"	10'-2"	8'-0"
	2x8	1½"x7¼"	18'-2"	14'-10"	12'-0"	15'-9"	12'-10"	10'-3"
Pre-1960	2x4	1¾"x3¾"	11'-3"	9'-9"	7'-9"	10'-3"	8'-6"	6'-9"
	2x6	1¾"x5¾"	17'-0"	14'-0"	11'-3"	14'-9"	12'-0"	9'-9"
	2x8	1¾"x7¾"	22'-3"	18'-0"	14'-6"	19'-0"	15'-6"	12'-6"

Beyond a visual review by the Contractor checking for unusual sagging or deterioration, additional assurance that the roof structure complies with minimum structural building code requirements may be required. Table 2 is a table that may be used. For post-1960 construction, these span tables approximate the rafter span tables found in the current building codes. For pre-1960 construction, the rafter span tables are based on structural calculations with lumber sizes and wood species & grade appropriate for older construction. Note 5 below lists the basic assumptions upon which this table is based.

Table 2 Notes:

1. See Figure 4 for definition of roof rafter maximum horizontal span.
2. “Non-tile Roof ” = asphalt shingle, wood shingle & wood shake, with an assumed roof assembly weight of 10 psf.
3. “Tile Roof ” = clay tile or cement tile, with an assumed roof assembly weight of 20psf
4. Unaltered manufactured plated-wood trusses may be assumed to be code compliant and meet intent of Table 2.
5. This table is based on the following assumptions:
    - Span/deflection ratio is equal to or greater than 180.
    - For post-1960 construction, wood species and grade is Douglas Fir-Larch No. 2.
    - For pre-1960 construction, wood species and grade is Douglas Fir-Larch No. 1.
    - Other wood species and/or grade are also acceptable if allowable bending stress is equal or greater to that listed above.

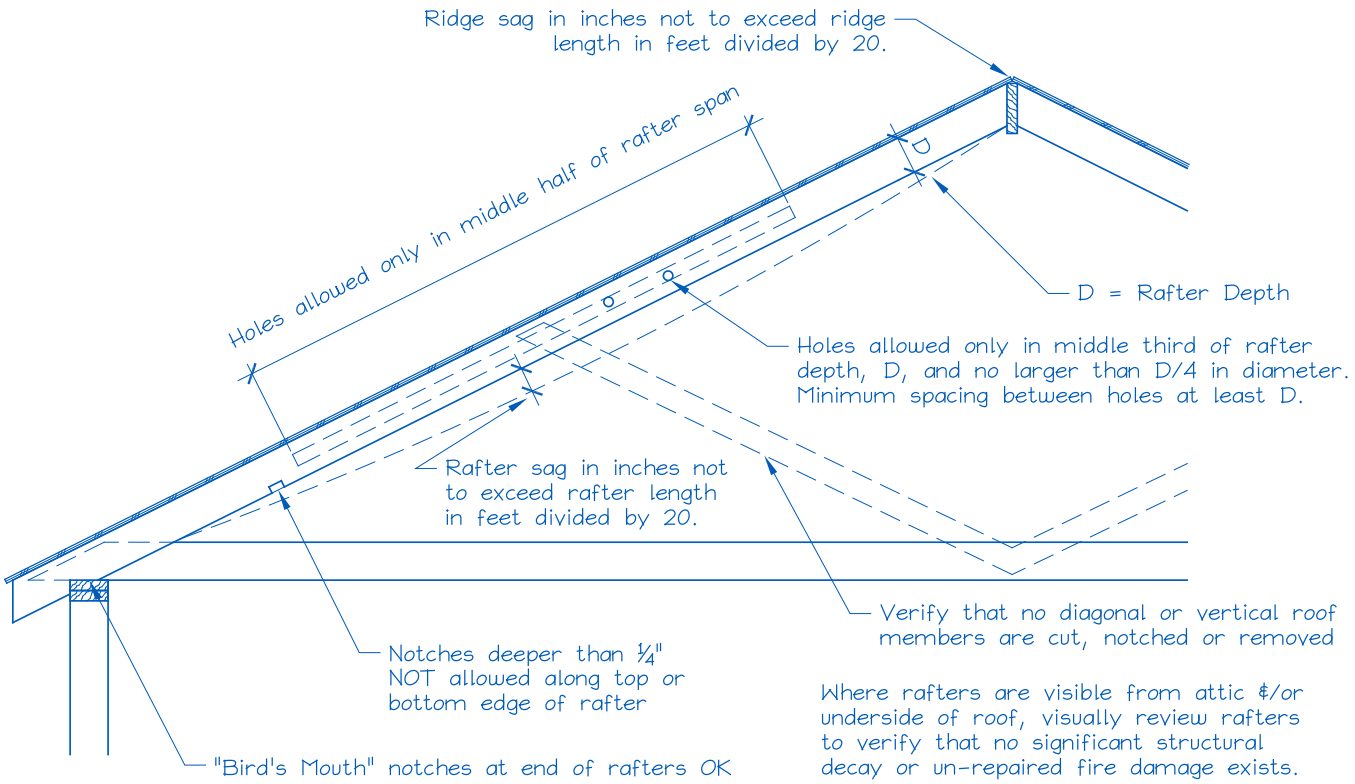


Figure 1. Roof Visual Structural Review (Contractor's Site Audit) of Existing Conditions.

The site auditor should verify the following:

6. No visually apparent disallowed rafter holes, notches and truss modifications as shown above.
7. No visually apparent structural decay or un-repaired fire damage.
8. Roof sag, measured in inches, is not more than the rafter or ridge beam length in feet divided by 20.

Rafters that fail the above criteria should not be used to support solar arrays unless they are first strengthened.

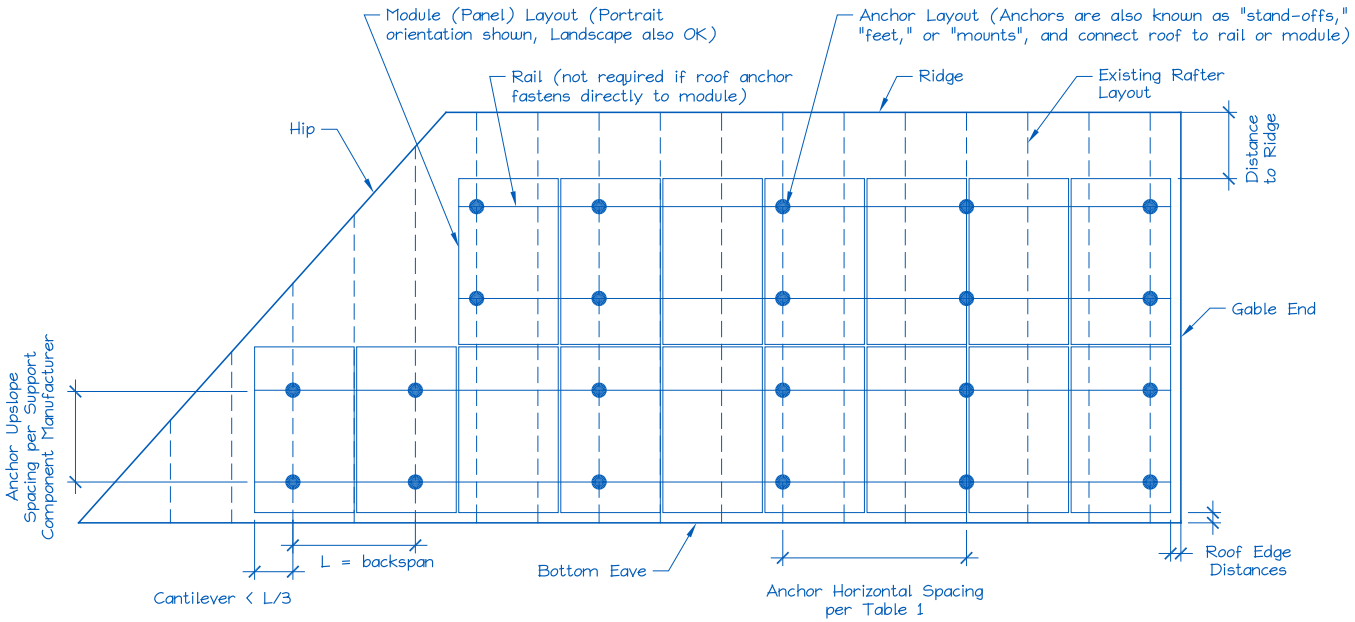


Figure 2. Sample Solar Panel Array and Anchor Layout Diagram (Roof Plan).

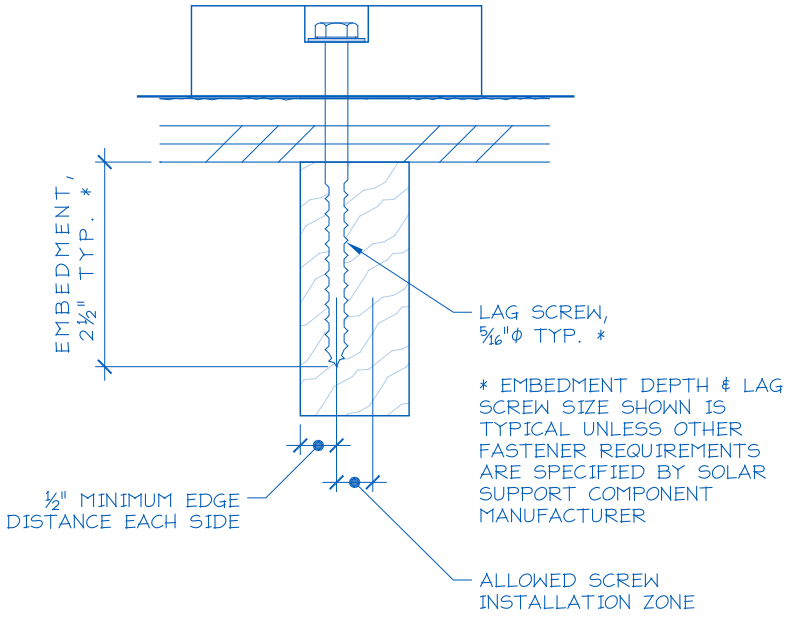


Figure 3. Typical Anchor with Lag Screw Attachment.

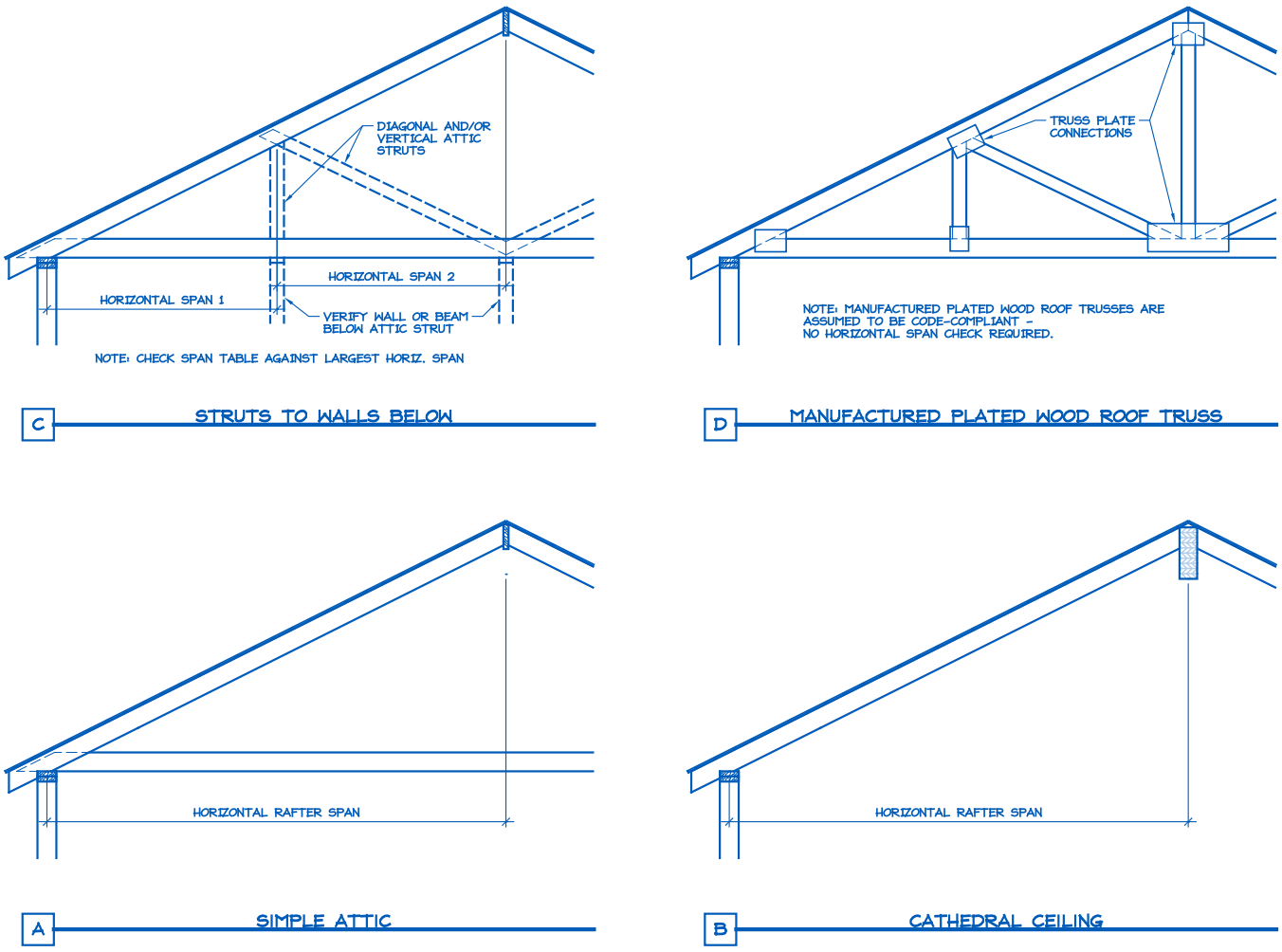


Figure 4. Definition of Rafter Horizontal Span.

CITY OF SONOMA - TOOLKIT DOCUMENT #7

Inspection Guide for PV Systems in One- and Two-Family Dwellings

(For Rooftop Photovoltaic Systems meeting the Standard Plan)

Revised 1/28/2020

This document has two sections. Neither section is all-inclusive as this document is simply a tool to aid the inspection process.

SECTION 1 – Field Inspection Guide: The purpose of this section is to give the field inspector a single-page reminder of the most important items in a field inspection.

SECTION 2- Comprehensive Reference: This reference details items that may be relevant in the field inspection of rooftop PV systems that comply with the comprehensive or simplified versions of the "Solar PV Standard Plan." Not all items outlined in this section are relevant to each PV system. This inspection reference details most of the issues that relate to the PV system during the inspection process.

All California Electrical Code (CEC), California Residential Code (CRC), California Building Code (CBC) and California Fire Code (CFC) references are to the 2019 versions unless otherwise noted.

SECTION 1: Field Inspection Guide for Standard Plan Rooftop Photovoltaic (PV) Systems

Make sure all PV system AC/DC disconnects and circuit breakers are in the open position and verify the following:

1. Approved plans, job inspection record card and roof access are provided for the inspector.
2. A signed Smoke & Carbon Monoxide Alarm Installation Certification certifying that that all required Smoke & Carbon Monoxide Alarms are provided in the residence in accordance with Sections R314 and R315 of the California Residential Code.
3. Roof access point and code-compliant access pathways are provided in accordance per the plans.
4. All work done in a neat and workmanlike manner (CEC 110.12).
5. PV module model number, quantity and location according to the approved plan.
6. Array mounting system and structural connections according to the approved plan.
7. Roof penetrations flashed/sealed according to the approved plan.
8. Array exposed conductors are properly secured, supported and routed to prevent physical damage.
9. Conduit installation according to CRC R324.7.3 and CEC 690.31(G).
10. Firefighter access according to approved plan.
11. Roof-mounted PV systems have the required fire classification (CBC 1505.9 or CRC R902.4).
12. Grounding/bonding of rack and modules according to the manufacturer's installation instructions that are approved and listed.
13. 10. Equipment installed, listed and labeled according to the approved plan (e.g., PV modules, DC/DC converters, combiners, inverters, disconnects, load centers and electrical service equipment).
14. For grid-connected systems, inverter is marked "utility interactive."
15. For ungrounded inverters, installation complies with CEC 690.35 requirements.
16. Conductors, cables and conduit types, sizes and markings according to the approved plan.
17. Overcurrent devices are the type and size according to the approved plan.
18. Disconnects according to the approved plan and properly located as required by the CEC.
19. Inverter output circuit breaker is located at opposite end of bus from utility supply at load center and/or service panelboard (not required if the sum of the inverter and utility supply circuit breakers is less than or equal to the panelboard bus rating).
20. PV system markings, labels and signs according to the approved plan.
21. Connection of the PV system to the grounding electrode system according to the approved plan.
22. Access and working space for operation and maintenance of PV equipment such as inverters, disconnecting means and panelboards (not required for PV modules) (CEC 110.26).
23. Verify that the roof rafters are not over-spanned.

SECTION 2: Comprehensive Inspection Reference

GENERAL

1. Module manufacturer, make, model and number of modules match the approved plans. (CBC 107.4)
2. DC PV modules are listed to UL 1703. Ac modules are listed to UL 1703 and UL 1741. (CEC 110.3, 690.4(B) & CBC 1510.7 & CRC R918)
3. Modules are attached to the mounting structure according to the manufacturer's instructions and the approved plans. (CEC 110.3(B), CBC 107.4 & CRC R918)
4. Roof penetrations/attachments are properly flashed. (CBC Chapter 15 & 2012 CRC Chapter 9)
5. Rooftop systems are designed in accordance with the CBC. (CBC 1510.7 & CRC R918)
6. Roof access points, paths and clearances need to comply with the CFC & CBC. (CFC 605.11.1 - 605.11.1.2.6, CRC R324, CBC 3111.2)
7. PV installation shall comply with requirements of the standard plan.
8. PV systemoperating at 80 volts or greater shall be protected by a listed DC arc fault protection. (CEC 690.11)
9. All work done in a neat and workmanlike manner. (CEC 110.12)

ELECTRICAL REQUIREMENTS

PV Array Configuration

10. DC modules are properly marked and labeled. (CEC 110.3, 690.4(B) & 690.51)
11. AC modules are properly marked and labeled. (CEC 110.3, 690.4(B) & 690.52)
12. PV modules are in good condition (i.e., no broken glass or cells, no discoloration, frames not damaged, etc.). (CEC 110.12(B))
13. Residential one and two family dwelling limited to maximum PV system voltage of 600 volts. (CEC 690.7(C))

Bonding and grounding

14. A complete grounding electrode system is installed. (CEC 690.47(A) & (B))
15. Modules are bonded and grounded in accordance with the manufacturer's installation instructions, that are listed and approved, using the supplied hardware or listed equipment specified in the instructions and identified for the environment. (CEC 690.43 & 110.3(B))
16. Racking systems are bonded and grounded in accordance with the manufacturer's installation instructions, that are listed and approved, using the supplied hardware or listed equipment specified in the instructions and identified for the environment. (CEC 690.43 & 110.3(B))
17. Properly sized equipment grounding conductor is routed with the circuit conductors. (CEC 690.45, 250.134(B) & 300.3(B))
18. AC andDC grounding electrode conductors are properly connected as required by code. Separate electrodes, if used, are bonded together. (CEC 690.47, 250.50 & 250.58)
19. Bonding fittings are used on concentric/eccentric knockouts with metal conduits for circuits over 250 volts. (CEC 250.97) (see also exceptions 1 through 4)
20. Bonding fittings are used for ferrous metal conduits enclosing grounding electrode conductors. (CEC 250.64(E))

PV Source/output Circuit Conductor Management

21. Cables are secured by staples, cable ties, straps, hangers or similar fittings at intervals that do not exceed 4.5 feet. (CEC 334.30 & 338.12(A)(3))
22. Cables are secured within 12 inches of each box, cabinet, conduit body or other termination. (CEC 334.30 & 338.12(A)(3))

23. Exposed single conductors, where subject to physical damage, are protected. (CEC 230.50(B) & 300.5(D))
24. Exposed single conductors used for ungrounded systems are listed and identified as “PV wire” (CEC 690.35(D)(3). For other conductor requirements for ungrounded systems, see CEC690.35(D).

Conductors

25. Exposed single conductor wiring is a 90o C, wet rated and sunlight resistant type USE-2 or approved/listed PV wire. (CEC 690.31(C)(1) & 110.2) If the wiring is in a conduit, it is 90o C, wet rated type RHW-2, THWN- 2, or XHHW-2. (CEC 310.15)
26. Conductor insulation is rated at 90o C to allow for operation at 70o C+ near modules. (CEC310.15)
27. Grounded conductor is identified white or gray. (CEC 200.6)
28. Open conductors are supported, secured and protected. (CEC 338.12(A)(3) & 334.30)
29. Conductors are not in contact with the roof surface. (CEC 334.30)
30. DC conductors inside a building are in a metal raceway or MC metal-clad cable that complies with 250.118(10), or metal enclosures. (CEC 690.31(G))
31. If more than one nominal voltage system conductor is installed in the raceway, permanent identification and labeling is required. (CEC 200.6(D) & 210.5(C))
32. For underground conductor installations, the burial depth is appropriate and warning tape is in place. (CEC 300.5(D)(3) & Table 300.5)
33. Aluminum is not placed in direct contact with concrete. (CEC 250.120(B) & 110.11)
34. PV circuit and premises wiring is separated. (CEC 690.31(B))
35. PV system conductors shall be grouped and identified. (CEC 690.31(B))

Overcurrent Protection

36. Overcurrent protection devices (OCPD) in the DC circuits are listed for DC operation. (CEC 110.3(A), (B) & 690.9(C))
37. Overcurrent protection devices shall be provided per the approved plans. (CEC 690.9(A))
38. Dc Combiner is listed to UL 1741. (CEC 690.4(B))
39. For load side connections, PV output OCPD is located at the opposite end of the bus from the feeder connection, unless the sum of 125% of the inverter output circuit current and rating of the overcurrent device protecting the busbar does not exceed the busbar ampacity. (CEC 705.12(D)(2)(3)(b))

Electrical Connections

40. Crimp terminals are listed and installed using a listed tool specified for use in crimping those specific crimps. (CEC 110.3(B) & 110.14)
41. Pressure terminals are listed for the environment and tightened to manufacturer recommended torque specifications. (CEC 110.11, 110.3(B) & 110.14)
42. Connectors are listed for the voltage of the system and have appropriate temperature and ampere ratings. (CEC 110.3(B) & 110.14)
43. Twist-on wire connectors are listed for the environment (i.e., wet, damp, direct burial, etc.) and installed per manufacturer’s instructions. (CEC 110.11, 110.3(B), 110.14 & 300.5(B))
44. Power distribution blocks are listed. (CEC 690.4(B) & CEC 314.28(E))
45. Terminals containing more than one conductor are listed for multiple conductors. (CEC 110.14(A)& 110.3(B))
46. Connectors and terminals used other than class B and C stranded conductors (fine stranded conductors) are listed and identified for use with specific conductor class or classes.. (CEC 110.14(A) &110.3(B))
47. Connectors that are readily accessible and operating at over 30 volts require a tool for opening. (CEC 690.33(C))
48. All connectors are fully engages, tight and secure. (CEC 110.3(B) & 110.12)

49. Wiring and connections of inverters, PV source circuits, etc., and all interconnections are performed by qualified personnel. (CEC 690.4(C))

Disconnects

50. Disconnects used in DC circuits are listed for DC operation and located as allowed by the AHJ. (CEC 110.3)
51. Disconnects are installed for all current carrying conductors of the PV source. (CEC 690.13 - 690.15 & 690.35(A))
52. Disconnects are installed for the PV equipment. NOTE: For inverters and other equipment that are energized from more than one source, the disconnecting means must be grouped and identified (CEC 690.15)
53. Disconnects and overcurrent protection are installed for all ungrounded conductors in ungrounded PV power systems. (CEC 240.15 & 690.35(A))
54. Where connectors are used as disconnecting means, they shall be used in accordance with CEC 690.33(E). (CEC 690.33(E) & 690.17)

Inverters

55. Inverters are listed to UL 1741. (CEC 690.4(B)) NOTE: grid-tied system inverters need to be identified for use in interactive power systems.
56. Point of connection is at a dedicated breaker or disconnect. (CEC 705.12(D)(1))
57. Where a back-fed breaker is used as a utility interconnection means, the breaker is not marked “line and load.” (CEC 110.3(B), 705.12(D)(4))
58. Listed AC and DC disconnects and overcurrent protection are grouped and identified. (CEC690.13 & 690.15)
59. No multiwire branch circuits are installed where single 120-volt inverters are connected to 120/240-volt load centers. (CEC 690.10(C))
60. The barrier is reinstalled between the AC, DC wiring and communication wires. (CEC 110.3(B) & 110.27)

Signs and Labels

61. All interior and exterior DC conduit, enclosures, raceways, cable assemblies, junction boxes, combiner boxes and disconnects are marked. (CEC 690.31(G)(3), &690.53)
62. The markings on the conduits, raceways and cable assemblies are every 10 feet, within one foot of all turns or bends and within one foot above and below all penetrations of roof/ceiling assemblies, walls and barriers. (CEC 690.31(G)(4))
63. The markings say “WARNING: PHOTOVOLTAIC POWER SOURCE” and have 3/8-inch (9.5mm) minimum-sized white letters on a red background. The signs are made of reflective weather resistant material. (CEC 690.31 (G)(3) & (CEC 690.31(G)(4))
64. Where PV circuits are embedded in built-up, laminate or membrane roofing materials in roof areas not covered by PV modules and associated equipment, the location of circuits shall be clearly marked. (CEC 690.31(G)(1))
65. Required labels shall be permanent and be suitable for the environment. The following labels are required as applicable. (CEC 110.21(B))

Table 1. Signage Requirements for PV systems		
Code Section	Location of Label	Text
CEC 690.5(C)	Utility-interactive inverter & battery enclosure	**WARNING: ELECTRIC SHOCK HAZARD IF A GROUND FAULT IS INDICATED, NORMALLY GROUNDED CONDUCTORS MAY BE UNGROUNDED AND ENERGIZED**
CEC 690.35(F)	All enclosures with ungrounded circuits or devices which are energized and may be exposed during service	**WARNING: ELECTRIC SHOCK HAZARD. THE DC CONDUCTORS OF THIS PHOTOVOLTAIC SYSTEM ARE UNGROUNDED AND MAY BE ENERGIZED.**
CEC 690.13, 690.15, 690.53, 690.54	On the AC and DC disconnects	**PHOTOVOLTAIC SYSTEM DISCONNECT**
CEC 690.53	On the DC disconnects	**OPERATING CURRENT** _____ **OPERATING VOLTAGE** _____ **MAXIMUM SYSTEM VOLTAGE** _____ **SHORT CIRCUIT CURRENT** _____
CEC 690.54	At interactive points of interconnection, usually the main service	**RATED AC OUTPUT CURRENT** _____ **AMPS** **NORMAL OPERATING AC VOLTAGE** _____ **VOLTS**
CEC 690.56(B), 690.13, 705.10 CEC 690.4(D)	At the electrical service and at the PV inverter if not at the same location	A directory providing the location of the service disconnecting means and the photovoltaic system disconnecting means
CEC 690.17(E)	On the DC disconnect and on any equipment that stays energized in the off position from the PV supply	**WARNING! ELECTRIC SHOCK HAZARD. DO NOT TOUCH TERMINALS. TERMINALS ON BOTH THE LINE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION.**
CEC 705.12 (D)(2)(3)(b)	Inverter output OCPD	**WARNING: INVERTER OUTPUT CONNECTION DO NOT RELOCATE THIS OVERCURRENT DEVICE.**
CEC 690.31(G)(3), 690.31(G)(4)	On conduit, raceways and enclosures, mark every 10 feet, at turns, above/ below penetrations	**WARNING: PHOTOVOLTAIC POWER SOURCE.** *Note: This label shall have a red background with white lettering*
CEC 690.12(4), CEC 690.56(C)	At the location of the rapid shutdown initiation method	**PHOTOVOLTAIC SYSTEM EQUIPPED WITH RAPID SHUTDOWN** *Note: This label shall have a red background with white lettering*

FIRE SAFETY REQUIREMENTS

1. Rooftop-mounted PV panels and modules have the proper fire classification rating. (CBC 1505.9 & CRC R918.1.3)

2. Conduit, wiring systems and raceways for photovoltaic circuits are 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 605.11.1.2.7 & CRC R324.7.3)

3. Conduit runs between sub arrays and to DC combiner boxes are 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 605.11.1.2.7 & CRC R324.7.3)
4. DC Combiner Boxes are located so that conduit runs are minimized in the pathways between arrays. (CFC 605.11.1.2.7 & CRC 324.7.3)
5. DC wiring in enclosed spaces in buildings is installed in metallic conduit or raceways. Conduit runs along the bottom of load bearing members. (CFC 605.11.1.2.7 & CRC R324.7.3)

6. Roofs with slopes greater than 2:12 (except for detached, non-habitable structures) shall have solar panel layouts with access pathways that comply with approved roof plan that meet the following criteria:

    a. Pathways: Not less than two minimum 36-inch-wide pathways on separate roof planes, from lowest roof edge to ridge, shall be provided on all buildings. At least one pathway shall be provided on the street or driveway side of the roof. For each roof plane with a photovoltaic array, a minimum 36-inch-wide pathway from the lowest roof edge to ridge shall be provided on the same roof plane as the photovoltaic array, on an adjacent roof plane, or straddling the same and adjacent roof planes (CFC 605.11.1.2.1 & CRC R324.6.1)

    b. Setbacks at ridge: For photovoltaic arrays occupying 33 percent or less of the plan view total roof area, a minimum 18-inch-wide setback is required on both sides of a horizontal ridge. For photovoltaic arrays occupying more than 33 percent of the plan view total roof area, a minimum 36-inch-wide setback is required on both sides of a horizontal ridge. (CFC 605.11.1.2.2 & CRC R324.6.2)

    c. Alternative setbacks at ridge: Where an automatic sprinkler system is installed within the dwelling in accordance with NFPA 13D, setbacks at ridge shall conform with one of the following (CFC 605.11.1.2.2.1& CRC R324.6.2.1):
        i. For photovoltaic arrays occupying not more than 66 percent of the plan view total roof area, not less than an 18-inch clear setback is required on both sides of a horizontal ridge.

        ii. For photovoltaic arrays occupying more than 66 percent of the plan view total roof area, not less than a 36-inch clear setback is required on both sides of a horizontal ridge.
    d. Emergency escape and rescue opening: Panels and modules installed on dwellings shall not be placed on the portion of a roof that is below an emergency escape and rescue opening. A 36-inch-wide pathway shall be provided to the emergency escape and rescue opening. (CFC 605.11.1.2.6 & CRC R324.6.4)

    e. Pathways shall be over areas capable of supporting fire fighters accessing the roof. Pathways shall be located in areas with minimal obstructions such as vent pipes, conduit, or mechanical equipment. (CFC 605.11.1 & CRC R324.6.1)