

Helping Assure the Correct Installation of a PV System

Les Nelson

International Association of Plumbing and Mechanical Officials

**Forum on Regional Cooperation:
Developing Quality Infrastructure for
Photovoltaic Energy Generation**

September 13, 2017

Santiago, Chile



Quality Infrastructure for PV Installations

➤ Contractor (Installer) Licensing

- Some US states require licensing while others require registration
 - Licensing involves passing an examination and demonstrating experience to prove competency in a trade.
 - Registration is a written record of who is performing the work, and does not guarantee expertise or competency.

➤ Adherence to Building Code Requirements

➤ Permitting of Projects

➤ Inspection of Completed Projects

➤ Certification of Contractors (NABCEP) and Continuing Education Requirement



PV Installations by US State

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The Open PV Project



Open PV State Rankings

This visualization ranks states by the cost, count and capacity of their photovoltaic installs. Click one of the 'Rank By' buttons to sort by that column in the table. You can also click a state to find its row in the current ranking.

Note that the state rankings are out of a total of 52 because the Open PV Project includes the District of Columbia and Puerto Rico as 'states' to ensure these regions are represented in the rankings.

Did you know?

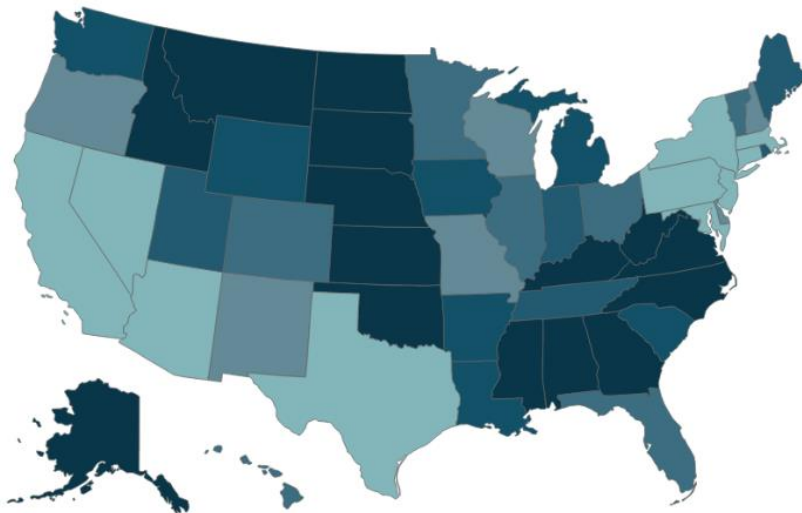
California ranks first among all states in number of solar PV systems installed with 626,818. The next closest state, Arizona, has 89,361 installs.

Legend



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Rank By Total Count		Rank By Avg. Cost \$/W		Rank By Capacity MW	
Rank	State	Count	Cost \$/W	Capacity (MW)	
#1	CA	626818	6.27	7378.79	
#2	AZ	89361	5.14	1647.18	
#3	MA	71421	5.27	1941.27	
#4	NJ	51046	7.39	2283.74	
#5	NY	51000	5.56	575.23	
#6	CT	23643	5.35	248.61	
#7	NV	16048	4.60	359.85	
#8	TX	14341	4.91	324.57	
#9	MD	11416	6.14	183.91	
#10	PA	11415	6.11	241.20	
#11	NM	8356	5.89	187.71	

#1 California 626,818 systems
#2 Arizona 89,361

<https://openpv.nrel.gov/rankings>



California Licensure Requirements

- **Contractor's license is required for Building Permit**
 - "A" General Engineering Contractor
 - "B" General Building Contractor
 - C-10 Specialty Electrical Contractor
 - C-46 Specialty Solar Contractor
- **Education/testing requirements (all licenses):**
 - Written examinations
 - Law and Business Section
 - Specific trade examination
 - 4 years experience; (technical training, apprenticeship training and education may be credited instead of 3 years experience; at least 1 year practical experience).
- **Must be bonded** (a type of insurance which pays directly to project owner)

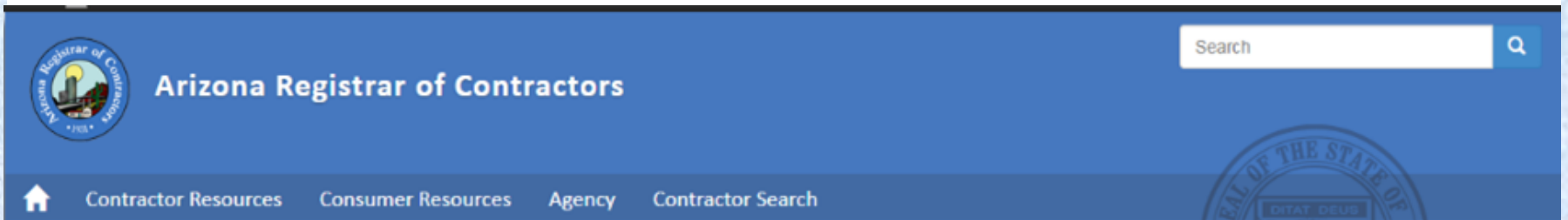


Licensing authority: [California Contractors State License Board](#)



Arizona Licensure Requirements

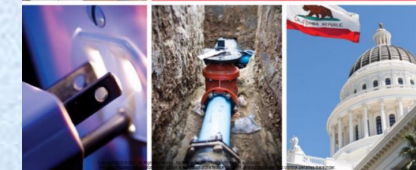
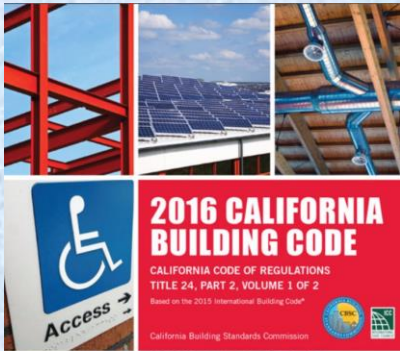
- **Contractor's license is required for installation**
 - A-17 Electrical and Transmission Lines
 - C11 Electrical (Commercial)
 - R11 Electrical (Residential)
- **Education/testing requirements (all licenses):**
 - Written examinations
 - Business Management
 - Specific trade examination
 - 4 years experience
- **Must be bonded** (a type of insurance which pays directly to project owner)



Licensing authority: [Arizona Registrar of Contractors](#)

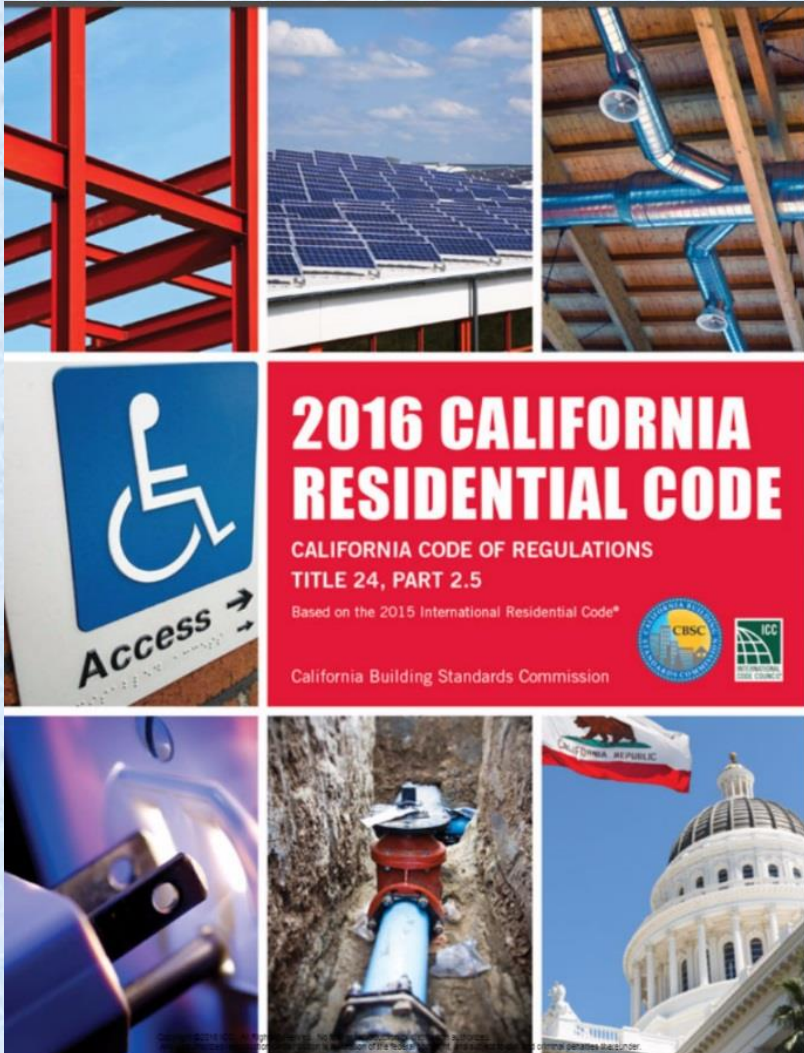


California Building Codes



<http://www.bsc.ca.gov/Codes.aspx>

Example Code Language



SECTION 324 SOLAR ENERGY SYSTEMS

R324.1 General. Solar energy systems shall comply with the provisions of this section.

R324.2 Solar thermal systems. Solar thermal systems shall be designed and installed in accordance with *the California Plumbing Code* and the *California Fire Code*.

R324.3 Photovoltaic systems. Photovoltaic systems shall be designed and installed in accordance with Sections R324.3.1 through R324.7.2.7 and *the California Electrical Code*. Inverters shall be listed and labeled in accordance with UL 1741. Systems connected to the utility grid shall use inverters listed for utility interaction.

R324.3.1 Equipment listings. Photovoltaic panels and modules shall be listed and labeled in accordance with UL 1703.

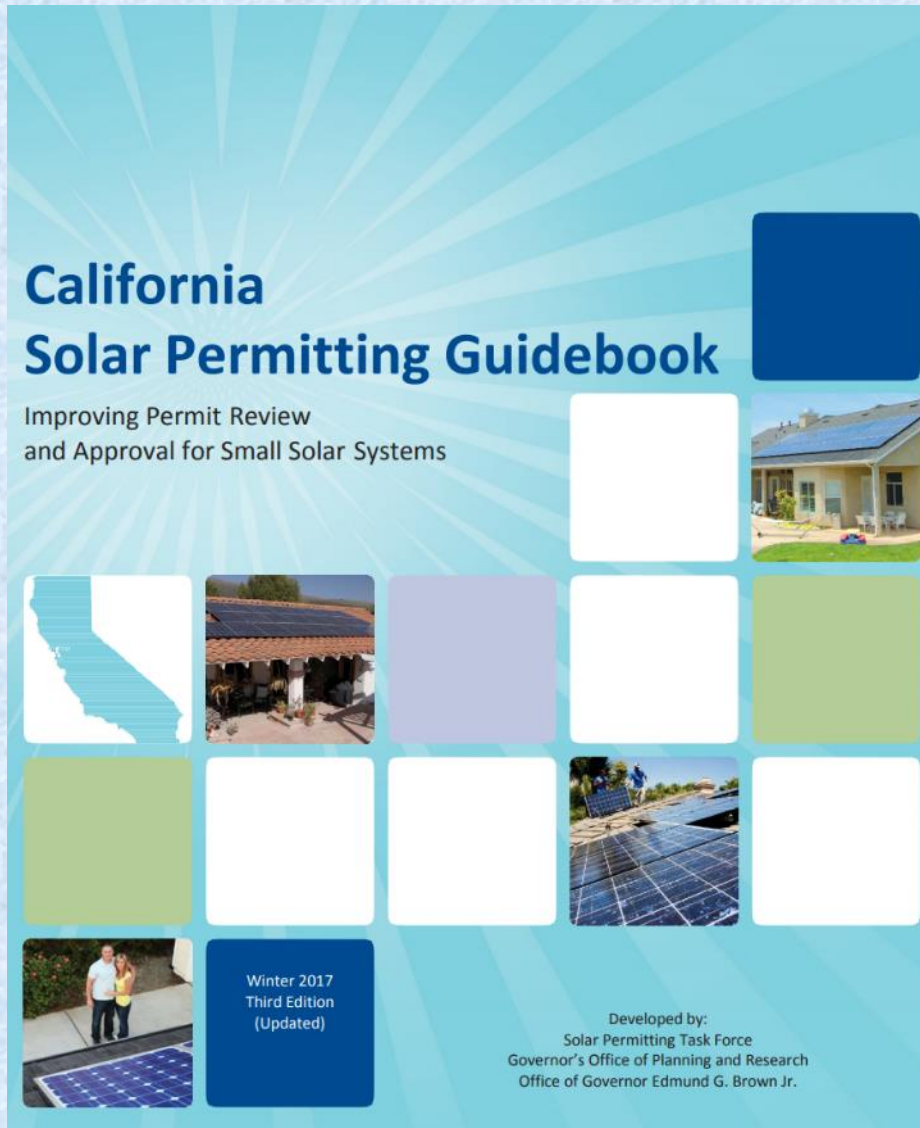
R324.4 Rooftop-mounted photovoltaic systems. Rooftop-mounted photovoltaic panel systems installed on or above the roof covering shall be designed and installed in accordance with Section R907.

R324.4.1 Roof live load. Roof structures that provide support for photovoltaic panel systems shall be designed for applicable roof live load. The design of roof structures need not include roof live load in the areas covered by photovoltaic panel systems. Portions of roof structures not covered by photovoltaic panels shall be designed for roof live load. Roof structures that provide support for photovoltaic panel systems shall be designed for live load, L_R , for the load case where the photovoltaic panel system is not present.

R324.5 Building-integrated photovoltaic systems. Building-integrated photovoltaic systems that serve as roof coverings shall be designed and installed in accordance with Section R905.

R324.5.1 Photovoltaic shingles. Photovoltaic shingles shall comply with Section R905.16.

California Solar Permitting



- Created by working group including California State Government, PV industry, electric utilities and local government
- Addresses the issue of long wait times for permits from cities
- Standardizes paperwork
- Increases project quality and safety by identifying necessary PV system components

California Solar Permitting

STEPS FOR PERMIT REVIEW AND APPROVAL

Local Enforcing Agency Review



Local Utility Approval

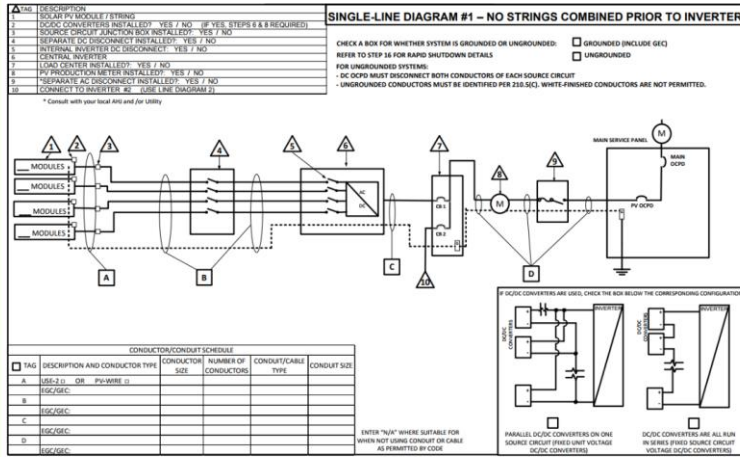


Permit Fee Limits for PV

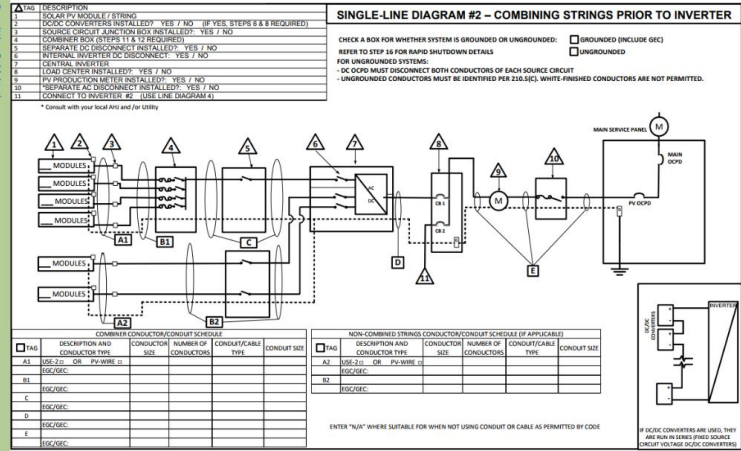
Residential		Commercial	
15 kW or less	\$500	50 kW or less	\$1000
More than 15 kW	\$500 + \$15 per kW above 15	50 kW – 250 kW	\$1000 + \$7 per kW above 50 kW
		More than 250 kW	\$2400 + \$5 per kW above 250 kW

Standard Plans for PV from Guidebook

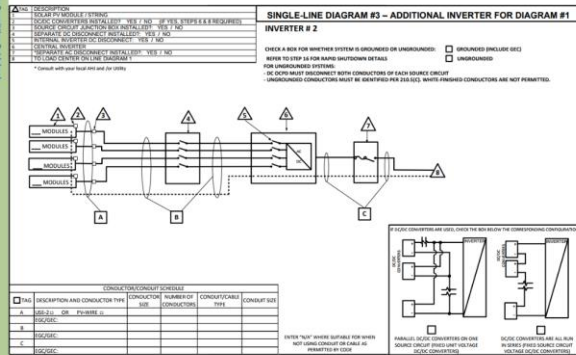
Solar PV Standard Plan — Simplified
Central/String Inverter Systems for One- and Two-Family Dwellings



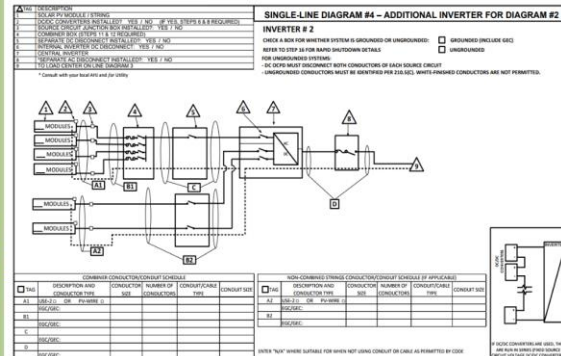
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Solar PV Standard Plan — Simplified
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Solar PV Standard Plan — Simplified
Central/String Inverter Systems for One- and Two-Family Dwellings



System Inspection Guidelines

1 Page Reminder – Most Important Items

6 Page Comprehensive Inspection List

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

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

1. All work done in a neat and workmanlike manner (CEC 110.12).
2. PV module model number, quantity and location according to the approved plan.
3. Array mounting system and structural connections according to the approved plan.
4. Roof penetrations flashed/scaled according to the approved plan.
5. Array exposed conductors are properly secured, supported and routed to prevent physical damage.
6. Conduit installation according to CRC R324 and CEC 690.4.
7. Firefighter access according to approved plan.
8. Roof-mounted PV systems have the required fire classification (CBC 1505.9 or CRC R902.4).
9. Grounding/bonding of rack and modules according to the manufacturer's installation instructions that are approved and listed.
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).
11. For grid-connected systems, inverter is marked "utility interactive."
12. For ungrounded inverters, installation complies with CEC 690.35 requirements.
13. Conductors, cables and conduit types, sizes and markings according to the approved plan.
14. Overcurrent devices are the type and size according to the approved plan.
15. Disconnects according to the approved plan and properly located as required by the CEC.
16. 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).
17. PV system markings, labels and signs according to the approved plan.
18. Connection of the PV system to the grounding electrode system according to the approved plan.
19. 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).

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 & 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. (CFC 605.11.3.1 - 605.11.3.3.3, CRC R331.4.1 through R324)
7. PV installation shall comply with requirements of the standard plan.
8. PV system operating 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

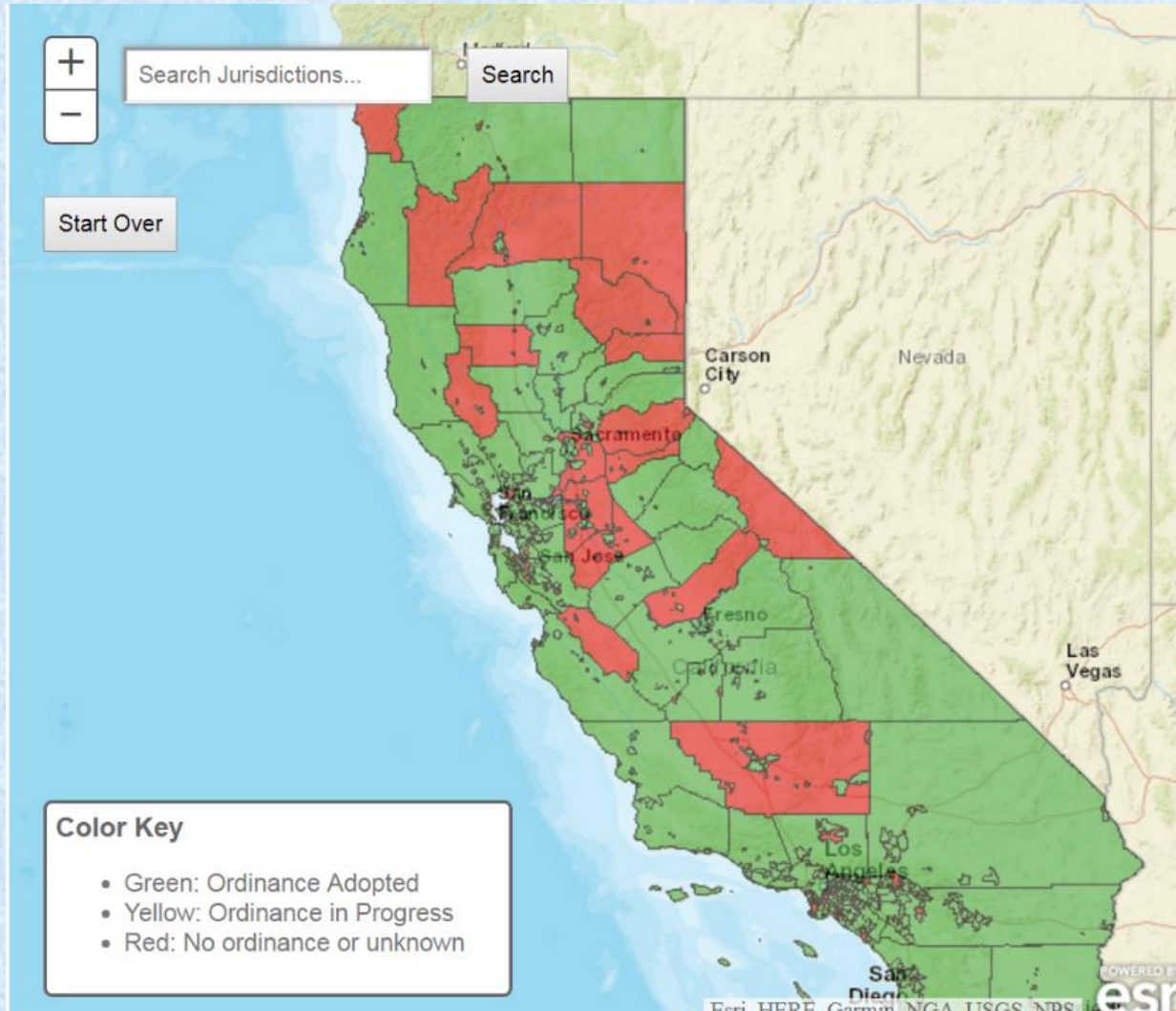
10. DC modules are properly marked and labeled. (CEC 110.3, 690.4[D] & 690.51)
11. AC modules are properly marked and labeled. (CEC 110.3, 690.4[D] & 690.52)
12. PV modules are in good condition (i.e., no broken glass or cells, no discoloration, frames not damaged, etc.). (CEC 110.12[B])
13. Residential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

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 and DC grounding electrode conductors are properly connected as required by code. Separate electrodes, if used, are bonded together. (CEC 690.47, 250.50 & 250.58)



Compliance Map for Adoption of Solar Permitting Guidelines



Ongoing Need for Training to Maintain Quality

➤ Training

- Training before Licensing
- Training before Certification

➤ Certification

- Above and Beyond Licensing

➤ Continuing Education

- Codes change every 3 years or less
- Ongoing Training to Maintain Certification (and in some states licensure)





Thank You!

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