Solar Inspection and Permitting
Brought to you by the Local Government Energy Partnership, SolSmart and The Solar Foundation
March 23, 2021
AGENDA

- Introduction and SolSmart overview
- Why streamline permitting & inspections?
- Permitting Best Practices (structural & electrical)
- Inspection Best Practices (inspection checklist)
- Q+A

Speakers

- David Golembeski, Program and Communications Specialist
- Richard Lawrence, Program Director
Solar Permitting and Inspection Best Practices

March 25, 2021
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With Special Acknowledgement to Bill Brooks, PE
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SolSmart Technical Consultant
Primary author of SolSmart Permitting Guidelines
(and most of the content in this presentation)
Agenda

- Intro & Overview
  - SolSmart Program
  - Why Streamline Solar Permitting & Inspection?
- PV Permitting Guidelines
  - Overview
  - Structural Guidelines
  - Electrical Guidelines
- Automated Permitting with SolarAPP
- Inspection Best Practices
- Questions
Acknowledgment and Disclaimer

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Intro & Overview:
SolSmart Program
What is SolSmart?

SolSmart is a national designation and technical assistance program that helps local governments make it faster, easier, and more affordable for residents and businesses to go solar.

A SolSmart designation:
- Recognizes communities that have taken key steps to address local barriers to solar energy and foster the growth of mature local solar markets.
- Demonstrates that a community is “open for solar business,” making it attractive to solar companies and other business development.

SolSmart provides targeted, no-cost technical assistance to help communities reduce soft costs and earn SolSmart designation.
<table>
<thead>
<tr>
<th>Technical Assistance Program</th>
<th>Designation Program Administrator</th>
</tr>
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<tbody>
<tr>
<td>The SOLAR FOUNDATION™</td>
<td>ICMA</td>
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<tr>
<td>CADMUS</td>
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<tr>
<td>NREL</td>
<td>National Civic League</td>
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<td>RAP</td>
<td>National Renewable Energy Laboratory</td>
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<tr>
<td><a href="http://www.solsmart.org">www.solsmart.org</a></td>
<td>ICMA</td>
</tr>
</tbody>
</table>
SolSmart Designees
SolSmart Actions

Increase transparency
• Post a permitting checklist online
• Develop a solar landing page

Increase understanding
• Provide training on solar PV to staff working in permitting and inspection
• Train planning staff on planning and zoning best practices for solar PV

Reduce barriers
• Decrease permit turnaround time
• Codify that solar PV is a by-right accessory use in the zoning ordinance

Streamline processes
+ Clear solar guidelines

Better submittals to local government departments
+ Solar training for staff

Shorter processing times

Time savings for department staff
+ Budget savings for local governments
SolSmart Criteria for Designation

- 75 unique credits in 5 different categories that promote best practices to help local governments improve their solar markets
- Each credit has a corresponding point value ranging from 5 to 20
- Foundational Categories:
  - Permitting and Inspection
  - Planning and Zoning
- Special Focus Categories:
  - Government Operations
  - Community Engagement
  - Market Development
To receive designation, communities must complete the following:

**Complete 3 prerequisites**
- 20 points in Permitting & Inspection
- 20 points in Planning & Zoning
- 60 total points

**Attain SolSmart Bronze and**
- Complete 3 additional prerequisites
- 100 total points

**Attain SolSmart Silver and**
- Complete 2 additional prerequisites
- 200 total points
SolSmart Technical Assistance

Robust Technical Assistance Team

• Nine organizations with years of experience providing local governments with the solutions and expertise needed to remove barriers to solar deployment and implement best practices including:
  o Engineering
  o Procurement
  o Solar PV system design
  o Feasibility assessments
  o Policy and market expertise

• Dissemination of best practices through 1:1 consulting, issue briefs, webinars, trainings (virtual and in-person)

"The process of going solar can be intimidating for property owners and confusing for permitting staff. SolSmart allowed our City to think through our solar procedures and policies and helped us develop clear guidelines for homeowners and staff that have made everyone's life easier." – Kathryn Eklund, Sustainability Coordinator, Red Lodge, Montana
SolSmart Technical Assistance

- SolSmart technical assistance providers work with elected officials, local government staff, and community members to help communities update processes using established best practices
- The technical assistance is funded by SolSmart, and there is no cost to the community
  - Communities must commit staff time to working toward SolSmart designation
  - Communities must demonstrate a commitment to achieving designation
- Delivery of technical assistance can be tailored to fit the community needs
  - Online – resource library, email, webinars, templates
  - Phone – conference calls
  - In person – site visits, technical workshops

www.solsmart.org
Technical Assistance: Guides, Templates, and Resources

The SolSmart program has an extensive resource library to make the designation process as easy as possible for communities.

- The updated program guide walks through each credit of the SolSmart designation criteria.
- The program guide has links to templates and other resources directly relevant to each credit.
- More in-depth resources can be found on the SolSmart Resources page. Here you’ll find webinars and issue briefs tagged with the specific criteria they address.
- Within the resources are several free training webinars specific to the SolSmart credits.
Intro & Overview:
Why Simplified Permitting?
Photovoltaic Systems

PV Systems require specialized knowledge to properly design, install, and inspect.

• High Voltage DC circuits and need for DC rated equipment
• Several different types of primary configurations and high levels of system variability
• Sizing dependent on high and low temperatures at location
• Special grounding considerations and options
• Systems may be energized even when shut off
• Mechanical/structural concerns not typical of other electrical work
• More rapid technology development and more significant code changes each cycle
• Batteries present another level of complexity and requirements

The more you can educate yourself and receive specialized training the better!
Why Simplify Permitting and Inspections?

**SOLAR INDUSTRY PERSPECTIVE**
- Reduced costs
- Reduced costs
- Reduced costs
- Clarity of requirements and process
- Consistent application of requirements
- Reduced staffing needs
- Less truck rolls
- More reliable scheduling
- Lower engineering costs
- Greater customer satisfaction
- Increased sales & installation volume

**BUILDING OFFICIAL PERSPECTIVE**
- Reduced training needs
- More consistent and complete applications
- Improved staff efficiency
- Focus efforts on more complex systems
- Ability to handle increased volume
- Better health & safety outcomes
- Greater constituent satisfaction
- Increased revenue

And...
- Local economic development
- Progress on clean energy goals
Why Simplify Permitting and Inspections?

Source LBNL
https://emp.lbl.gov/sites/default/files/tracking_the_sun_2018_edition_final_0.pdf

U.S. solar PV installations and forecast, 2010-2030E

Average Residential PV Installation Cost

<table>
<thead>
<tr>
<th>Country</th>
<th>Cost</th>
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<tr>
<td>USA</td>
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<tr>
<td>Australia</td>
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<tr>
<td>UK</td>
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<td>Germany</td>
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<td>Spain</td>
<td>$1.40</td>
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</tr>
<tr>
<td>India</td>
<td>$1.00</td>
</tr>
</tbody>
</table>

Notes: Installed prices for countries other than the United States are primarily from IRENA (2018) and refer to average prices in either Q1 or Q2 2017; the one exception is the value reported for small commercial systems in France, which comes from de L’Epine-Hospes (2018) and is an annual number for all of 2017.

Figure 17. Comparison of Installed Prices in 2017 across Countries (Pre-Sales Tax/VAT)
Several third-party inspection firms that perform inspections for state incentive programs and quality assurance for finance providers have found a significant number of systems fail their comprehensive inspection processes – all had been permitted, passed local AHJ inspection, and been given permission to operate.

**Cadmus Group:**
- 1800+ Systems Inspected
- Major or Critical Issues - 28%
- Minor or Incidental issues – 47%
- Problem Free – 25%
- More than half not grounded properly, more than on fifth had improperly sized or improperly protected conductors, 70% lacked proper labels.

**Institute for Building Technology and Safety (IBTS):**
- 26,000+ Systems Inspected:
  - System Labeling Deficiencies – 20-50%
  - Wire Management Issues – 10-41%
  - Roof Penetrations Problems – 10-22%
  - Improper Grounding – 10-15%
Permitting and Inspection Best Practices
Recommendations:

1. Post requirements online
2. Implement expedited permit process
3. Utilize a single standardized permit application
4. Enable online permit processing
5. Insure quick turnaround times
6. Charge reasonable fees
7. Limit local requirements
8. Require only one inspection
9. Offer a narrow inspection appointment window
10. Provide staff training for solar
Simplified PV Permitting Guidelines:
Overview & Purpose
SolSmart Simplified PV Permit Guidelines

SolSmart.org/permitting

• How to implement a streamlined permitting process for small PV systems
  • Information to collect about system
  • Structural Review Checklist
  • Electrical Review Checklist
  • Standard Electrical Diagrams (fillable templates & examples)

• Detailed commentary documents explaining how simplified process ensures code compliance
  • Structural Commentary (65 pgs.)
  • Electrical Commentary (14 pgs.)
SolSmart Simplified PV Permit Guidelines

• Guidelines are intended to provide a format whereby local jurisdictions can quickly confirm code compliant PV system designs using simple checklists.
• Most residential, and some small commercial, PV systems will meet the criteria to be eligible for simplified review.
• Systems, or the locations and structures on which they are proposed, which do not meet the criteria set forth in the guidelines may still be code compliant but will need additional review and/or engineering to confirm.
• **Guideline is not intended to create, explicitly or implicitly, any new requirements.**
Current Codes and Standards

Guideline is designed to confirm compliance with:

• NEC Article 690, 705, and chapters 1-4
• IRC R331, R902, R905, R908
• IBC 1505, 1509, 1511
• IFC 605.11
• ASCE 7-10, 7-16

Source: International Code Council
Purposes of Simplified Permitting

• A simplified, expedited permit process for small solar PV systems simplifies and consolidates the structural, electrical and fire review of the PV system
• It can eliminate the need for detailed engineering studies and often avoids unnecessary delays
• It is not the intent of an expedited process to circumvent the engineering process
• It is to recognize the similarities among these smaller systems and establish guidelines to determine when a PV project is within the boundaries of typical, well-engineered systems that are clearly compliant with electrical and building codes

Source: NREL
Elements of Simplified Permitting

- Use of a simple eligibility checklist to determine whether projects qualify for expedited permitting and requisite written materials.
- Use of a standard application to collect information about the proposed project.
- Use of a standard plan to describe the proposed solar PV project in the permit application. A standard plan reduces applicant errors and can simplify review.
- A streamlined process for structural and electrical review.
- For eligible projects, plan review and permit issuance are completed “over the counter” for walk-in applications or electronic submittals, or automatically through online software. If over-the-counter approval is not offered, a maximum timeframe of 1-3 days in which to review the permit application is provided.
The “Box” to Qualify Simplified Permit Review

- PV system no larger than 15.36 kW
- Installed on the rooftop of a permitted, one- or two-family dwelling (or structure of similar construction)
- String inverter, DC converter, or Microinverter based system
- Snow load no greater than 60 lb./ft²
- Wind load no greater than 150 mph (member-attached may be up to 180 mph with additional measures)
- Location not in wind category D or on slope greater than 5%
- ...
- And design meets requirements in structural and electrical checklists, including fire code setbacks
Guidelines Cover Most of 48 States and Most PV Systems
Examples of Systems That Don’t Fit The Box

- Systems with Energy Storage
- Building Integrated Arrays
- Ground Mounted Arrays
- Awning, Carport, and Shade Structure Arrays
- Systems requiring Main Panel Upgrades
- Homes with Existing Systems

Source: Tesla
Guidelines Outline

• Structural Checklist
  • General Site, Structure, and Array Requirements
  • Member-Attached Provisions
    • High Wind Requirements (180 MPH)
    • Low Wind/Snow Requirements (120 MPH / 10 psf)
  • Sheathing-Attached Provisions

• Electrical Checklist
  • General Electrical Requirements

• Standard Electrical Diagrams
  • String Inverter or DC Converter
    • Supply side connection or
    • Load side connection
  • Micro Inverter or AC Module
    • Supply side connection or
    • Load side connection

Source: Energy Sage and SolarReviews
Information to Collect

1. **Permit Application**: Permit applications normally include information about the project scope, project location, and the installer. Use of standardized application is recommended when available.

2. **Site Plan**: Drawing(s) showing location of major components on the property. Does not need not be exactly to scale but should represent relative location of components at site (see supplied example site plan). PV arrays in compliance with IRC fire setback requirements need no separate fire service review (with Fire Service MOU).
3. **Electrical Diagram**: showing PV array configuration, wiring system, overcurrent protection, inverter, disconnects, required signs, and ac connection to building (see supplied standard electrical diagram).

4. **Product Specification Sheets and Installation Manuals**: (if available) for all major PV system components such as, PV modules, dc-to-dc converters, inverters, and mounting systems.
Simplified PV Permitting Guidelines:
Structural Requirements
Base Structural Requirements

1. Houses built in compliance with building structural codes and shows no signs of damage, significant deterioration, or alteration
2. Single layer of roofing (no second layer of comp)
3. Sheathing at least 7/16” thick (plywood or OSB)
4. PV modules mounted within 2” and 10” of roof deck
5. PV array distributed weight less than 4 lb./ft²
6. Wood rafter with supports 48” apart or closer
7. Mean Roof Height not greater than 40’ for member-attached and 30’ for sheathing-attached
8. Areas with significant seismic activity (Category C, D, E, or F), PV array covers no more than half of total roof surface

GENERAL STATEMENT:
If any structural item cannot be checked off, the building official may require the installer to provide structural calculations and/or details, stamped and signed by a design professional, addressing the unchecked item.
Member-Attached Array Requirements

- 1. Array is set back from all roof edges and ridge by at least twice the gap under the modules (or more, where fire access pathways are required).
- 2. Array does not cantilever over the perimeter anchors more than 19”.
- 3. Gap under modules (roof surface to underside of module) is no greater than 10”.
- 4. Gaps between modules are (select one below):
  - a. at least 0.25” on both short and long sides of modules, or
  - b. 0” on short side, and at least 0.50” on long sides.
- 5. Mounting rail orientation or rail-less module long edges run perpendicular to rafters or trusses
- 6. The anchor/mount/stand-off spacing perpendicular to rafters or trusses:
  - a. does not exceed 4’-0”, and anchors in adjacent rows are staggered where rafters or trusses are at 24” or less on center
7. Upslope/downslope anchor spacing follows manufacturer’s instructions.

8. Anchor fastener is (select one below):
   - a. 5/16” diameter lag screw with 2.5” embedment into structural member, or
   - b. fastener other than (a.) embedded in structural members in accordance with manufacturer’s structural attachment details. Manufacturer’s anchor layout requirements must not exceed the anchor spacing requirements shown in Items 5 and 6 above.
High Wind Requirements (up to 180 mph)

(High wind option applies to member-attached only)

- 1. Edge of array is more than 3 feet from any roof edge (Wind Zone 1).
- 2. Mean roof height is not greater than 30 ft.
- 3. Array does not cantilever over the perimeter anchors by more than 6”.
- 4. Anchor/mount/stand-off spacing does not exceed 2’-0”
Options for Low Snow and Wind

- 10 PSF
- 0 PSF
- 120 MPH
Low Snow / Wind Requirements

1. Mounting rail orientation or rail-less module long edges run parallel to rafters and are spaced no more than 4’-0” apart,

2. The anchor/mount/stand-off spacing perpendicular to rafters or trusses (select one below):
   - a. does not exceed 4’-0”, and anchors in adjacent rows are staggered where rafters or trusses are at 24” or less on center, or
   - b. does not exceed 4’-0”, anchor layout is orthogonal, roof slope is 6:12 or less, Ground Snow Load is no greater than 10 psf, and Design Wind Speed does not exceed 120 mph, or
   - c. does not exceed 6’-0”, anchor layout is orthogonal, roof slope is 6:12 or less, Ground Snow Load is zero, and Design Wind Speed does not exceed 120 mph.
Sheathing-Attached Array Requirements

1. Array is set back from all roof edges and ridge by at least twice the gap under the modules (or more, where fire access pathways are required).
2. Array does not cantilever over the perimeter anchors more than 19”.
3. Gap under modules (roof surface to underside of module) is no greater than 5”.
4. Gap between modules is at least 0.75” on both short and long sides of modules.
5. Roof slope is 2:12 (9 degrees) or greater.
6. Roof framing and sheathing nailing options (select a or b below):
   a. Initially Dry Wood Rafters, or Manufactured Wood Trusses [lumber grade stamps visible and state “SD”, “S-DRY” (Surfaced Dry) or “KD” (Kiln-Dried)]; or
   b. Initially Wet Wood Rafters (or unmarked), meeting one of the following field-verified sheathing nail options. (select i or ii below)
      i. Deformed shank nails, 6d or greater; or
      ii. 6d or 8d smooth shank common or box nails, nailed into dense lumber, either Douglas Fir (stamp: DF or DF-L) or Southern Pine (stamp: SPIB).
BANDS OF STRENGTH—Middle 16” of Sheet
7. Anchor location restrictions—all anchors must comply with at least one of the options below.

   a. Some anchors are not within bands of strength, and all the following (i., ii. & iii.) apply:
      i. Edge of array is more than 3 feet from any roof edge (Wind Zone 1), and
      ii. Tributary area is 9 ft² or less (up to half the area of a 60 cell PV module), and
      iii. Wind Exposure B only, and design wind speed does not exceed 120 mph.
7. (cont.) Anchor location restrictions—all anchors must comply with at least one of the options below.

☐ b. All anchors are within bands of strength, and all of the following (i., ii. & iii.) apply:

☐ i. Edge of array is more than 3 feet from any roof edge (Wind Zone 1), and

☐ ii. Tributary area is 14 ft² or less (40”x48”).

☐ iii. One of the two wind cases below (x. or y.) applies:

☐ x. Exposure B, and design wind speed does not exceed 140 mph, or

☐ y. Exposure C, and design wind speed does not exceed 120 mph.
8. Anchor-to-sheathing connection has an allowable stress design (ASD) uplift capacity of at least 166 lbs. under short duration loading, which corresponds to a mean ultimate tested uplift capacity of at least 520 lbs.
Simplified PV Permitting Guidelines:
Electrical Requirements
Electrical PV System Requirements

- 1. Major electrical components including PV modules, dc-to-dc converters, and inverters, are identified for use in PV systems.
- 2. Array mounting system is UL2703 certified for bonding and grounding. Alternatively, the array mounting system may incorporate UL2703 grounding devices to bond separate exposed metal parts together or to the equipment grounding conductor.
- 3. The PV array consists of no more than 2 series strings per inverter input and no more than 4 series strings in total per inverter.
4. Field Installed PV array wiring meets the following requirements:
   a. All exposed PV source circuit wiring is 10 AWG PV Wire.
   b. All PV source circuit wiring in raceway is 10 AWG THWN-2, XHHW-2, or RHW-2.
   c. Any field-installed PV output circuit wiring is 6 AWG THWN-2, XHHW-2, or RHW-2.
   d. PV system circuits on buildings meet requirements for controlled conductors in 690.12.

5. The total inverter capacity has a continuous ac power output 15,360 Watts or less and meets the requirements of 705.12(D) when installed on the load side of the service disconnecting means (complies with Table 705.12(D) in Technical Appendix). (choose one below)
   - Load-side connection complying with Table 705.12(D)
   - Supply-side connection complying with 705.12(A)
6. Equipment is rated for the maximum dc voltage applied to the equipment (put N/A in all blanks that do not apply to the specific installation):

A. ASHRAE Extreme Annual Mean Minimum Design Dry Bulb Temperature (one source is www.solarabcs.org/permitting) =________; Table 690.7 (NEC) value____________

B. Max (temp adjusted) module Voc:
   Rated Voc ______V x Table 690.7 value______ = ________V

C. Dc-to-dc converter(s) or microinverter rated maximum input voltage: ________V
   (must be greater than Max module Voc in (B.))

D. Maximum number of dc-to-dc converters allowed in series (up to 600Vdc):___________

E. Maximum voltage of dc-to-dc converter circuit with maximum number in (C.):_______V

F. Inverter(s) rated maximum input voltage:__________V (must be greater than 1-4 below)
   1) Inverter 1 input 1: Max module Voc (B.)___________V x # in series______ = ________V
   2) Inverter 1 input 2: Max module Voc (B.)___________V x # in series______ = ________V
   3) Inverter 2 input 1: Max module Voc (B.)___________V x # in series______ = ________V
   4) Inverter 2 input 2: Max module Voc (B.)___________V x # in series______ = ________V
7. One of the standard electrical diagrams can be used to accurately represent the PV system.

*Fill out the appropriate standard electrical diagram completely. If the electrical system is more complex than the standard electrical diagram can effectively communicate, the project does not meet the requirements for a simplified permit application and additional information may be necessary for the jurisdiction to process the permit application.*
Example Central/String Inverter Standard Plans

• Use this plan ONLY for central/string inverter systems with or without DC converters not exceeding 15.36kW.
• The photovoltaic system must interconnect to the load side of a 120/240Vac service panel rated 400A or less (80-amp PV breaker or less).
• Not intended for more than two inverters, or more than one DC combiner per inverter (non-inverter-integrated).
Contractor Name, Address and Phone:
Bill and Ted's Solar
456 Excellent Drive
San Dimas, CA
800-555-1212
One-Line Standard Electrical Diagram for Small-Scale, Single-Phase PV Systems
Site Name: John and Jane Homeowner
Site Address: 12 Sunnyside St, Philadelphia, PA
System AC Size: 7.5 KW

One-Line Standard Electrical Diagram for Small-Scale, Single-Phase PV Systems
Site Name: John and Jane Homeowner
Site Address: 12 Sunnyside St, Philadelphia, PA
System AC Size: 7.5 KW
PV MODULE RATINGS @ STC (Guide Section 7)

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<tr>
<td>MAX POWER-POINT CURRENT (I_{pp})</td>
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</tr>
<tr>
<td>MAX POWER-POINT VOLTAGE (V_{mp})</td>
<td>31.3 V</td>
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<tr>
<td>OPEN-CIRCUIT VOLTAGE (V_{oc})</td>
<td>39.7 V</td>
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<tr>
<td>SHORT-CIRCUIT CURRENT (I_{sc})</td>
<td>9.84 A</td>
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<tr>
<td>MAX SERIES FUSE (OCPD)</td>
<td>20 A</td>
</tr>
<tr>
<td>MAXIMUM POWER (P_{max})</td>
<td>285 W</td>
</tr>
<tr>
<td>MAX VOLTAGE (TYP 1000V_{dc})</td>
<td>1000 V</td>
</tr>
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NOTES FOR ALL DRAWINGS:

- OCPD = OVERCURRENT PROTECTION DEVICE
- NATIONAL ELECTRICAL CODE® REFERENCES SHOWN AS (NEC XXX.XX)

DC-TO-DC CONVERTER RATINGS (if used)

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<tr>
<td>MAX VOLTAGE</td>
<td>V</td>
</tr>
<tr>
<td>MAXIMUM POWER</td>
<td>W</td>
</tr>
<tr>
<td>MAX OUTPUT CIRCUIT V (TYP 600V_{dc})</td>
<td>V</td>
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INVERTER RATINGS (Guide Section 4)

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<thead>
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<th>AMERICAN INVERTER</th>
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<tbody>
<tr>
<td>INVERTER MODEL</td>
<td>AI-7500</td>
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<tr>
<td>MAX DC VOLT RATING</td>
<td>600 V</td>
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<tr>
<td>MAX POWER @ 40°C</td>
<td>7500 W</td>
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<tr>
<td>NOMINAL AC VOLTAGE</td>
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<td>MAX AC CURRENT</td>
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<tr>
<td>MAX OCPD RATING</td>
<td>40 A</td>
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NOTE FOR ARRAY CIRCUIT WIRING

GUIDE SECTION 4 AND APPENDIX B)

LOWEST EXPECTED AMBIENT TEMPERATURE BASED ON ASHRAE MINIMUM MEAN EXTREME DRY BULB TEMPERATURE FOR ASHRAE LOCATION MOST SIMILAR TO INSTALLATION LOCATION. LOWEST EXPECTED AMBIENT TEMP: ___ -12 °C

NOTES FOR INVERTER CIRCUITS (Section 4)

1) IF UTILITY REQUIRES A VISIBLE BREAK SWITCH, DOES THIS SWITCH MEET THE REQUIREMENT? YES ☐ NO ☐ N/A ☐

2) IF GENERATION METER REQUIRED, DOES THIS METER SOCKET MEET THE REQUIREMENT? YES ☐ NO ☐ N/A ☐

3) SIZE INVERTER OUTPUT CIRCUIT (AC) CONDUCTORS ACCORDING TO INVERTER OCPD AMPERE RATING. (See Table xxx)

4) TOTAL OF ___ INVERTER OCPD(s), ONE FOR EACH INVERTER, DOES TOTAL SUPPLY BREAKERS COMPLY WITH 120% BUSBAR RULE IN 705.12(D)? YES ☐ NO ☐

*NOTE: MICROINVERTER AND AC MODULE SYSTEMS DO NOT NEED DC DISCONNECT SIGN SINCE 690.51 MARKING ON PV MODULE COVERS NEEDED INFORMATION.

NOTES FOR ONE-LINE STANDARD ELECTRICAL DIAGRAM FOR SINGLE-PHASE PV SYSTEMS

<table>
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<th>Contractor Name, Address and Phone:</th>
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</tbody>
</table>

| Site Name: | | Site Address: | | System AC Size: |
|------------|-----------------|-----------------|-----------------|
| ___________ | _______________ | _______________ | _______________ |

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<thead>
<tr>
<th>Drawn By:</th>
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<tr>
<th>Checked By:</th>
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</table>
Example Sheathing Attached System Site Plan

Structural Notes:
1. Roof pitch: 4:12
2. Roof covering: Single overlay asphalt shingles
3. Black dots represent anchor points
4. Mean roof height less than 30'
5. Roof structure: Truss on 24" centers
6. Roof deck: 7/16" OSB
7. Maximum anchor point distance: 48"m
8. Dwelling in wind exposure B
9. PV modules mounted 2" above roof covering
10. PV modules certified type 1 for fire purposes
11. Omirack mod 5.0 listed class A with type 1 modules

Diagram details:
- Inverter with supplied combiner and DC disconnect
- Existing all-in-one service equipment with 40-amp PV breaker as AC disconnect
- Rooftop J-box under movable PV module to transition exposed PV wire to THWN-2 conductors in ¾" EMT
- Inverter with supplied combiner and DC disconnect
- Existing all-in-one service equipment with 40-amp PV breaker as AC disconnect
- Roof access

Dimensions:
- Roof access: 51'-3"
- 3'-0"
- 3'-0"
Example Microinverter Standard Plans

• Use this plan ONLY for systems using microinverters or AC modules (ACM) not exceeding 15.36 kW, with no more than 4 output circuits, one PV module per microinverter
• The PV system must interconnect to the load side of a 120/240Vac, service panel rated 400A or less (80-amp breaker or less).
Contractor Name, Address and Phone:
_________________
_________________
_________________
_________________

Notes for One-Line Standard Electrical Diagram for Single-Phase PV Systems

<table>
<thead>
<tr>
<th>PV MODULE RATINGS @ STC (Guide Section 7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODULE MAKE</td>
</tr>
<tr>
<td>MODULE MODEL</td>
</tr>
<tr>
<td>MAX POWER-POINT CURRENT ($I_{pp}$)</td>
</tr>
<tr>
<td>MAX POWER-POINT VOLTAGE ($V_{pp}$)</td>
</tr>
<tr>
<td>OPEN-CIRCUIT VOLTAGE ($V_{oc}$)</td>
</tr>
<tr>
<td>SHORT-CIRCUIT CURRENT ($I_{sc}$)</td>
</tr>
<tr>
<td>MAX SERIES FUSE (OCPD)</td>
</tr>
<tr>
<td>MAXIMUM POWER ($P_{max}$)</td>
</tr>
<tr>
<td>MAX VOLTAGE (TYP 1000V$_{oc}$)</td>
</tr>
</tbody>
</table>

| MODULE MAKE | AMERICAN INVERTER                  |
| MODULE MODEL | AI-250                          |
| MAX DC VOLT RATING | 60 V                             |
| MAX POWER @ 40°C | 250 W                           |
| NOMINAL AC VOLTAGE | 240 V                          |
| MAX AC CURRENT | 1.04 A                          |
| MAX OCPD RATING | 20 A                            |

LOWEST EXPECTED AMBIENT TEMPERATURE BASED ON ASHRAE MINIMUM MEAN EXTREME DRY BULB TEMPERATURE FOR ASHRAE LOCATION MOST SIMILAR TO INSTALLATION LOCATION, LOWEST EXPECTED AMBIENT TEMP ___°C

1) IF UTILITY REQUIRES A VISIBLE-BREAK SWITCH, DOES THIS SWITCH MEET THE REQUIREMENT? YES ☐ NO ☐ N/A ☐
2) IF GENERATION METER REQUIRED, DOES THIS METER SOCKET MEET THE REQUIREMENT? YES ☐ NO ☐ N/A ☐
3) SIZE INVERTER OUTPUT CIRCUIT (AC) CONDUCTORS ACCORDING TO INVERTER OCPD AMPERE RATING. (See Table xxx)
4) TOTAL OF ___1___ INVERTER OCPD(s), ONE FOR EACH INVERTER, DOES TOTAL SUPPLY BREAKERS COMPLY WITH 120% BUSBAR RULE IN 705.12(D)? YES ☐ NO ☐

*NOTE: MICROINVERTER AND AC MODULE SYSTEMS DO NOT NEED DC DISCONNECT SIGN SINCE 690.51 MARKING ON PV MODULE COVERS NEEDED INFORMATION

Notes for Electrical Diagram:

- OCPD – OVERCURRENT PROTECTION DEVICE
- NATIONAL ELECTRICAL CODE® REFERENCES SHOWN AS (NEC XXX.XX)
- DC-TO-DC CONVERTER RATINGS (if used)
- INVERTER RATINGS (Guide Section 4)
- NOTES FOR ALL DRAWINGS:
- SIGNS—SEE GUIDE SECTION 7

*SIGN FOR DC DISCONNECT

- NATIONAL ELECTRICAL CODE® REFERENCES SHOWN AS (NEC XXX.XX)
- WARNING: ELECTRICAL SHOCK HAZARD—LINE AND LOAD MAY BE ENERGIZED IN OPEN POSITION

*SIGN FOR DISTRIBUTION PANELS

- SIGN FOR NEC 705.12(D)(2)(3)(b) (if used)

*SIGN FOR NECE 690.12 (for roof-mounted systems)

- WARNING: INVERTER OUTPUT CONNECTION; DO NOT RELOCATE THIS OVERCURRENT DEVICE.

PHOTOVOLTAIC SYSTEM EQUIPPED WITH RAPID SHUTDOWN

Drawn By: __________________________
Checked By: ________________________
Date: ______/____/____
Example Member-Attached System Site Plan

**Structural Notes:**
1. Roof pitch: 4:12
2. Roof covering: Single layer asphalt shingles
3. Black dots represent anchor points
4. Mean roof height less than 30'
5. Roof structure: 2x6 rafters on 24" centers with midspan support—max span 11'6".
6. Roof deck: 7/16" OSB
7. Maximum anchor point horizontal distance: 72'
8. Dwelling in wind exposure B
9. Anchors are 5/16" lag screws with 2.5 embedment in structure
10. Each anchor flashed with "anchor-flash" aluminum flashing
11. All module rails run perpendicular to rafters
12. PV modules mounted 5" above roof covering
13. PV modules certified type 1 for fire purposes
14. Omirack Mod 3.0 Listed Class A with Type 1 modules

- Attached System Site Plan
- 125-AMP AC subpanel with two, 20-AMP PV breakers
- Existing all-in-one service equipment with 40-AMP PV breaker as AC disconnect
- Rooftop J-box under movable PV module to transition exposed PV wire to THWN-2 conductors in ¾" EMT (typical 3 places)
- 30 American Solar AS 285 modules each connected to an American inverter AS-250 microinverter in two circuits of 15 microinverters each on existing roof structure
Automated PV Permitting With SolarAPP
Solar Automated Permit Processing (SolarAPP)

- A flexible, web-based PV-permitting tool for residential systems
- No-cost, contactless solution for AHJs
- Evaluates applications for safety and code compliance
  - Enables standardization of permitting processes
  - Ensures only complete, compliant applications are submitted
- Delivers automated, instant plan review and permit approval
- Provides a clear inspection checklist to streamline inspection processes
- Integrates with existing software platform(s)
- Incorporates energy storage and expand to other market segments
Solar Automated Permit Processing (SolarAPP)

- Website: https://solarapp.nrel.gov/
- Kickoff webinar: https://www.youtube.com/watch?v=pllKb165xYI
- Demonstration webinar: https://www.youtube.com/watch?v=wMDZYo7wf4I&t=1869s

For more information contact: solarapp@nrel.gov

To sign-up for piloting: https://www.surveymonkey.com/r/SolarAPPInterest
PV System Inspection Best Practices
Inspector’s role is to confirm system was built according to approved plans, that it meets minimum codes and standards, and complies with existing laws and regulations.

- NEC Article 690, 705, and chapters 1-4
- IRC R331, R902, R905, R908
- IBC 1505, 1509, 1511
- IFC 605.11
- ASCE 7-10, 7-16
- Local planning and zoning regulations
- And coming soon, NFPA 855 (Energy Storage)

Source: International Code Council
Documents Needed for Inspection

Required Information for Inspection:
1. Inspection Checklist – helps guide inspection and document findings.
2. Site Plan - shows location of major components on the property.
3. Electrical Diagram – shows electrical system configuration and equipment specifications.
4. Specification Sheets and Installation Manuals – may be needed to ensure system components were installed according to manufacturer instructions.
PV Field Inspection Checklist Template for the Region

Aligns with National Best Practices

Available on:

- MORPC’s Central Ohio Solar Energy Toolkit for Local Governments under Codes, Inspections and Permitting
- SolSmart.org
Example Site Plan

1. ROOF PITCH 4:12
2. ROOF COVERING: SINGLE LAYER ASPHALT SHINGLES
3. BLACK DOTS REPRESENT ANCHOR POINTS
4. MEAN ROOF HEIGHT LESS THAN 30’
5. ROOF STRUCTURE: 2X6 RAFTERS ON 24” CENTERS WITH MIDSPAN SUPPORT—MAX SPAN 11’6”.
6. ROOF DECK 7/16” OSB
7. MAXIMUM ANCHOR POINT HORIZONTAL DISTANCE: 72”
8. DWELLING IN WIND EXPOSURE B
9. ANCHORS ARE 5/16” LAG SCREWS WITH 2.5 EMBEDMENT IN STRUCTURE
10. EACH ANCHOR FLASHED WITH “ANCHOR-FLASH” ALUMINUM FLASHING
11. ALL MODULE RAILS RUN PERPENDICULAR TO RAFTERS
12. PV MODULES MOUNTED 5” ABOVE ROOF COVERING
13. PV MODULES CERTIFIED TYPE 1 FOR FIRE PURPOSES
14. OMNIRACK MOD 3.0 LISTED CLASS A WITH TYPE 1 MODULES

Image: Brooks Engineering
Example Electrical Diagram String Inverter

Contractor Name, Address and Phone:
Bill and Ted’s Solar
456 Excellent Drive
San Dimas, CA
800-555-1212

One-Line Standard Electrical Diagram for Small-Scale, Single-Phase PV Systems

Site Name: John & Jane Homeowner
Site Address: 12 Sunnyside St, Philadelphia, PA
System AC Size: 7.5 kW

---

Image: Brooks Engineering
Example Electrical Diagram – Module-Level Power Electronics
I.E. “MicroInverters”

Module Date DWG NO REV FSCM NO

0 5 3 2 1

TAG 8 6 5 4 3 2 1

GEC EGC X ALL THAT APPLY

THWN NO DC USE XHHW USE

DESCRIPTION OR CONDUCTOR TYPE

SERVICE PANEL 14/3/W 4-CORE 100A AMERICAN WIRE 

SERVICE DISCONNECT 14/3/W 4-CORE 100A AMERICAN WIRE 

BUILDING GROUNDING ELECTRODE

AC DISCONNECT

DC INVERTER

AC INVERTER

MICRO INVERTERS IN BRANCH CIRCUIT

FOR UNUSED MODULES PUT “X” IN BLANK ABOVE

CONDUIT AND CONDUCTOR SCHEDULE

TYPE DESCRIPTION PART NUMBER NOTES

1 PV DC or AC MODULE AS 285 AMERICAN SOLAR QUANTITY - 30 (SEE NOTES SHEET FOR DETAILS)

2 AC/DC INVERTER (SINGLE PHASE) AS 350 255 WATT SINGLE PHASE (SEE NOTES SHEET FOR DETAILS)

3 2-WAY (IF USED) 6"x4"x6 1/2-IP PVC JUNCTION BOX

4 PV ARRAY NA 2,200 A DC CIRCUITS WITH 15 MICRO-INV PER CIRCUIT

5 AC COMB. PANEL (IF USED) 125-A MAIN LOG PANEL W/ 450-A BREAKER AS MAIN

6 GEN METER (IF USED) FORM 2S 4-JAW 240V CYCLOMETER REGISTER WATT METER IN 150-A BASE

7 AC DISCONNECT (IF USED) 150-A 200A AMP-UNIPOL$(SEE GUIDE APPENDIX D)

8 SERVICE PANEL 2/0/0/0 240VAC 200-A MAIN, 300-A USE, 30-MASTER DC ORP (SEE NOTE 5 FOR INVERTER DC ORP, ALSO SEE GUIDE SECTION 5)

CHECKED BY Drawn By

CONTRACTOR NAME, ADDRESS AND PHONE:
Bill and Ted’s Solar
456 Excellent Drive
San Dimas, CA 91773

CONTRACTOR NAME:
John and Jane Homeowner
Site Address: 123 Sunnyside St., Boston, MA
System AC Size: 4.0 KW

ONE-LINE STANDARD ELECTRICAL DIAGRAM FOR MICRO-INVERTER OR AC MODULE PV SYSTEMS

SECTION: 1A

BILL AND TED’S SOLAR

456 EXCELLENT DRIVE

SAN DIMAS, CA 91773

CONTRACTOR NAME:
John and Jane Homeowner
SYSTEM AC SIZE: 4.0 KW

SITE ADDRESS: 123 SUNNYSIDE ST., BOSTON, MA

SOLSMART NATIONAL DRIVING LICENSE FOR MICRO-INVERTER OR AC MODULE PV SYSTEMS

BILL AND TED’S SOLAR

456 EXCELLENT DRIVE

SAN DIMAS, CA 91773

CONTRACTOR NAME:
John and Jane Homeowner
SYSTEM AC SIZE: 4.0 KW

SITE ADDRESS: 123 SUNNYSIDE ST., BOSTON, MA
General Guidelines

- Ideally start with system operating and confirm inverter is not reading any arc faults. Then have installer power down system, open all disconnects, and open equipment for inspection.
- Start inspection at the solar array and follow electrical path to the grid connection point.
- If roof access is not possible, try other methods: view from ladder, use camera mounted on “selfie stick”, require installer to submit detailed photos.
- Look for most common - and most serious - code violations.
- If time is limited focus on: Inverter, Array, Grid Connection Point, and Junction Boxes.
- Quality of workmanship is generally a good indication of code compliance.
1. All Work done in a neat and workmanlike manner? (NEC 110.12)
1. All Work done in a neat and workmanlike manner? (NEC 110.12)
2. PV module model number, quantity, and location(s) match plans
3. Array mounting system and structural connections according to plan

Photo: Pete Jackson

Photos: Cadmus Group
4. Roof penetrations flashed/sealed?
5. Array exposed cables are properly secured, supported, and routed to prevent physical damage

Photos: Cadmus Group
6. Conduit correctly installed and according to CRC R331.3 and NEC 690.4(F)
6. Conduit correctly installed and according to CRC R331.3 and NEC 690.4(F)

Photos: Brooks Engineering
7. Firefighter access setbacks to approved plan

Images: Cal Fire
8. Roof-mounted PV systems have the required fire classification
9. Grounding/bonding of rack and modules according to the manufacturer’s installation instructions

Photos: IBTS
10. Equipment listed and installed according to the approved plan
11. Inverter marked as “utility interactive”
12. Conductors, cables, and conduit types, sizes, and markings according to the approved plan

USE-2 & PV Wire outside, exposed to UV – OK!

THWN & SJO/SJOW Cord – NO!

Photos: Brooks Engineering
13. Overcurrent protection devices are the type and size according to the approved plan

Sum of the main circuit breaker and 125% of inverter output cannot exceed 120% of bus rating
13. Overcurrent protection devices are the type and size according to the approved plan.

600 V AC & DC – OK!

600 V AC; 300 V DC – have to read the fine print!
14. Disconnects installed according to the approved plan and properly located as required by NEC

AC & DC Discos on either side of inverter – OK!

DC Disco is next to inverter, but AC Disco is outside – NO!

Photos: Brooks Engineering
15. Inverter output circuit breaker is located at opposite end of bus from utility supply
16. PV System markings, labels, and signs installed according to approved plan
17. Connection of the PV system to the grounding electrode system according to approved plan
18. Access and working space for operation and maintenance of PV equipment is sufficient

Photos: Brooks Engineering
19. The rapid shutdown system is installed according to the approved plan [690.12]
Resources

Inspection Checklists:
IBTS: www.ibts.org/resources guides/solar-pv-inspections-checklist/

Labeling Guides:
www.hellermanntyton.us/industries/energy-solar/nec-690-pv-labeling-requirements
www.ibts.org/resources/guides/solar-labeling-requirements/

Books:
Photovoltaic Power Systems for Inspectors & Plan Reviewers, John Wiles
Photovoltaic Systems, James Dunlop
Understanding NEC Requirements for Solar Photovoltaic Systems, Mike Holt
PV Installation Professional Resource Guide, NABCEP (free)

Articles and other Resources:
IAEI Magazine articles by John Wiles: https://iaeimagazine.org/magazine/author/jwiles/
Solar America Board for Codes and Standards (ABCs) http://www.solarabcs.org/

And of course: SolSmart! - https://www.solsmart.org/resources/
Questions? We’re here to help!

As the Technical Assistance Provider for the SolSmart Program, The Solar Foundation can provide technical assistance free of charge to communities applying for SolSmart designation.

• TSF’ Experienced Staff
• Our Dedicated Advisors
• SME Consultants, such as Brooks Engineering & Cadmus.

CONTACT INFO:
Richard Lawrence
Program Director
The Solar Foundation
rlawrence@solarfound.org
(202) 469-3750
MORPC ENERGY PLANNING RESOURCES

- MORPC Energy Planning Services and Roadmap
- Local Government Energy Partnership
- Central Ohio Solar Toolkit for Local Governments

MORE INFORMATION:
https://www.morpc.org/program-service/energy-planning/
Email: jpdaversa@morpc.org