Solar Inspection and Permitting

Brought to you by the Local Government Energy Partnership, SolSmart and The Solar Foundation

March 23, 2021

AGENDA

MORPC

- 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

SOLSMART
NATIONALLY DISTINGUISHED. LOCALLY POWERED.

The SOLAR FOUNDATION™
for a bright future

Solar Permitting and Inspection Best Practices

March 25, 2021

Mid-Ohio Regional Planning Commission

The SOLAR FOUNDATION™ for a bright future

ICMA

Richard Lawrence

Program Director
The Solar Foundation
rlawrence@solarfound.org
(202) 469-3750

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

BROOKS ENGINEERING

The SOLAR FOUNDATION™ for a bright future

ICMA

www.solsmart.org

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

Acknowledgment: This material is based upon work supported by the Department of Energy, Office of Energy Efficiency and Renewable Energy (EERE), under Award Number DE-EE0007155.

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.

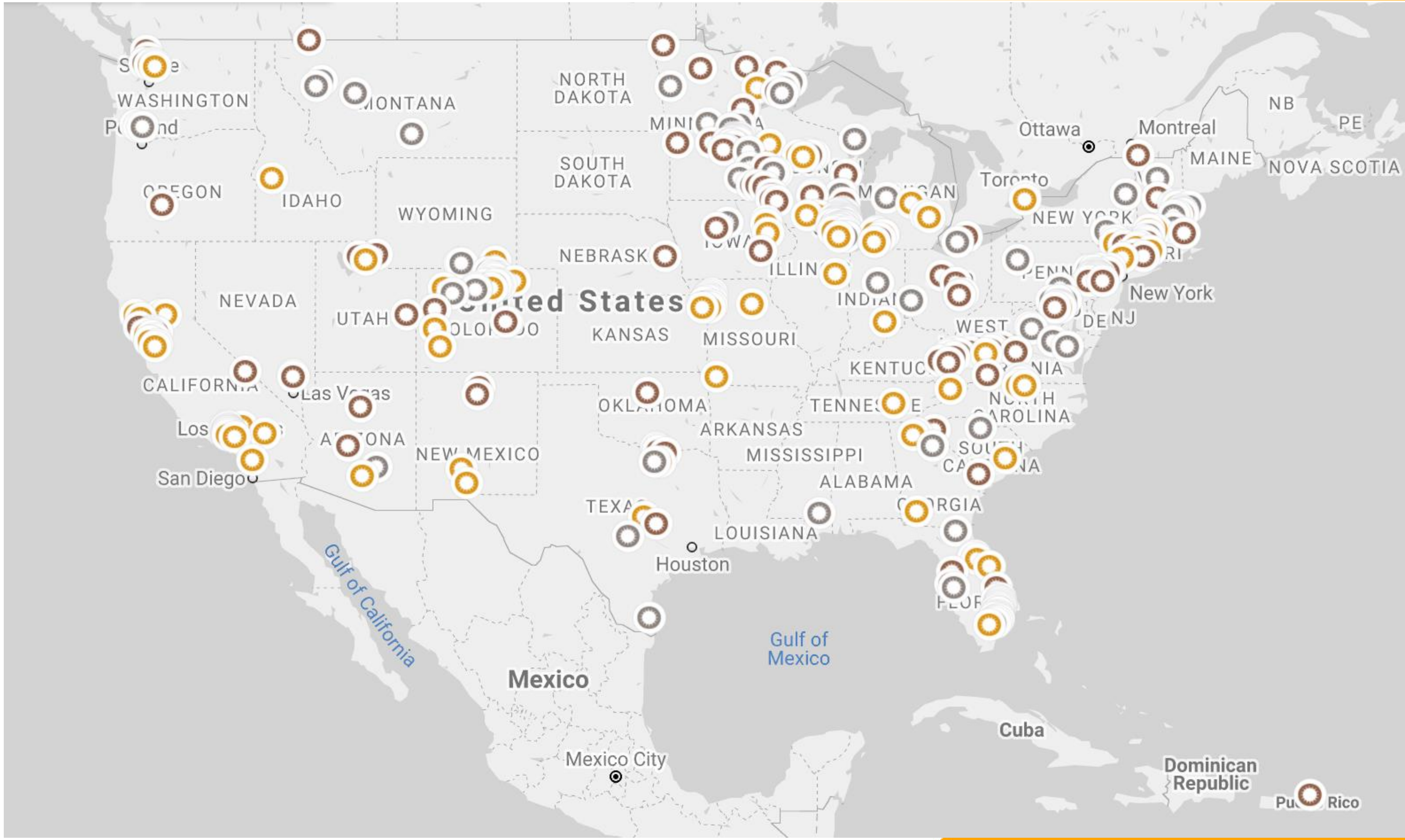
SolSmart provides **targeted, no-cost technical assistance** to help communities reduce soft costs and earn SolSmart designation.

Program Design and Execution

Technical Assistance Program	Designation Program Administrator
The Solar Foundation	ICMA
Cadmus	National Civic League
NLC National League of Cities	The Solar Foundation
NREL National Renewable Energy Laboratory	Home Innovation Research Labs
RAP	Cadmus
Brooks Engineering	
EPRI Electric Power Research Institute	
SEIA Solar Energy Industries Association	
Great Plains Institute	
NACo National Association of Counties	

SolSmart Designees

SOLSMART
NATIONALLY DISTINGUISHED. LOCALLY POWERED.



ICMA
Leaders at the Core of Better Communities

www.solsmart.org

SolSmart Actions

SOLSMART
NATIONALLY DISTINGUISHED. LOCALLY POWERED.

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

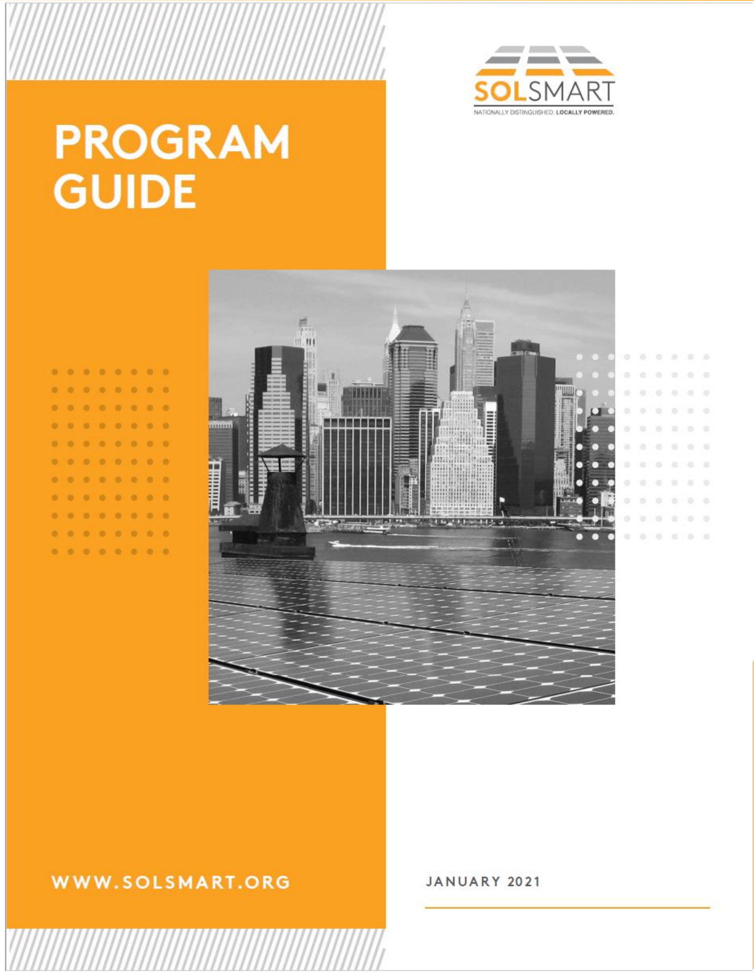
Reduce barriers

- 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



Designation Structure

To receive designation, communities must complete the following:

Bronze

Complete 3 prerequisites

20 points in Permitting & Inspection

20 points in Planning & Zoning

60 total points

Silver

Attain SolSmart Bronze and

Complete 3 additional prerequisites

100 total points

Gold

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:
  - Engineering
  - Procurement
  - Solar PV system design
  - Feasibility assessments
  - 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
NATIONALLY DISTINGUISHED. LOCALLY POWERED.

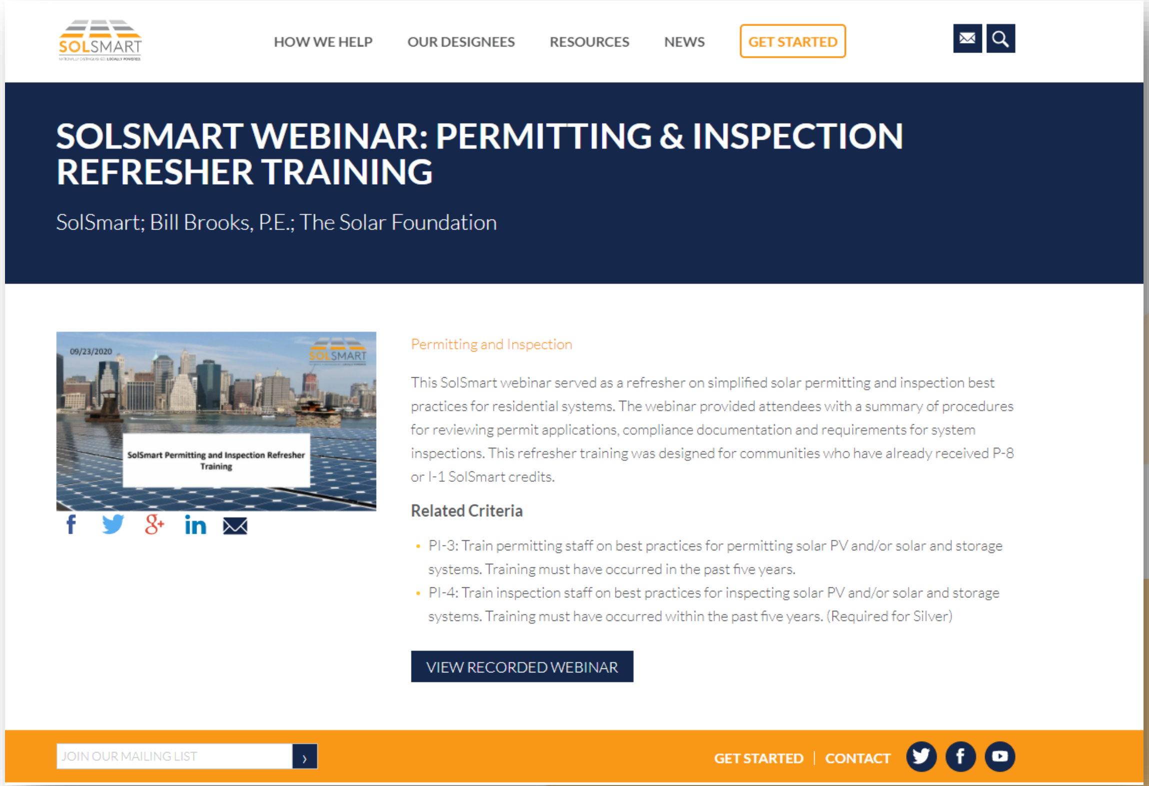
- SolSmart technical assistance providers work with elected officials, local government staff, and community members to help communities update processes using established best practices
- The technical assistance is funded by SolSmart, and there is no cost to the community
  - Communities must commit 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

Technical Assistance: Guides, Templates, and Resources

SOLSMART
NATIONALLY DISTINGUISHED. LOCALLY POWERED.

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.



The SOLAR FOUNDATION for a bright future

ICMA Leaders at the Core of Better Communities

www.solsmart.org

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!

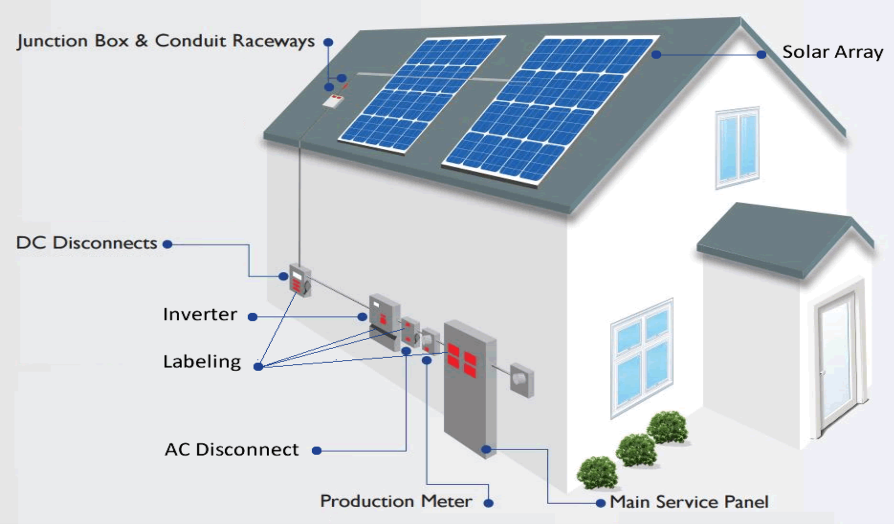


Image: IBTS

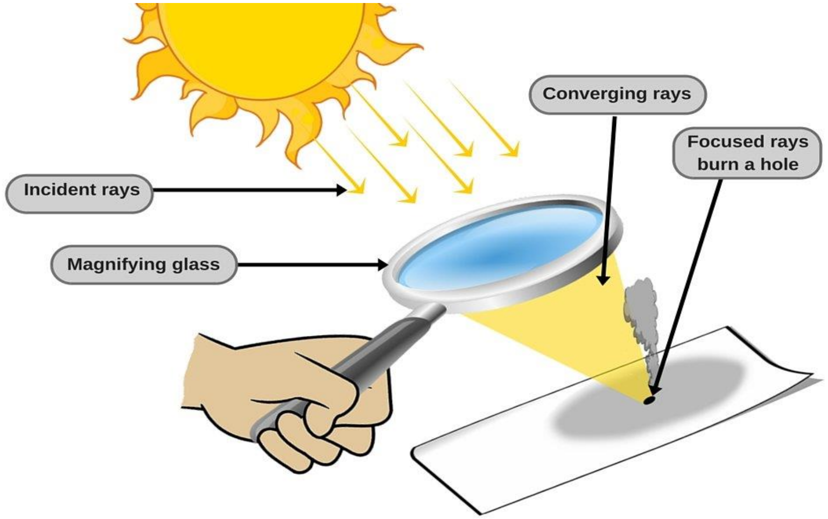


Image: scienceabc.com

Why Simplify Permitting and Inspections?

SOLSMART
NATIONALLY DISTINGUISHED. LOCALLY POWERED.

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…

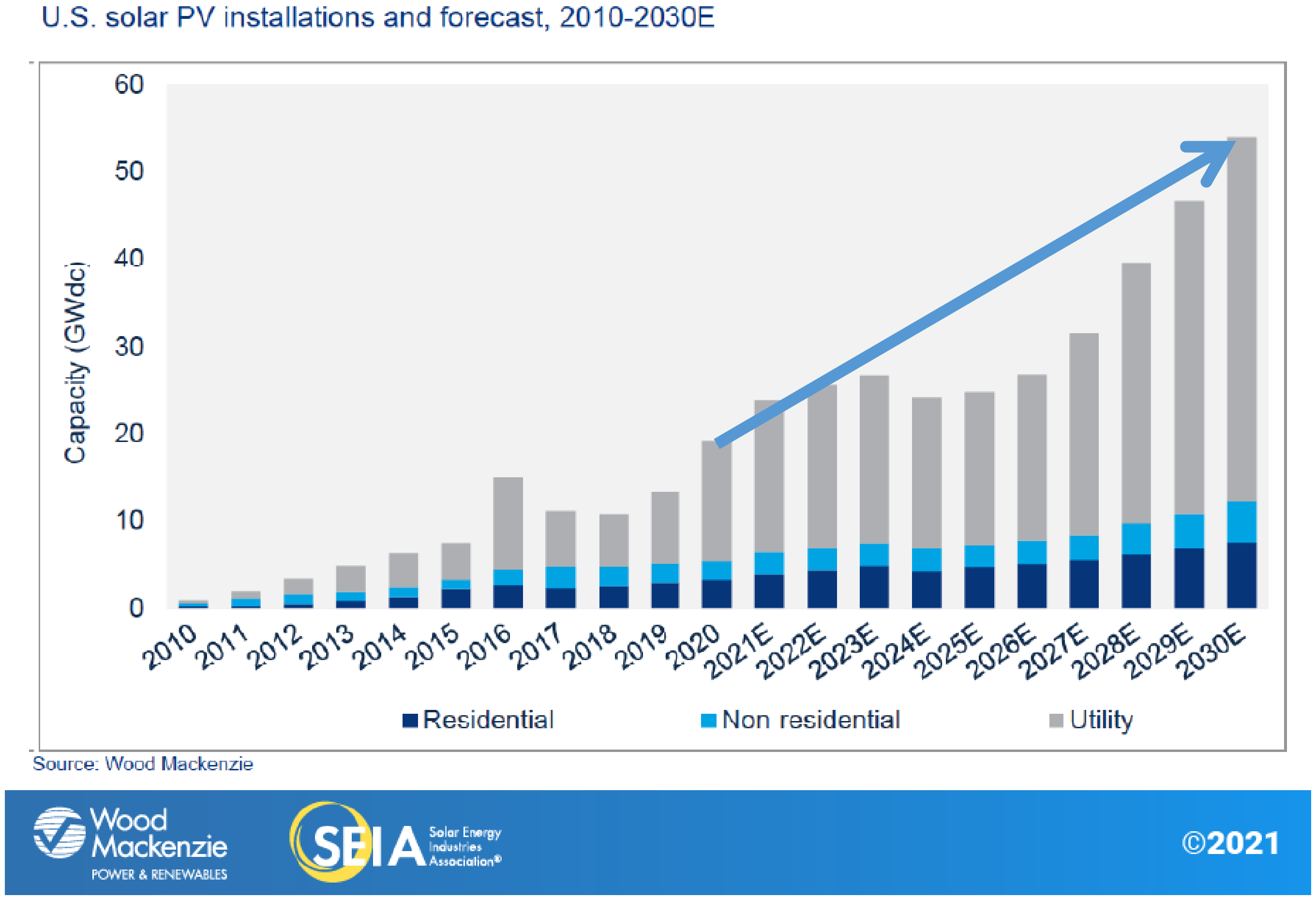
Local economic development

Progress on clean energy goals

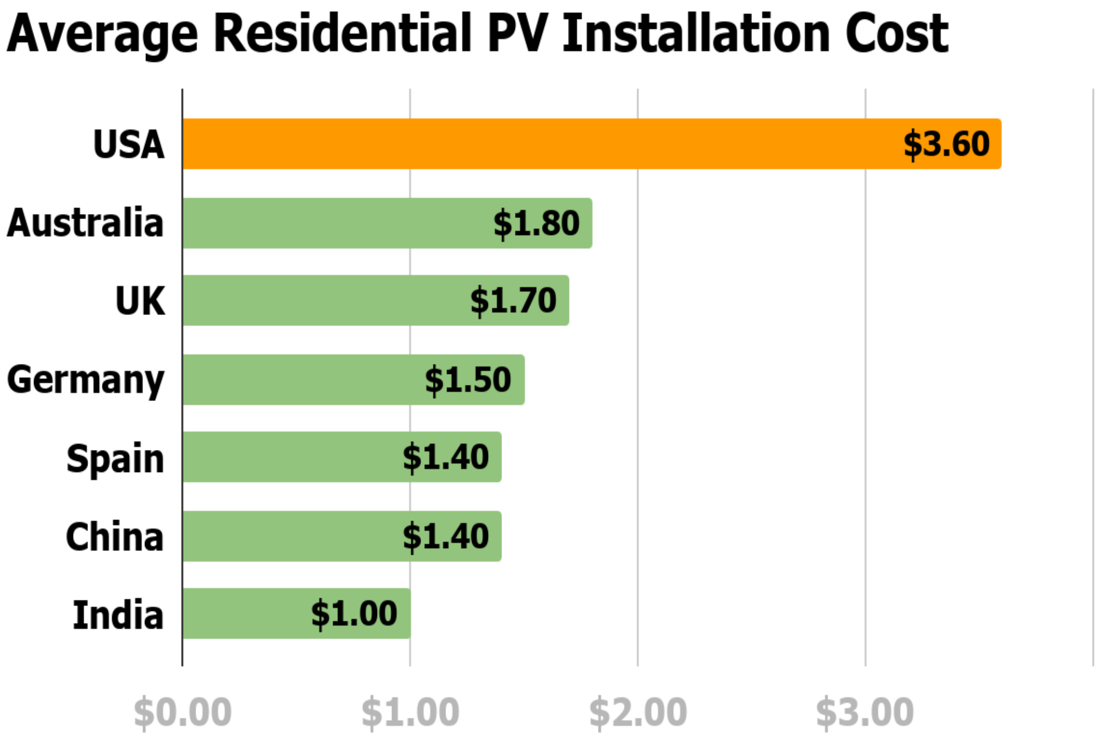
The SOLAR FOUNDATION™ for a bright future

ICMA Leaders at the Core of Better Communities

Why Simplify Permitting and Inspections?



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



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-Hespul (2018) and is an annual number for all of 2017.

Figure 17. Comparison of Installed Prices in 2017 across Countries (Pre-Sales Tax/VAT)

Code Enforcers Have Room for Improvement

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.

Photo: Littleton Fire Department

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

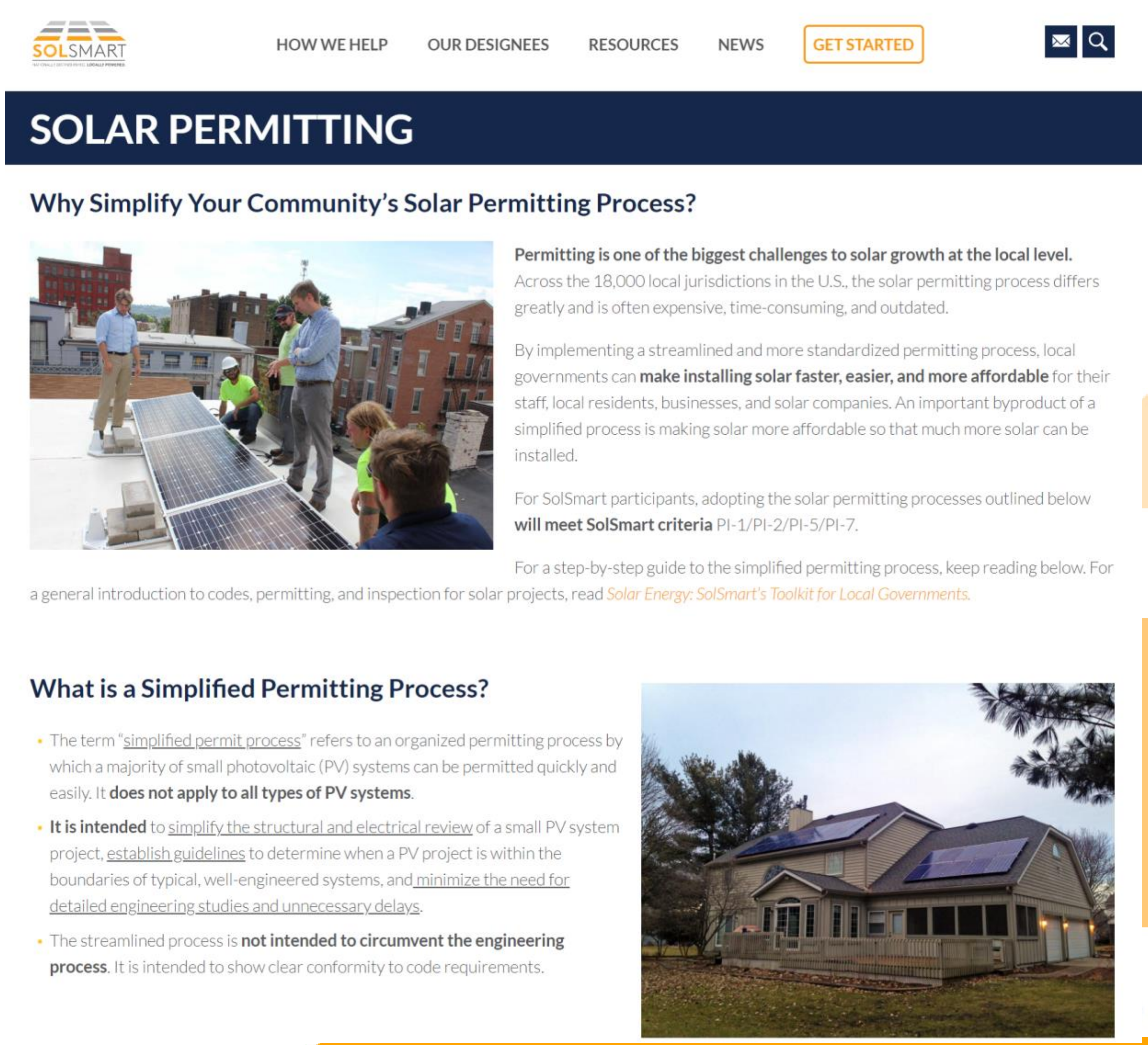
Simplified PV Permitting Guidelines:

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.)



HOW WE HELP   OUR DESIGNEES   RESOURCES   NEWS   GET STARTED

SOLAR PERMITTING

Why Simplify Your Community's Solar Permitting Process?

Permitting is one of the biggest challenges to solar growth at the local level. Across the 18,000 local jurisdictions in the U.S., the solar permitting process differs greatly and is often expensive, time-consuming, and outdated.

By implementing a streamlined and more standardized permitting process, local governments can **make installing solar faster, easier, and more affordable** for their staff, local residents, businesses, and solar companies. An important byproduct of a simplified process is making solar more affordable so that much more solar can be installed.

For SolSmart participants, adopting the solar permitting processes outlined below **will meet SolSmart criteria** PI-1/PI-2/PI-5/PI-7.

For a step-by-step guide to the simplified permitting process, keep reading below. For a general introduction to codes, permitting, and inspection for solar projects, read *Solar Energy: SolSmart's Toolkit for Local Governments*.

What is a Simplified Permitting Process?

- The term "simplified permit process" refers to an organized permitting process by which a majority of small photovoltaic (PV) systems can be permitted quickly and easily. It **does not apply to all types of PV systems**.
- **It is intended** to simplify the structural and electrical review of a small PV system project, establish guidelines to determine when a PV project is within the boundaries of typical, well-engineered systems, and minimize the need for detailed engineering studies and unnecessary delays.
- The streamlined process is **not intended to circumvent the engineering process**. It is intended to show clear conformity to code requirements.

SolSmart Simplified PV Permit Guidelines

SOLSMART
NATIONALLY DISTINGUISHED. LOCALLY POWERED.

- 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

SOLSMART
NATIONALLY DISTINGUISHED. LOCALLY POWERED.

- 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 <u>clearly compliant with electrical and building codes</u>

Source: NREL

The SOLAR FOUNDATION for a bright future

ICMA Leaders at the Core of Better Communities

Elements of Simplified Permitting

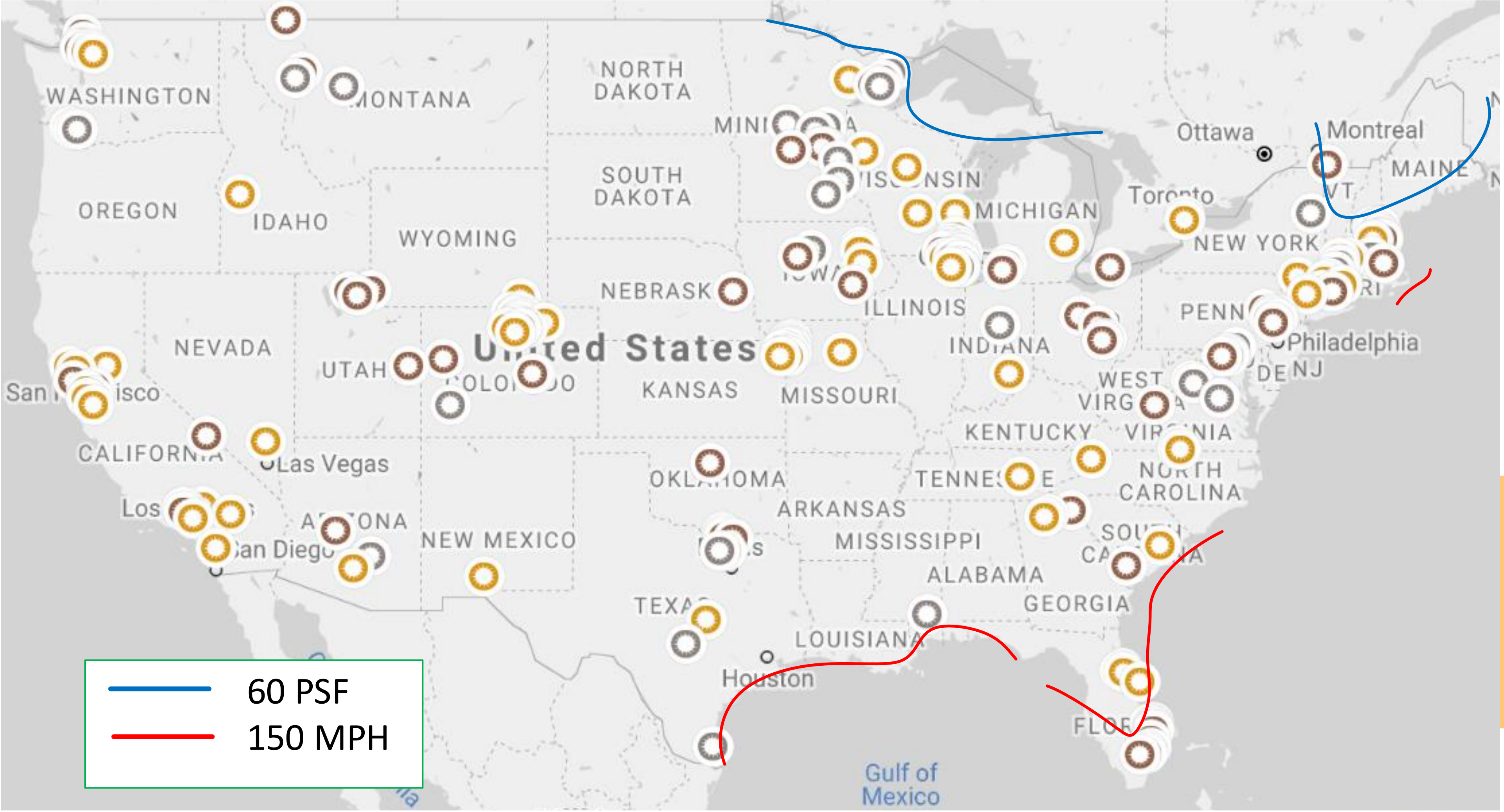
- Use of a simple **eligibility checklist** to determine whether projects qualify for expedited permitting and requisite written materials.
- Use of a **standard application** to collect information about the proposed project.
- Use of a **standard plan** to describe the proposed solar PV project in 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

SOLSMART
NATIONALLY DISTINGUISHED. LOCALLY POWERED.

- 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./ft^2
- 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



SOLSMART
NATIONALLY DISTINGUISHED. LOCALLY POWERED.

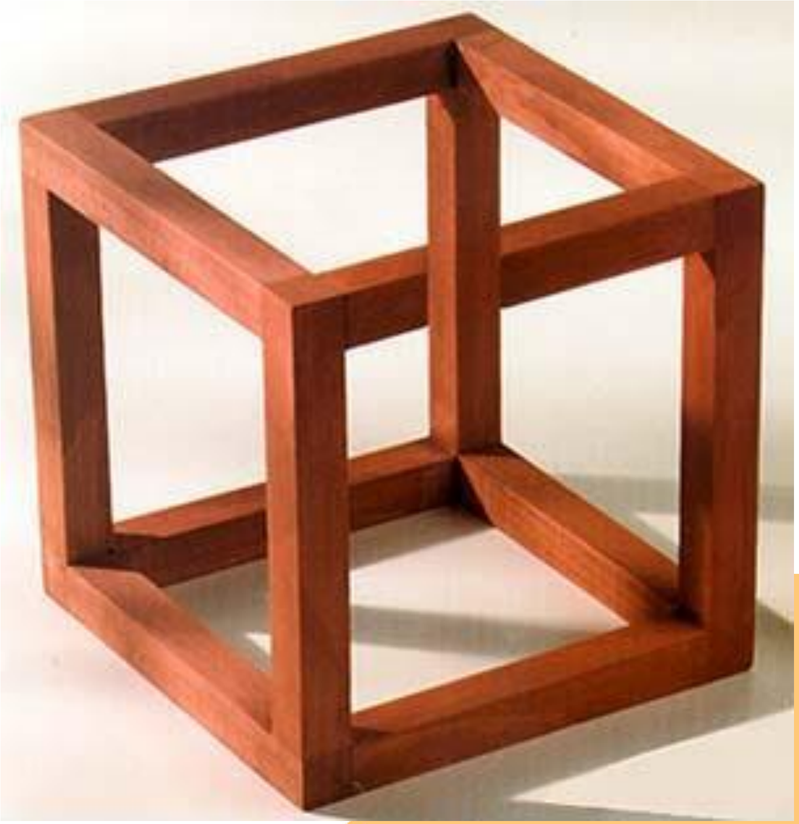
ICMA
Leaders at the Core of Better Communities

www.solsmart.org

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



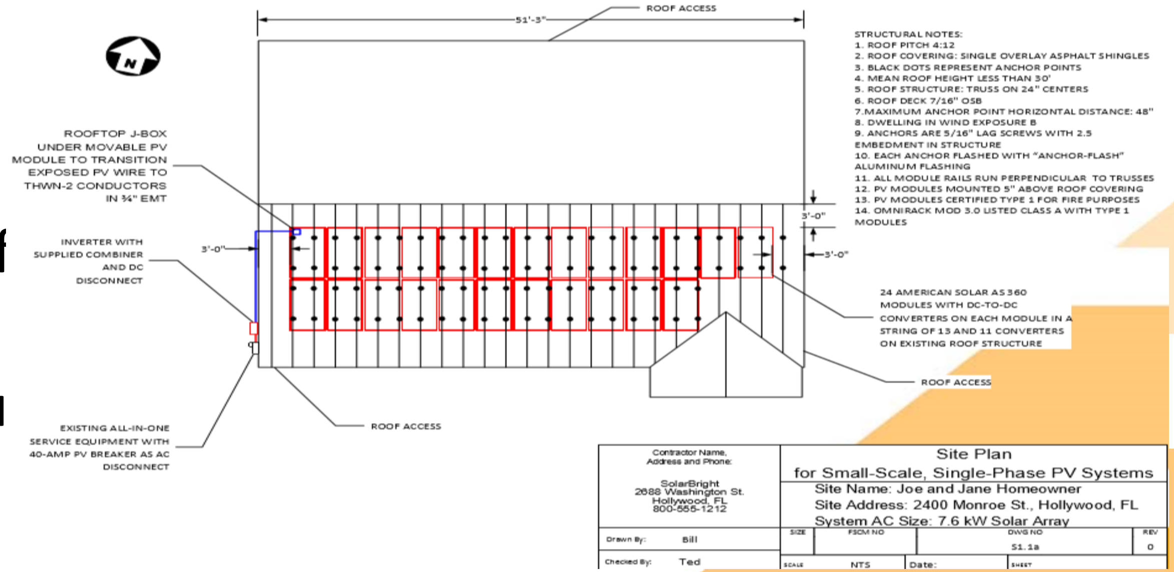
Guidelines Outline

- 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

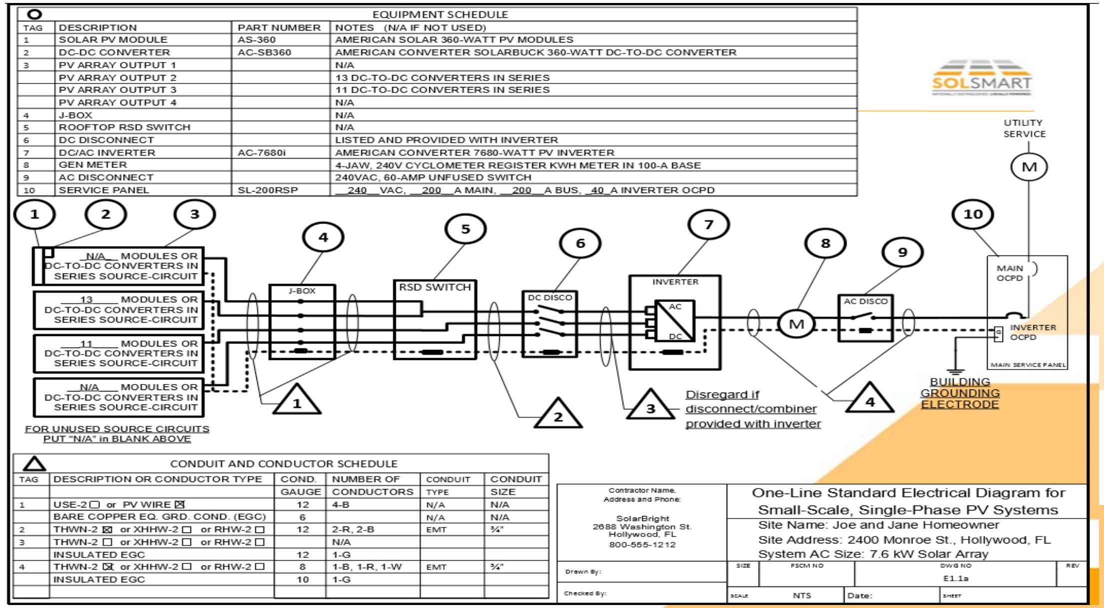
Information to Collect

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 bu 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).



Information to Collect (cont.)

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./ft^2
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*

Member-Attached Array Requirements (cont.)

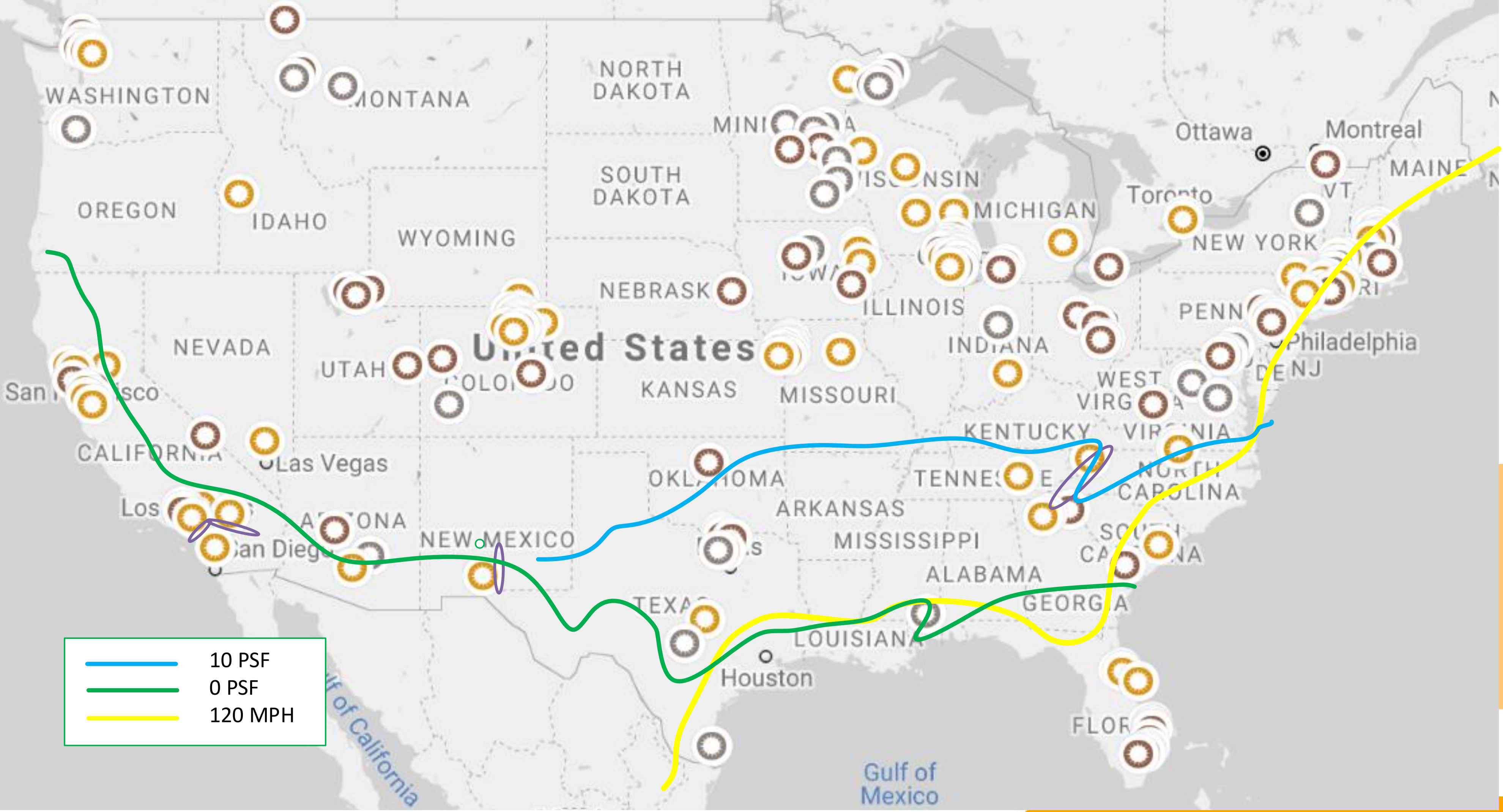
- ☐ 7. Upslope/downslope anchor spacing follows manufacturer's instructions.
- ☐ 8. Anchor fastener is (select one below):
  - ☐ *a. 5/16" diameter lag screw with 2.5" embedment into structural member, or*
  - ☐ *b. fastener other than (a.) embedded in structural members in accordance with manufacturer's 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



Low Snow / Wind Requirements

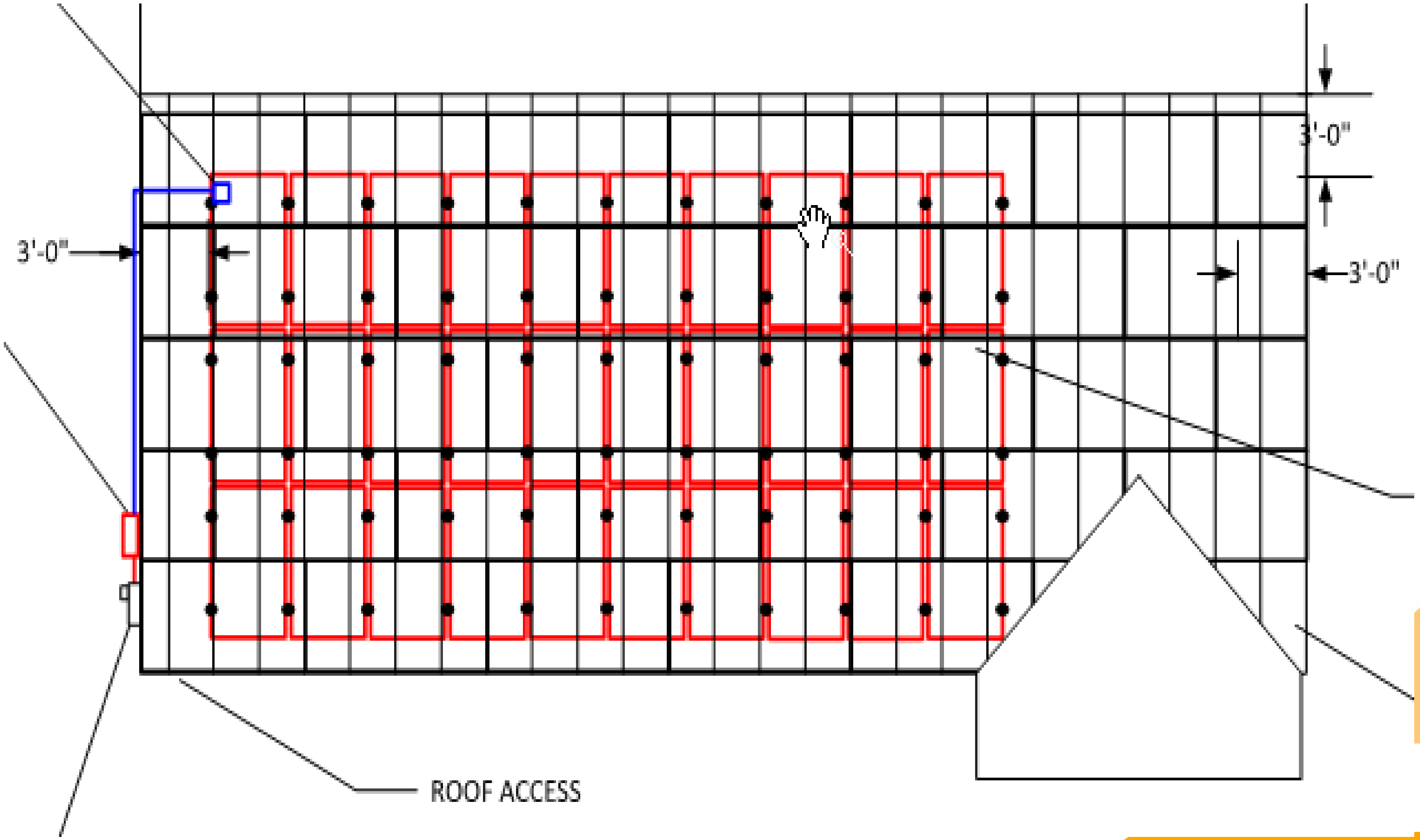
- ☐ 1. Mounting rail orientation or rail-less module long edges *run parallel to rafters and are spaced no more than 4'-0" apart,*
- ☐ 2. The anchor/mount/stand-off spacing perpendicular to rafters or trusses (select one below):
  - ☐ *a. does not exceed 4'-0", and anchors in adjacent rows are staggered 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

SOLSMART
NATIONALLY DISTINGUISHED. LOCALLY POWERED.

- ☐ 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



ELIGIBILITY CHECKLIST FOR SIMPLIFIED PV PERMITTING—Sheathing—No Bands of Strength

- ☐ 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 ft^2 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.*

ELIGIBILITY CHECKLIST FOR SIMPLIFIED PV PERMITTING—Sheathing—Bands of Strength

- ☐ 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 ft^2 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.*

Sheathing-Attached Array Requirements (cont.)

- 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.

Electrical PV System Requirements (cont.)

- ☐ 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)

Electrical PV System Requirements (cont.)

SOLSMART NATIONALLY DISTINGUISHED. LOCALLY POWERED.

☐ 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

Electrical PV System Requirements (cont.)

SOLSMART
NATIONALLY DISTINGUISHED. LOCALLY POWERED.

- ☐ 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.

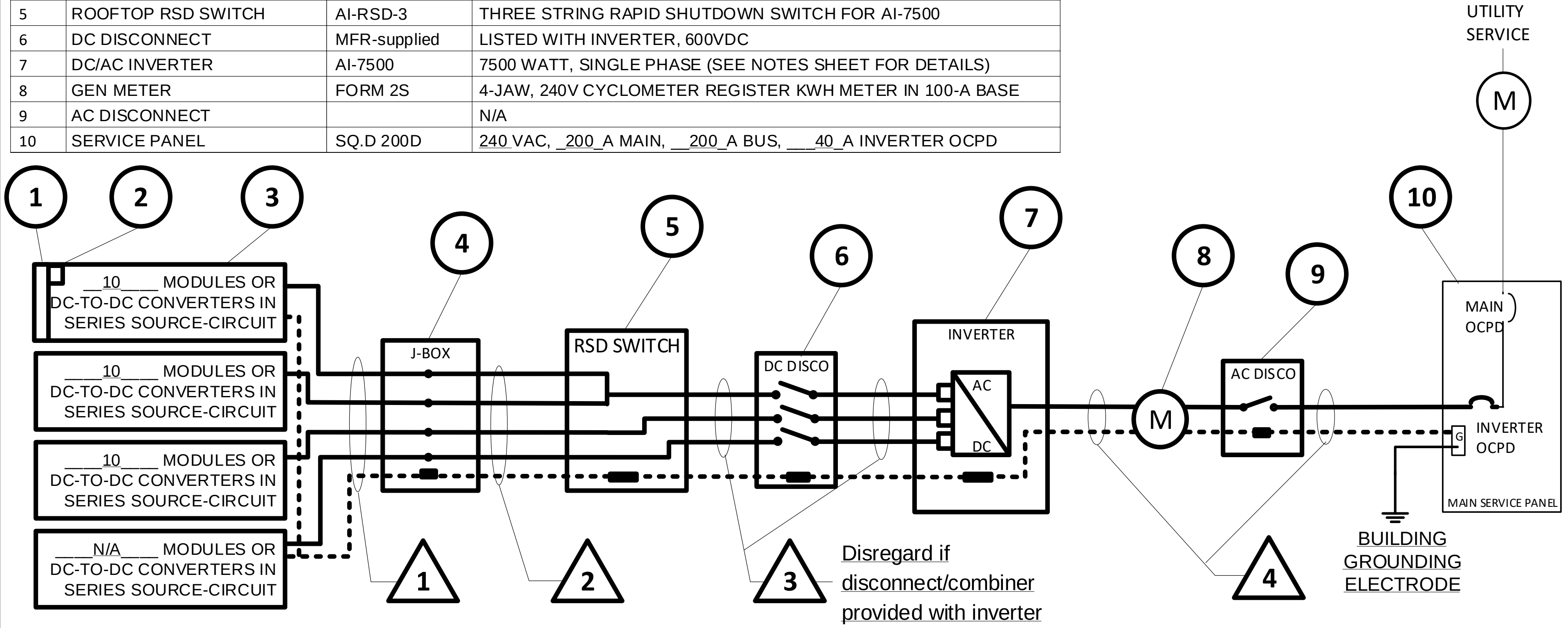
Example Central/String Inverter Standard Plans

- 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).

EQUIPMENT SCHEDULE

TAG	DESCRIPTION	PART NUMBER	NOTES (N/A IF NOT USED)
1	SOLAR PV MODULE	AS 285	AMERICAN SOLAR, QUANTITY - 30 (SEE NOTES SHEET FOR DETAILS)
2	DC-DC CONVERTER		N/A
3	PV ARRAY OUTPUT 1		2 STRINGS WITH 10 MODULES PER SERIES STRING
	PV ARRAY OUTPUT 2		1 STRING WITH 10 MODULES PER SERIES STRING
	PV ARRAY OUTPUT 3		N/A
4	J-BOX		6"x6"x4" NEMA 4, PVC JUNCTION BOX
5	ROOFTOP RSD SWITCH	AI-RSD-3	THREE STRING RAPID SHUTDOWN SWITCH FOR AI-7500
6	DC DISCONNECT	MFR-supplied	LISTED WITH INVERTER, 600VDC
7	DC/AC INVERTER	AI-7500	7500 WATT, SINGLE PHASE (SEE NOTES SHEET FOR DETAILS)
8	GEN METER	FORM 2S	4-JAW, 240V CYCLOMETER REGISTER KWH METER IN 100-A BASE
9	AC DISCONNECT		N/A
10	SERVICE PANEL	SQ.D 200D	240 VAC, _200_A MAIN, __200_A BUS, ___40_A INVERTER OCPD

SOLSMART
NATIONALLY DISTINGUISHED. LOCALLY POWERED.



FOR UNUSED SERIES STRINGS
PUT "N/A" in BLANK ABOVE

CONDUIT AND CONDUCTOR SCHEDULE

TAG	DESCRIPTION OR CONDUCTOR TYPE	COND. GAUGE	NUMBER OF CONDUCTORS	CONDUIT TYPE	CONDUIT SIZE
1	USE-2 ☐ or PV WIRE ☐	10		N/A	N/A
	BARE COPPER EQ. GRD. COND. (EGC)	6		N/A	N/A
2	THWN-2 ☐ or XHHW-2 ☐ or RHW-2 ☐	10			
3	THWN-2 ☐ or XHHW-2 ☐ or RHW-2 ☐	6			
	INSULATED EGC	10			
4	THWN-2 ☐ or XHHW-2 ☐ or RHW-2 ☐				
	INSULATED EGC				

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

Drawn By:	SIZE	FSCM NO	DWG NO E1.1a	REV
Checked By:	SCALE NTS	Date:	SHEET	

The SOLAR FOUNDATION for a bright future

ICMA Leaders at the Core of Better Communities

www.solsmart.org

PV MODULE RATINGS @ STC (Guide Section ?)

MODULE MAKE	AMERICAN SOLAR
MODULE MODEL	AS-285
MAX POWER-POINT CURRENT (I_{MP})	9.20 A
MAX POWER-POINT VOLTAGE (V_{MP})	31.3 V
OPEN-CIRCUIT VOLTAGE (V_{OC})	39.7 V
SHORT-CIRCUIT CURRENT (I_{SC})	9.84 A
MAX SERIES FUSE (OCPD)	20 A
MAXIMUM POWER (P_{MAX})	285 W
MAX VOLTAGE (TYP 1000V_{DC})	1000 V

NOTE FOR ARRAY CIRCUIT WIRING (Guide Section 4 and Appendix E):

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 ___1__ INVERTER OCPD(s), ONE FOR EACH INVERTER. DOES TOTAL SUPPLY BREAKERS COMPLY WITH 120% BUSBAR RULE IN 705.12(D)? YES ☒ NO ☐

NOTES FOR ALL DRAWINGS:

OCPD = OVERCURRENT PROTECTION DEVICE

NATIONAL ELECTRICAL CODE® REFERENCES SHOWN AS *(NEC XXX.XX)*

DC-TO-DC CONVERTER RATINGS (if used)

CONVERTER MAKE	
CONVERTER MODEL	
MAX CURRENT	A
MAX VOLTAGE	V
MAXIMUM POWER	W
MAX OUTPUT CIRCUIT V (TYP 600V_{DC})	V

INVERTER RATINGS (Guide Section 4)

INVERTER MAKE	AMERICAN INVERTER
INVERTER MODEL	AI-7500
MAX DC VOLT RATING	600 V
MAX POWER @ 40°C	7500 W
NOMINAL AC VOLTAGE	240 V
MAX AC CURRENT	31.25 A
MAX OCPD RATING	40 A

SIGNS–SEE GUIDE SECTION 7

*SIGN FOR DC DISCONNECT

PHOTOVOLTAIC POWER SOURCE	
RATED MPP CURRENT	27.6 A
RATED MPP VOLTAGE	313 V
MAX SYSTEM VOLTAGE	461 V
MAX CIRCUIT CURRENT	36.9 A

WARNING: ELECTRICAL SHOCK HAZARD–LINE AND LOAD MAY BE ENERGIZED IN OPEN POSITION

SIGN FOR PV SYSTEM DISCONNECT

SOLAR PV SYSTEM DISCONNECT	
AC OUTPUT CURRENT	31 A
NOMINAL AC VOLTAGE	240 V

SIGN FOR DISTRIBUTION PANELS

THIS PANEL FED BY MULTIPLE SOURCES (UTILITY AND SOLAR)

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

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

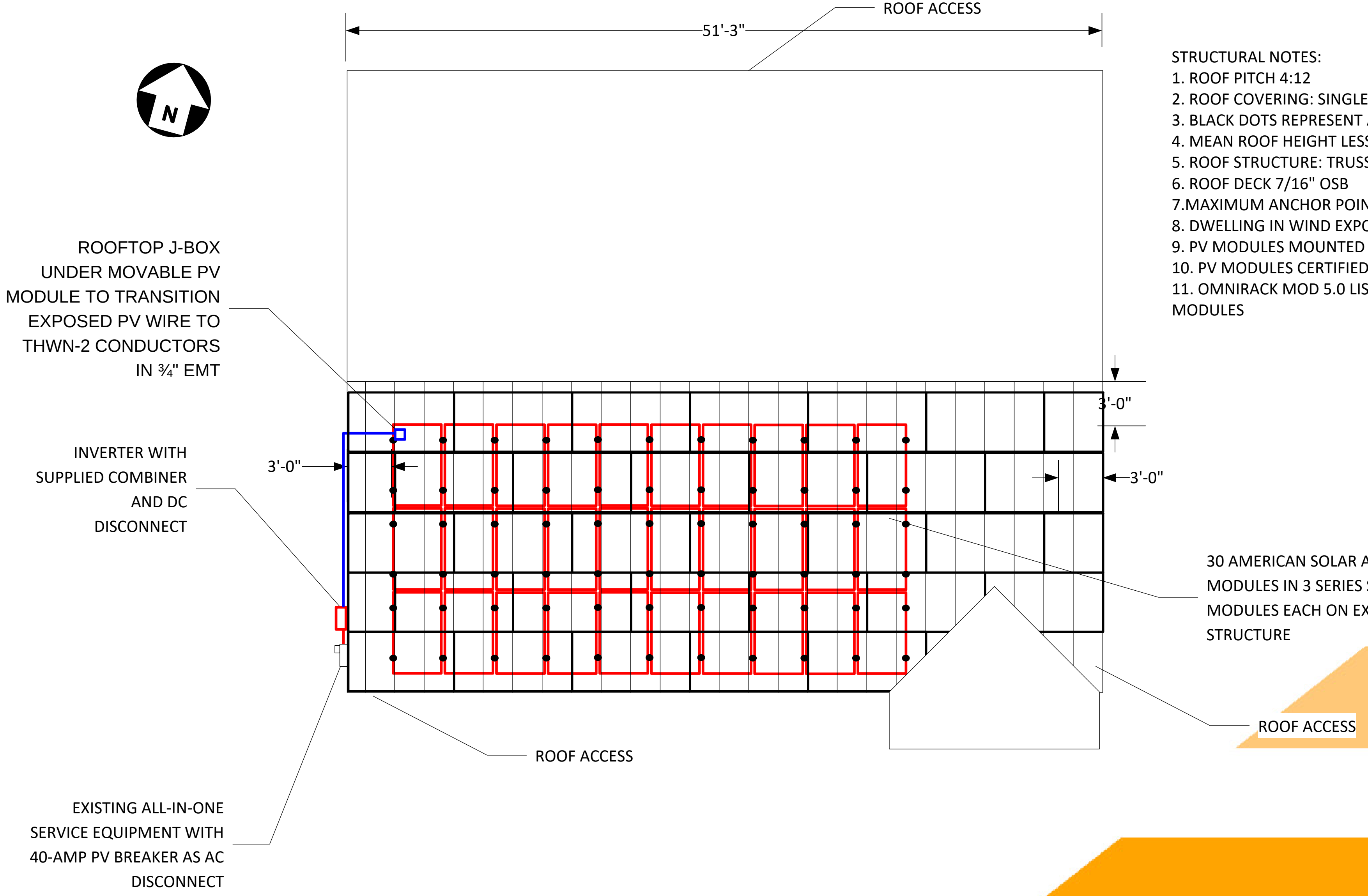
SIGN FOR NEC 690.12 (for roof-mounted systems)

PHOTOVOLTAIC SYSTEM EQUIPPED WITH RAPID SHUTDOWN

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

Contractor Name, Address and Phone: ______ ______ ______ ______	Notes for One-Line Standard Electrical Diagram for Single-Phase PV Systems Site Name: ______ Site Address: ______ System AC Size: ______			
Drawn By:	SIZE	FSCM NO	DWG NO E1.2a	REV
Checked By:	SCALE NTS	Date:	SHEET	

Example Sheathing Attached System Site Plan

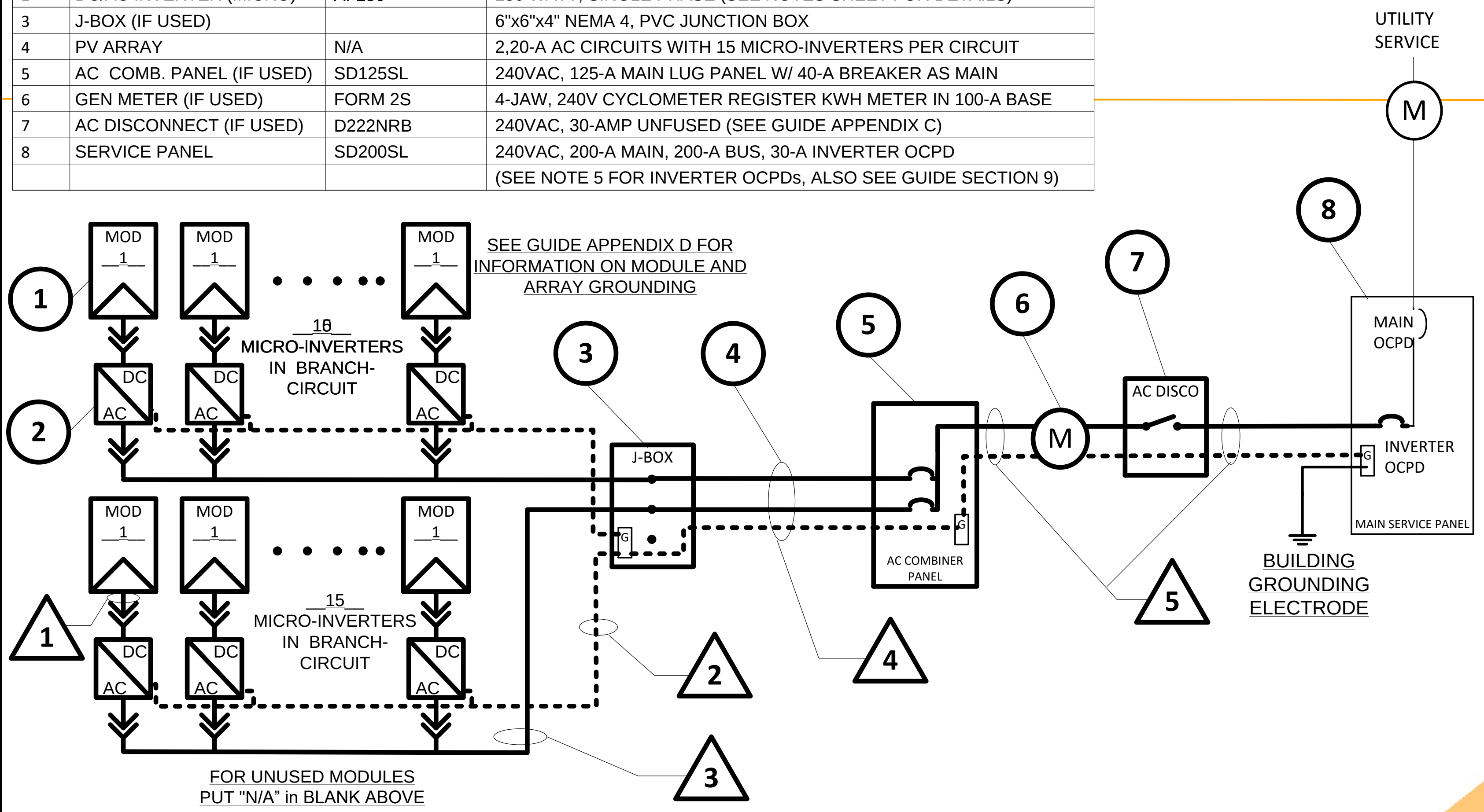


STRUCTURAL NOTES:
1. ROOF PITCH 4:12
2. ROOF COVERING: SINGLE OVERLAY ASPHALT SHINGLES
3. BLACK DOTS REPRESENT ANCHOR POINTS
4. MEAN ROOF HEIGHT LESS THAN 30'
5. ROOF STRUCTURE: TRUSS ON 24" CENTERS
6. ROOF DECK 7/16" OSB
7.MAXIMUM ANCHOR POINT DISTANCE: 48"
8. DWELLING IN WIND EXPOSURE B
9. PV MODULES MOUNTED 2" ABOVE ROOF COVERING
10. PV MODULES CERTIFIED TYPE 1 FOR FIRE PURPOSES
11. OMNIRACK MOD 5.0 LISTED CLASS A WITH TYPE 1 MODULES

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).

◯	EQUIPMENT SCHEDULE		
TAG	DESCRIPTION	PART NUMBER	NOTES
1	PV DC or AC MODULE	AS 285	AMERICAN SOLAR, QUANTITY - 20 (SEE NOTES SHEET FOR DETAILS)
2	DC/AC INVERTER (MICRO)	AI-250	250 WATT, SINGLE PHASE (SEE NOTES SHEET FOR DETAILS)
3	J-BOX (IF USED)		6"x6"x4" NEMA 4, PVC JUNCTION BOX
4	PV ARRAY	N/A	2,20-A AC CIRCUITS WITH 15 MICRO-INVERTERS PER CIRCUIT
5	AC COMB. PANEL (IF USED)	SD125SL	240VAC, 125-A MAIN LUG PANEL W/ 40-A BREAKER AS MAIN
6	GEN METER (IF USED)	FORM 2S	4-JAW, 240V CYCLOMETER REGISTER KWH METER IN 100-A BASE
7	AC DISCONNECT (IF USED)	D222NRB	240VAC, 30-AMP UNFUSED (SEE GUIDE APPENDIX C)
8	SERVICE PANEL	SD200SL	240VAC, 200-A MAIN, 200-A BUS, 30-A INVERTER OCPD
			(SEE NOTE 5 FOR INVERTER OCPDs, ALSO SEE GUIDE SECTION 9)



△	CONDUIT AND CONDUCTOR SCHEDULE				
TAG	DESCRIPTION OR CONDUCTOR TYPE	COND. GAUGE	NUMBER OF CONDUCTORS	CONDUIT TYPE	CONDUIT SIZE
1	USE-2 ☐ or PV WIRE ☐	MFG	MFG Cable	N/A	N/A
2	GEC ☒ EGC ☒ X ALL THAT APPLY	6 AWG	1 BARE CU	N/A	N/A
3	EXTERIOR CABLE LISTED W/ INV.	MFG	MFG Cable	N/A	N/A
4	THWN-2 ☒ or XHHW-2 ☐ or RHW-2 ☐	12 AWG	2-B, 2-R, 2-W	EMT	¾"
	GEC ☒ EGC ☒ X ALL THAT APPLY	8 AWG	1 GREEN	SAME	SAME
	NO DC GEC IF 690.35 SYSTEM				
5	THWN-2 ☒ or XHHW-2 ☐ or RHW-2 ☐	10 AWG	1-R, 1-B, 1-W	EMT	¾"
	GEC ☒ EGC ☒ X ALL THAT APPLY	8 AWG	1 GREEN	SAME	SAME

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 Micro-Inverter or AC Module PV Systems

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

Drawn By:	Bill	SIZE	FSCM NO	DWG NO	REV
				E1.1a	0
Checked By:	Ted	SCALE	NTS	Date:	SHEET

PV MODULE RATINGS @ STC (Guide Section ?)

MODULE MAKE	AMERICAN SOLAR
MODULE MODEL	AS-285
MAX POWER-POINT CURRENT (I_{MP})	9.20 A
MAX POWER-POINT VOLTAGE (V_{MP})	31.3 V
OPEN-CIRCUIT VOLTAGE (V_{OC})	39.7 V
SHORT-CIRCUIT CURRENT (I_{SC})	9.84 A
MAX SERIES FUSE (OCPD)	20 A
MAXIMUM POWER (P_{MAX})	285 W
MAX VOLTAGE (TYP $1000V_{DC}$)	1000 V

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 __-15_°C

NOTES FOR ALL DRAWINGS:

OCPD = OVERCURRENT PROTECTION DEVICE

NATIONAL ELECTRICAL CODE® REFERENCES SHOWN AS *(NEC XXX.XX)*

DC-TO-DC CONVERTER RATINGS (if used)

CONVERTER MAKE	
CONVERTER MODEL	
MAX CURRENT	A
MAX VOLTAGE	V
MAXIMUM POWER	W
MAX OUTPUT CIRCUIT V (TYP $600V_{DC}$)	V

INVERTER RATINGS (Guide Section 4)

INVERTER MAKE	AMERICAN INVERTER
INVERTER 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

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 ☐

SIGNS–SEE GUIDE SECTION 7

*SIGN FOR DC DISCONNECT

PHOTOVOLTAIC POWER SOURCE	
RATED MPP CURRENT	
RATED MPP VOLTAGE	
MAX SYSTEM VOLTAGE	
MAX CIRCUIT CURRENT	

WARNING: ELECTRICAL SHOCK HAZARD–LINE AND LOAD MAY BE ENERGIZED IN OPEN POSITION

SIGN FOR PV SYSTEM DISCONNECT

SOLAR PV SYSTEM DISCONNECT	
AC OUTPUT CURRENT	31 A
NOMINAL AC VOLTAGE	240 V

SIGN FOR DISTRIBUTION PANELS

THIS PANEL FED BY MULTIPLE SOURCES (UTILITY AND SOLAR)

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

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

SIGN FOR NEC 690.12 (for roof-mounted systems)

PHOTOVOLTAIC SYSTEM EQUIPPED WITH RAPID SHUTDOWN

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

Contractor Name, Address and Phone:

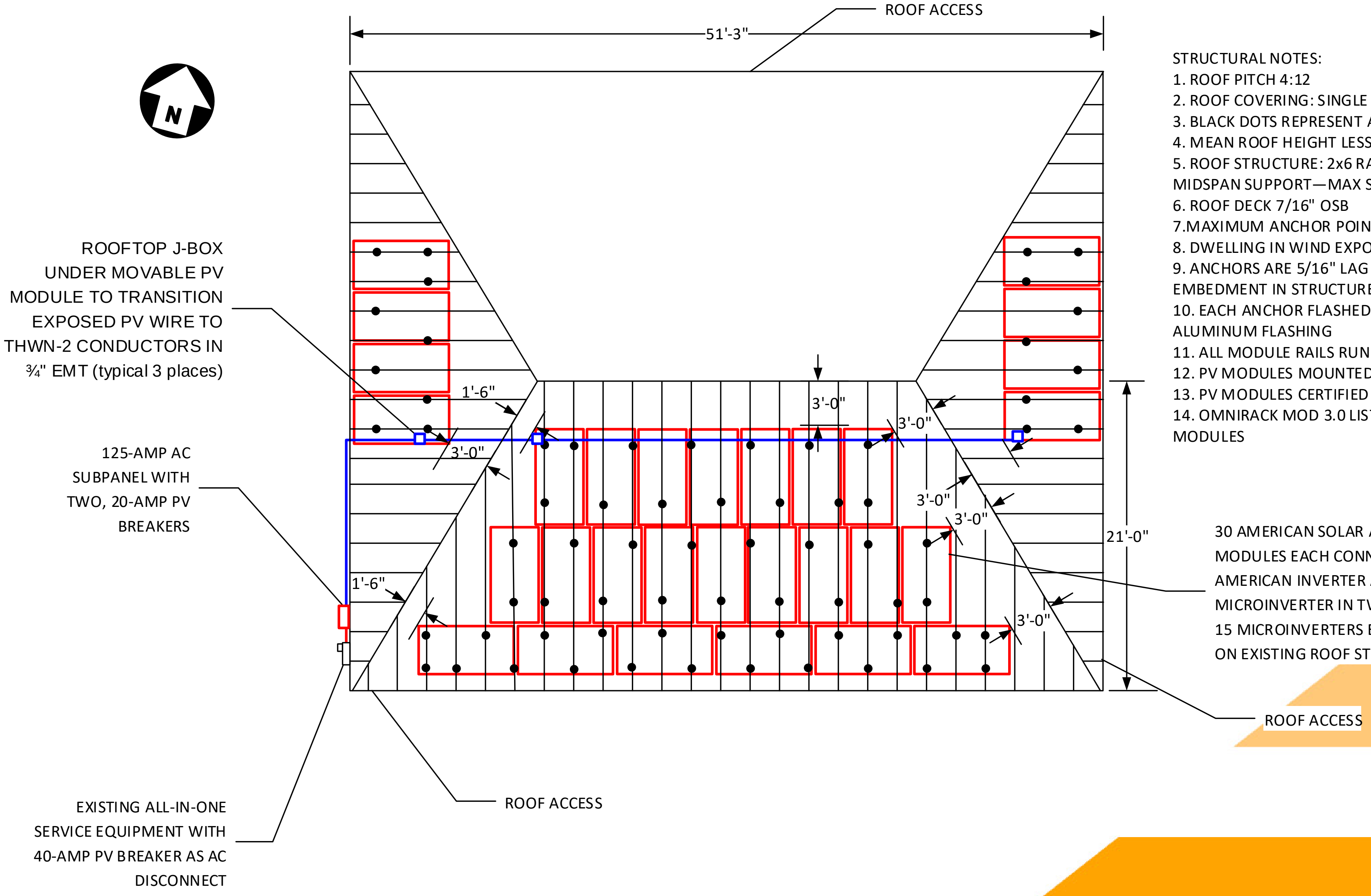
____
____
____
____

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

Site Name: ____________________
Site Address: ____________________
System AC Size: ____________________

Drawn By:	SIZE	FSCM NO	DWG NO E1.2a	REV
Checked By:	SCALE NTS		Date:	SHEET

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. OMNIRACK MOD 3.0 LISTED CLASS A WITH TYPE 1 MODULES

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 APP

NREL
Transforming ENERGY

U.S. DEPARTMENT OF
ENERGY
Office of
ENERGY EFFICIENCY & RENEWABLE ENERGY

Solar Automated Permit Processing (SolarAPP)

SOLSMART
NATIONALLY DISTINGUISHED. LOCALLY POWERED.

- 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
- Piloting webinar:
  - https://youtu.be/iaocESF9Ilg.
- SolarAPP Benefits Memo:
  - https://www.thesolarfoundation.org/wp-content/uploads/2020/07/SolarAPP-Benefits-OnePager.pdf

For more information contact:
solarapp@nrel.gov

To sign-up for piloting:
https://www.surveymonkey.com/r/SolarAPPInterest

PV System Inspection Best Practices

LAWS, REGS & CODES

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.

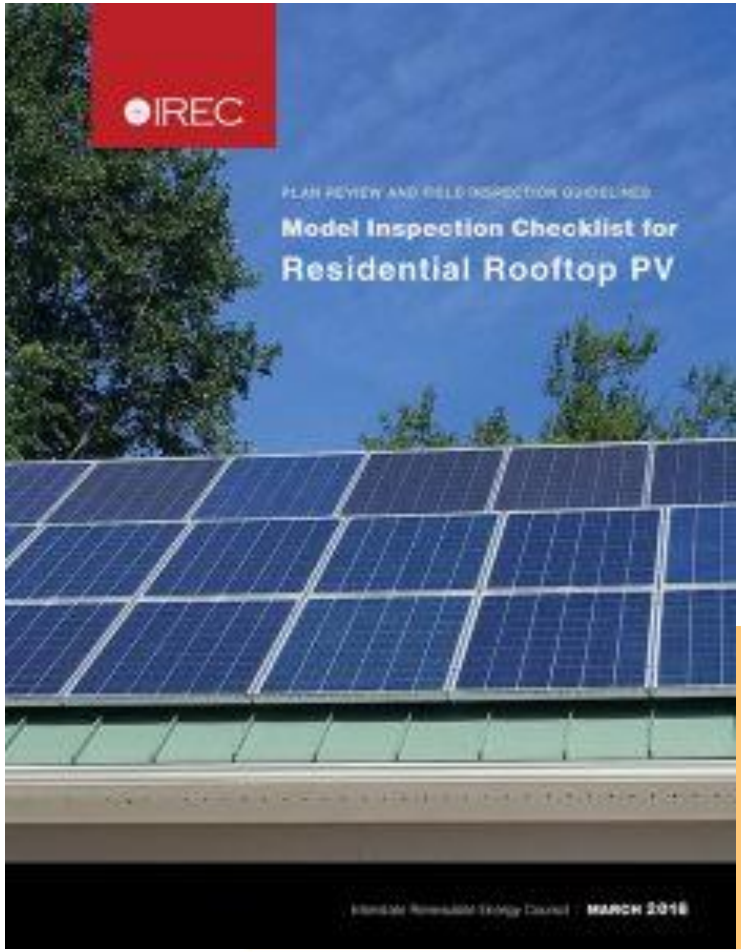
- NEC Article 690, 705, and chapters 1-4
- IRC R331, R902, R905, R908
- IBC 1505, 1509, 1511
- IFC 605.11
- ASCE 7-10, 7-16
- Local planning and zoning regulations
- And coming soon, NFPA 855 (Energy Storage)

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

Space for Logo and/or Contact information:
Office/Department | Room | Address | Phone Number | Email Address |Website

Rooftop Solar Photovoltaic (PV) System Field Inspection Checklist

This checklist provides basic guidelines for inspecting most residential rooftop solar PV systems (15 kW and under). Ground-mounted systems, systems with energy storage, building-integrated systems, and commercial systems, for example, would not be fully covered by this checklist. The intent of using the checklist is to provide transparent and well-defined information to minimize the number of re-inspections and accelerate project completion for most PV systems. These guidelines are not exhaustive.

Make sure all PV disconnects and circuit breakers are in the open position and verify the following:
Helpful tip: Update the following checklist to include any relevant state or local code requirements.

- ☐ **1.** All work done in a neat and workmanlike manner [NEC 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 and manufacturers' instructions.
- ☐ **4.** Roof penetrations flashed/sealed according to the approved plan and manufacturers' instructions.
- ☐ **5.** Exposed cables are properly secured, supported, and routed to prevent physical damage.
- ☐ **6.** Conduit installation according to NEC 690.31(D) and the approved plan.
- ☐ **7.** Firefighter access according to IRC R324 and the approved plan.
- ☐ **8.** Roof-mounted PV mounting system and modules have sufficient fire classification [IRC R324.4.2].
- ☐ **9.** Grounding/bonding of rack, modules, inverter(s), and other electrical equipment according to the manufacturer's instructions.
- ☐ **10.** Equipment installed, listed, and labeled according to the approved plan and manufacturers' instructions (e.g., PV modules, inverters, dc-to-dc converters, rapid shutdown equipment).
- ☐ **11.** For grid-connected systems, inverter is marked "interactive," or documentation is provided to show that inverter meets utility interconnection requirements.
- ☐ **12.** Conductors, cables, and conduit types, sizes, and markings according to the approved plan.
- ☐ **13.** Overcurrent devices are the type and size according to the approved plan.
- ☐ **14.** Disconnects according to the approved plan and properly located as required by the NEC.
- ☐ **15.** Inverter output circuit breaker is located at opposite end of bus from utility supply at load center and/or service panelboard. If panel is center-fed, inverter output circuit breaker can be at either end of busbar [NEC 705.12(B)] (not required if the sum of the inverter and utility supply circuit breakers is less than or equal to the panelboard bus rating).
- ☐ **16.** PV system markings, labels, and signs according to the approved plan.
- ☐ **17.** Connection of the PV system equipment grounding conductors according to the approved plan.
- ☐ **18.** Access and working space for operation and maintenance of PV equipment such as inverters, disconnecting means and panelboards (not required for PV modules) [NEC 110.26].
- ☐ **19.** The rapid shutdown system is installed and operational according to the approved plan and manufacturers' instructions [NEC 690.12].

[Solar PV Field Inspection Checklist Version 1, Updated 3/10/21]

Example Site Plan

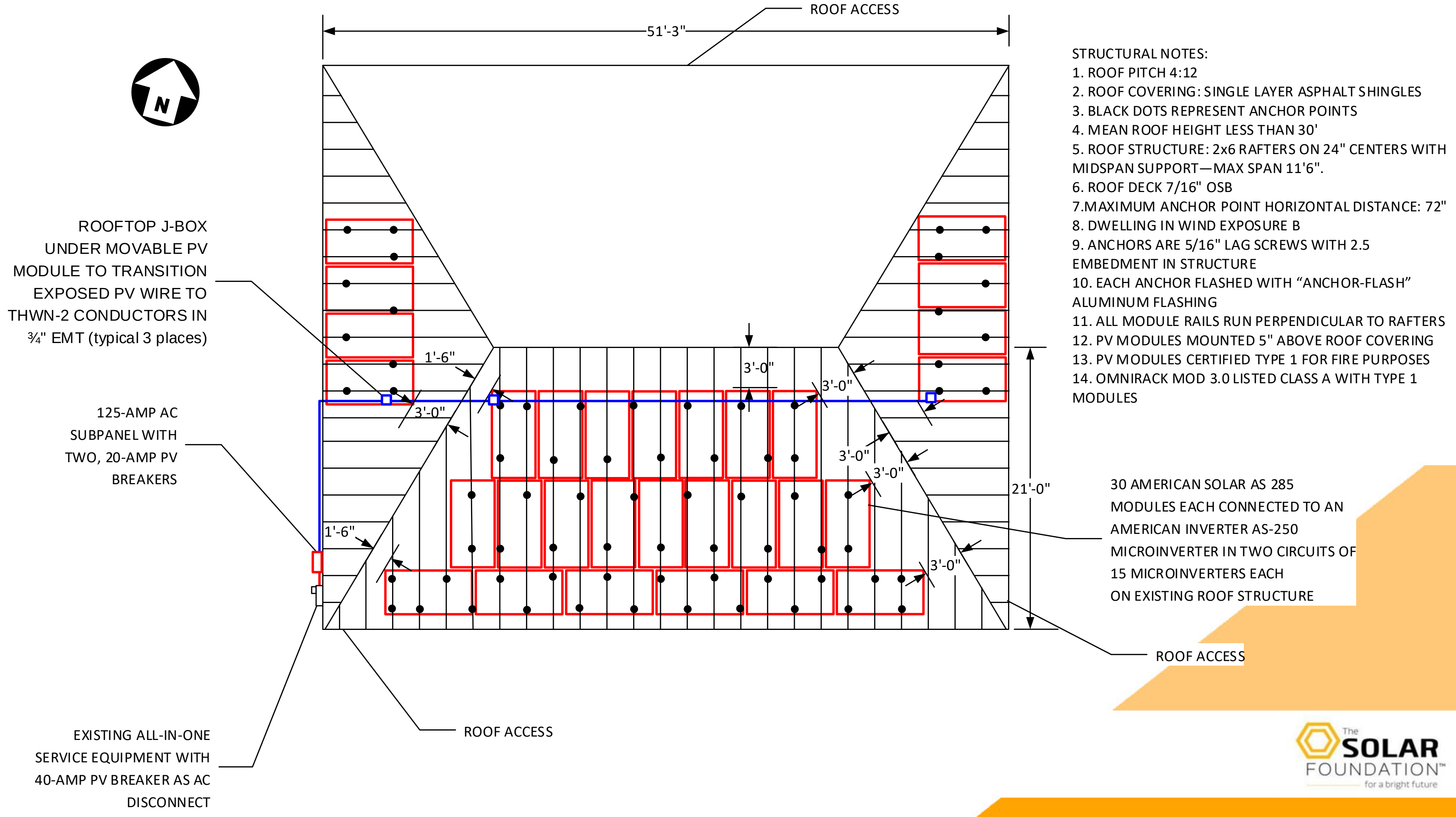
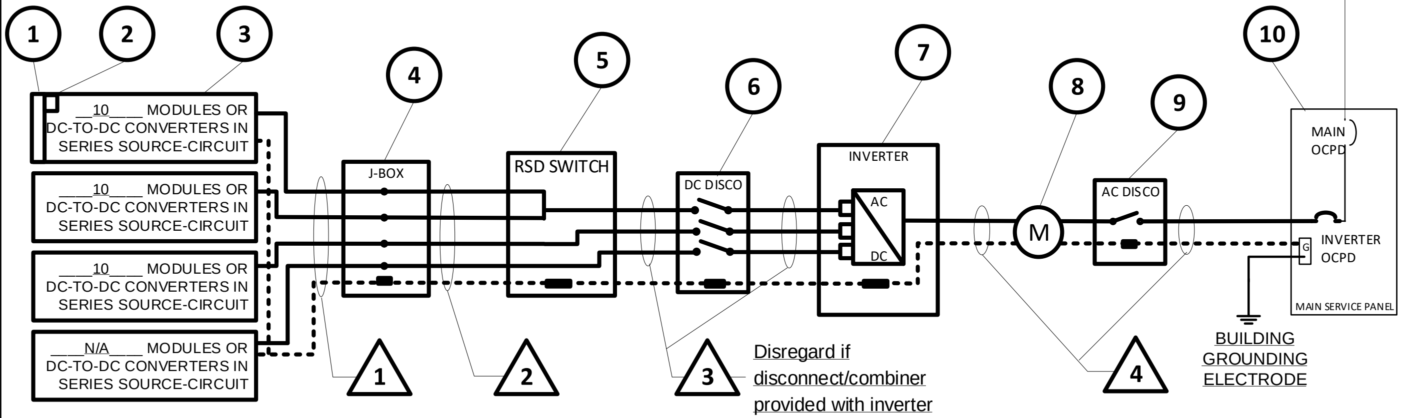


Image: Brooks Engineering

Example Electrical Diagram String Inverter

SOLSMART
NATIONALLY DISTINGUISHED. LOCALLY POWERED.

EQUIPMENT SCHEDULE			
TAG	DESCRIPTION	PART NUMBER	NOTES (N/A IF NOT USED)
1	SOLAR PV MODULE	AS 285	AMERICAN SOLAR, QUANTITY - 30 (SEE NOTES SHEET FOR DETAILS)
2	DC-DC CONVERTER		N/A
3	PV ARRAY OUTPUT 1		2 STRINGS WITH 10 MODULES PER SERIES STRING
	PV ARRAY OUTPUT 2		1 STRING WITH 10 MODULES PER SERIES STRING
	PV ARRAY OUTPUT 3		N/A
4	J-BOX		6"x6"x4" NEMA 4, PVC JUNCTION BOX
5	ROOFTOP RSD SWITCH	AI-RSD-3	THREE STRING RAPID SHUTDOWN SWITCH FOR AI-7500
6	DC DISCONNECT	MFR-supplied	LISTED WITH INVERTER, 600VDC
7	DC/AC INVERTER	AI-7500	7500 WATT, SINGLE PHASE (SEE NOTES SHEET FOR DETAILS)
8	GEN METER	FORM 2S	4-JAW, 240V CYCLOMETER REGISTER KWH METER IN 100-A BASE
9	AC DISCONNECT		N/A
10	SERVICE PANEL	SQ.D 200D	240 VAC, _200_A MAIN, __200_A BUS, ___40_A INVERTER OCPD



FOR UNUSED SERIES STRINGS PUT "N/A" in BLANK ABOVE

CONDUIT AND CONDUCTOR SCHEDULE					
TAG	DESCRIPTION OR CONDUCTOR TYPE	COND. GAUGE	NUMBER OF CONDUCTORS	CONDUIT TYPE	CONDUIT SIZE
1	USE-2 ☐ or PV WIRE ☐	10		N/A	N/A
	BARE COPPER EQ. GRD. COND. (EGC)	6		N/A	N/A
2	THWN-2 ☐ or XHHW-2 ☐ or RHW-2 ☐	10			
3	THWN-2 ☐ or XHHW-2 ☐ or RHW-2 ☐	6			
	INSULATED EGC	10			
4	THWN-2 ☐ or XHHW-2 ☐ or RHW-2 ☐				
	INSULATED EGC				

Contractor Name, Address and Phone:	One-Line Standard Electrical Diagram for Small-Scale, Single-Phase PV Systems			
Bill and Ted's Solar 456 Excellent Drive San Dimas, CA 800-555-1212	Site Name: John and Jane Homeowner Site Address: 12 Sunnyside St, Philadelphia, PA System AC Size: 7.5 KW			
Drawn By:	SIZE	FSCM NO	DWG NO E1.1a	REV
Checked By:	SCALE NTS	Date:	SHEET	

Image: Brooks Engineering

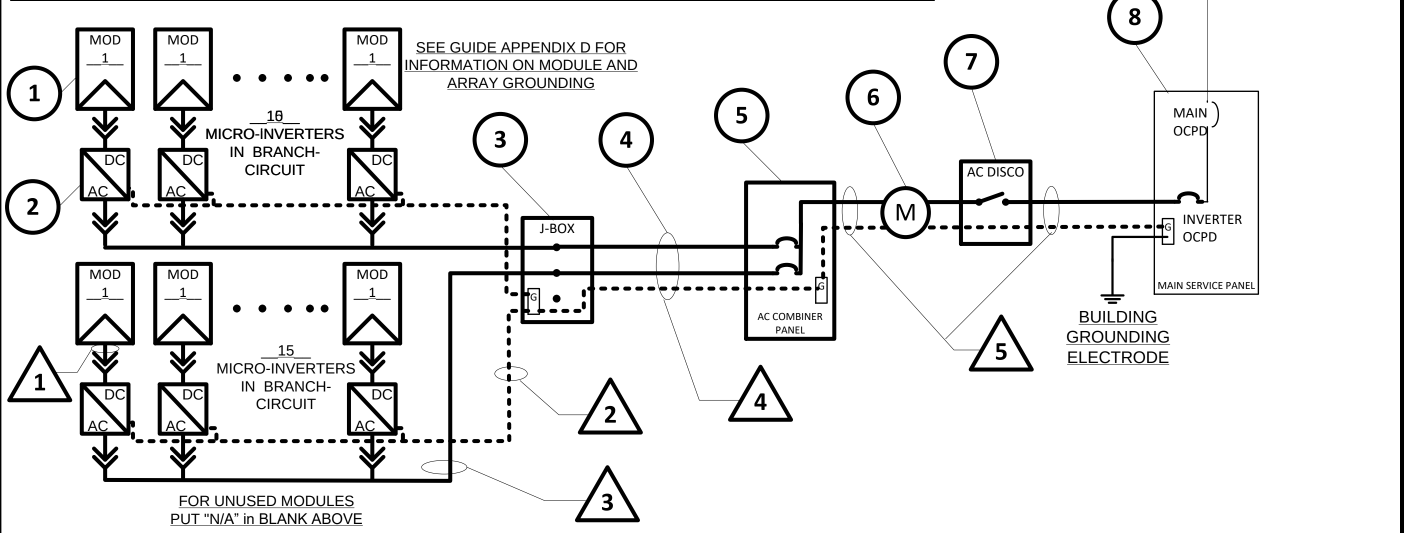
The SOLAR FOUNDATION™ for a bright future

ICMA Leaders at the Core of Better Communities

Example Electrical Diagram – Module-Level Power Electronics I.E. “MicroInverters”

EQUIPMENT SCHEDULE

TAG	DESCRIPTION	PART NUMBER	NOTES
1	PV DC or AC MODULE	AS 285	AMERICAN SOLAR, QUANTITY - 20 (SEE NOTES SHEET FOR DETAILS)
2	DC/AC INVERTER (MICRO)	AI-250	250 WATT, SINGLE PHASE (SEE NOTES SHEET FOR DETAILS)
3	J-BOX (IF USED)		6"x6"x4" NEMA 4, PVC JUNCTION BOX
4	PV ARRAY	N/A	2,20-A AC CIRCUITS WITH 15 MICRO-INVERTERS PER CIRCUIT
5	AC COMB. PANEL (IF USED)	SD125SL	240VAC, 125-A MAIN LUG PANEL W/ 40-A BREAKER AS MAIN
6	GEN METER (IF USED)	FORM 2S	4-JAW, 240V CYCLOMETER REGISTER KWH METER IN 100-A BASE
7	AC DISCONNECT (IF USED)	D222NRB	240VAC, 30-AMP UNFUSED (SEE GUIDE APPENDIX C)
8	SERVICE PANEL	SD200SL	240VAC, 200-A MAIN, 200-A BUS, 30-A INVERTER OCPD
			(SEE NOTE 5 FOR INVERTER OCPDs, ALSO SEE GUIDE SECTION 9)



CONDUIT AND CONDUCTOR SCHEDULE

TAG	DESCRIPTION OR CONDUCTOR TYPE	COND. GAUGE	NUMBER OF CONDUCTORS	CONDUIT TYPE	CONDUIT SIZE
1	USE-2 ☐ or PV WIRE ☐	MFG	MFG Cable	N/A	N/A
2	GEC ⊠ EGC ⊠ X ALL THAT APPLY	6 AWG	1 BARE CU	N/A	N/A
3	EXTERIOR CABLE LISTED W/ INV.	MFG	MFG Cable	N/A	N/A
4	THWN-2 ⊠ or XHHW-2 ☐ or RHW-2 ☐	12 AWG	2-B, 2-R, 2-W	EMT	¾"
	GEC ⊠ EGC ⊠ X ALL THAT APPLY	8 AWG	1 GREEN	SAME	SAME
	NO DC GEC IF 690.35 SYSTEM				
5	THWN-2 ⊠ or XHHW-2 ☐ or RHW-2 ☐	10 AWG	1-R, 1-B, 1-W	EMT	¾"
	GEC ⊠ EGC ⊠ X ALL THAT APPLY	8 AWG	1 GREEN	SAME	SAME

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

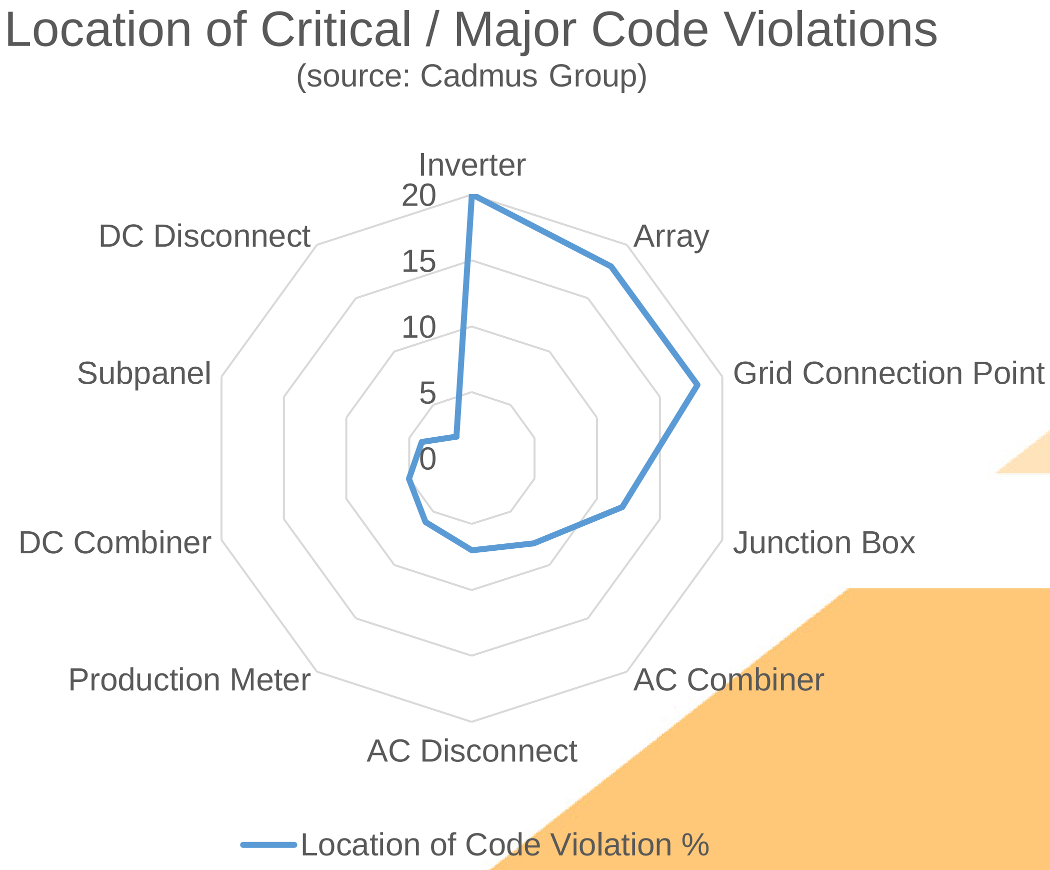
One-Line Standard Electrical Diagram
for Micro-Inverter or AC Module PV Systems
Site Name: John and Jane Homeowner
Site Address: 123 Sunnyside St., Boston, MA
System AC Size: 4.0 KW

Drawn By: Bill	SIZE	FSCM NO	DWG NO E1.1a	REV 0
Checked By: Ted	SCALE NTS	Date:	SHEET	

Image: Brooks Engineering

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)

Photo: Solairgen

Photo: IBTS

1. All Work done in a neat and workmanlike manner? (NEC 110.12)

Photos: Brooks Engineering

2. PV module model number, quantity, and location(s) match plans

Photo: Green Sun

3. Array mounting system and structural connections according to plan

Photo: Pete Jackson

Photos: Cadmus Group

4. Roof penetrations flashed/sealed?

Photos: IBTS

5. Array exposed cables are properly secured, supported, and routed to prevent physical damage

Photos: Cadmus Group

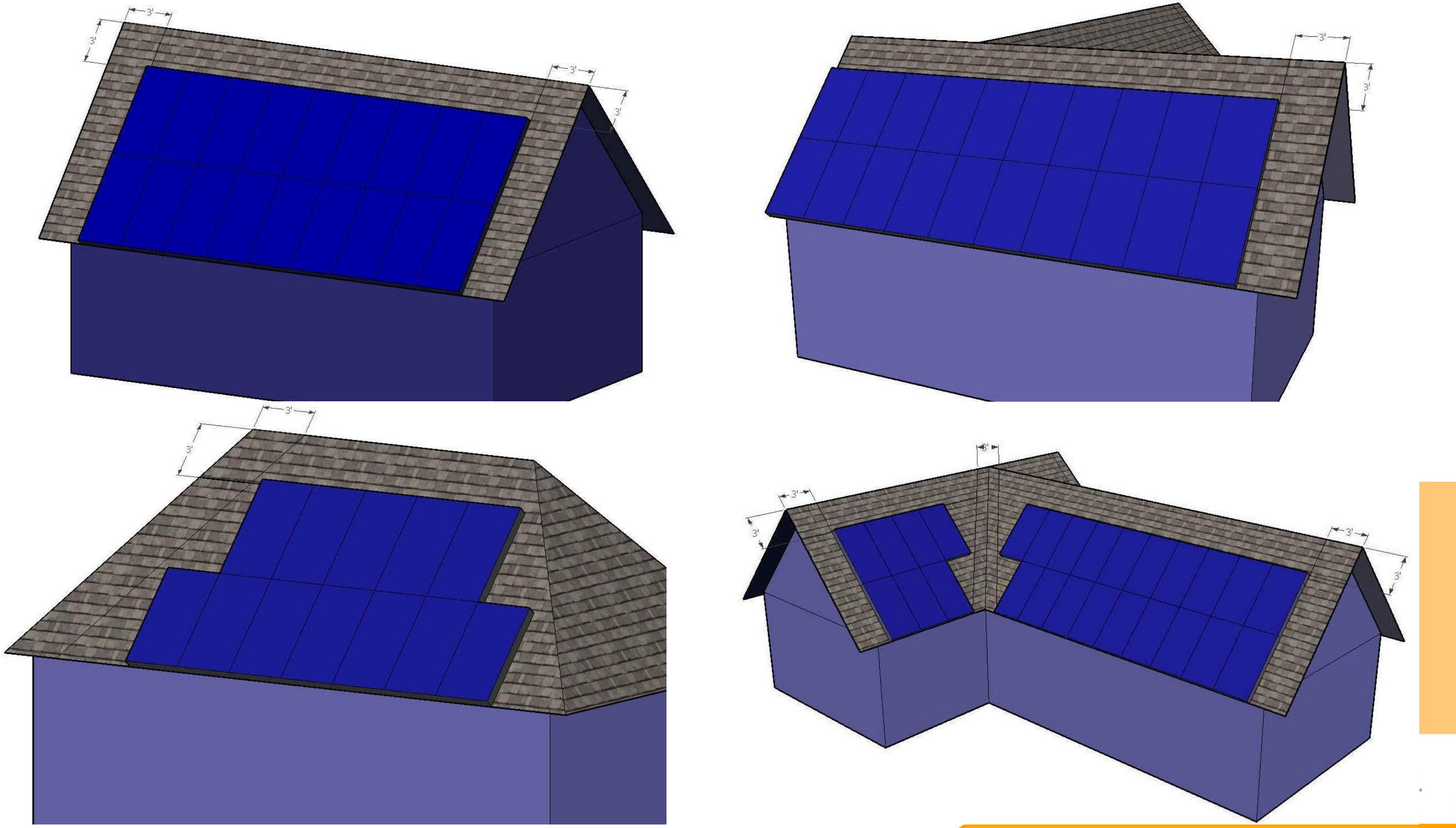
6. Conduit correctly installed and according to CRC R331.3 and NEC 690.4(F)

Photos: Cadmus Group

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

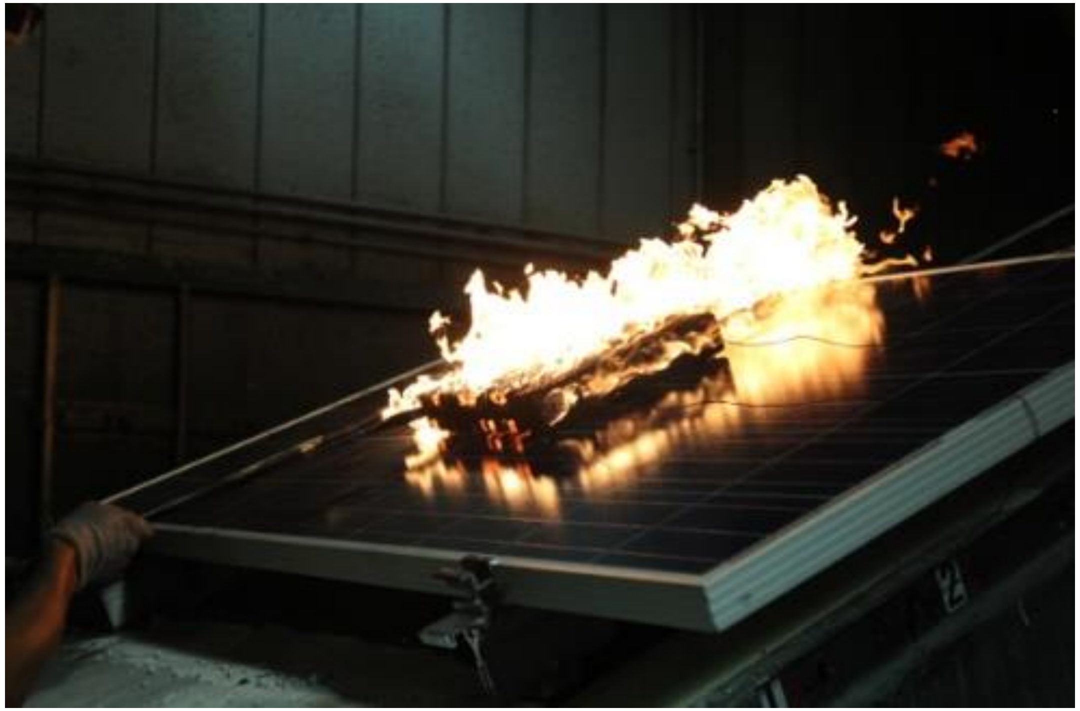


Photo: Solar Power World

CERTIFICATE OF COMPLIANCE

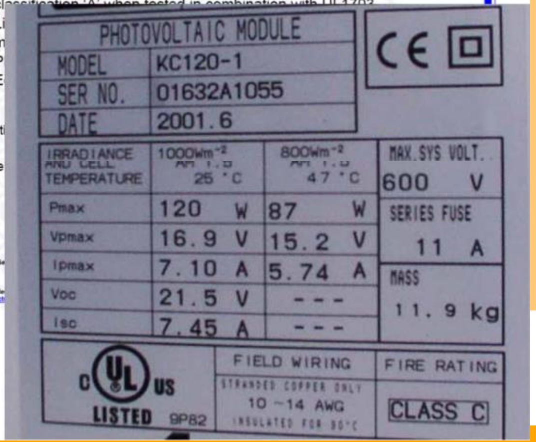
Certificate Number	20150102 - E346702
Report Reference	E346702 - 20140208
Issue Date	2015-JANUARY-02

161 Mitchell Blvd Ste 104
San Rafael, CA 94903-2085 USA

This is to certify that representative samples of	Mounting Systems, Mounting Devices, Clamping Devices and Ground Lugs for Use with Photovoltaic Modules and Panels Zep System (Steep Slope) with Type 1 modules Have been investigated by UL in accordance with the Standard(s) indicated on this Certificate.
Standard(s) for Safety:	UL 2703, "Outline of Investigation for Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs for Use with Flat-Plate Photovoltaic Modules and Panels."
Additional Information:	See the UL Online Certifications Directory at www.ul.com/database for additional information The Zep System (Steep Slope) achieved a system fire classification 'A' when tested in combination with UL 1703

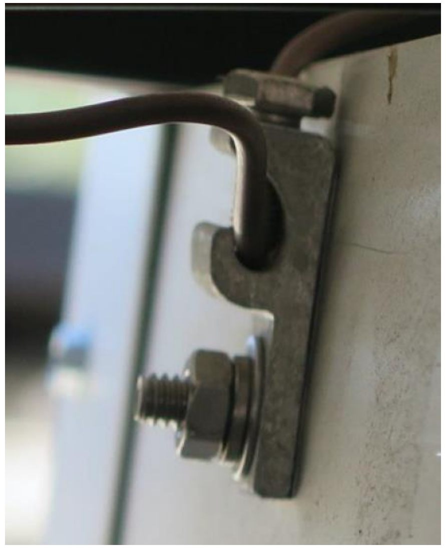
Only those products bearing the UL Cert
Certification and Follow-Up Service.

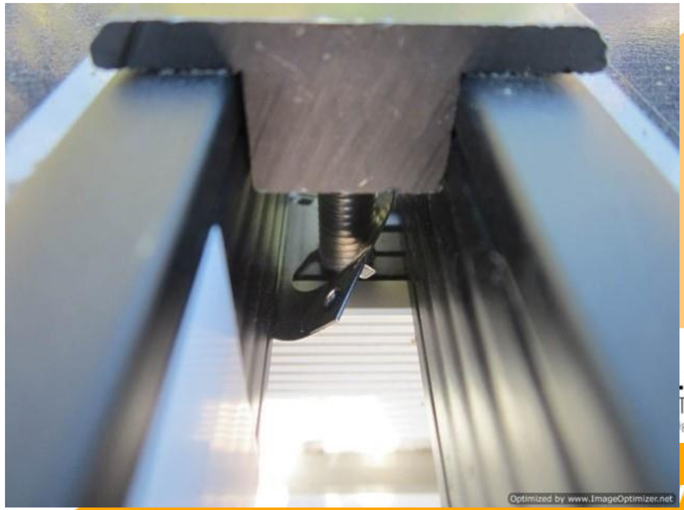
Look for the UL Certification Mark on the



ICMA
Leaders at the Core of Better Communities

9. Grounding/bonding of rack and modules according to the manufacturer’s installation instructions

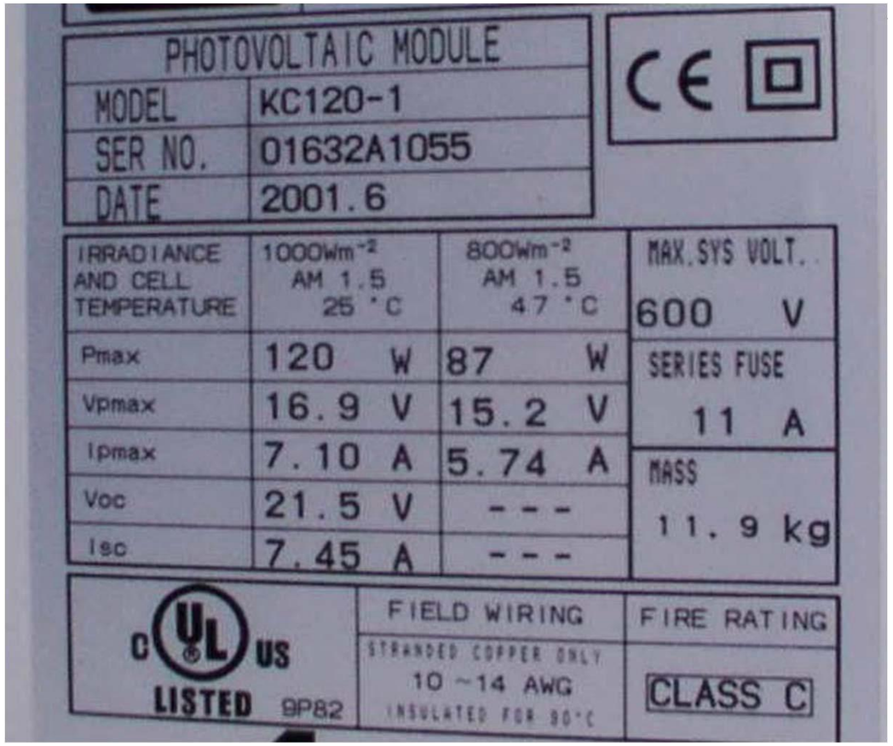




Photos: IBTS

10. Equipment listed and installed according to the approved plan
11. Inverter marked as “utility interactive”

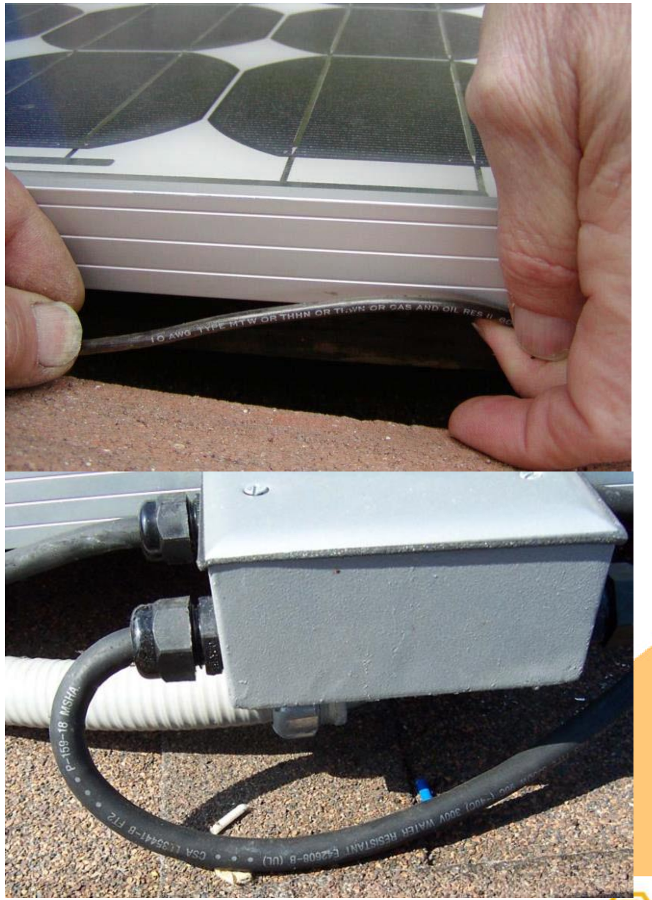
SOLSMART
NATIONALLY DISTINGUISHED. LOCALLY POWERED.



Photos: Brooks Engineering

12. Conductors, cables, and conduit types, sizes, and markings according to the approved plan

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

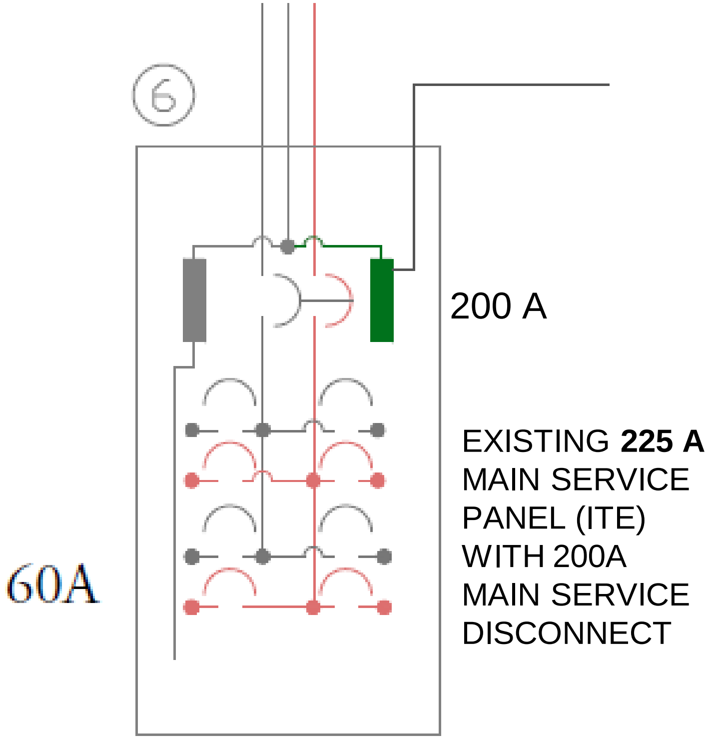


Photos: Brooks Engineering

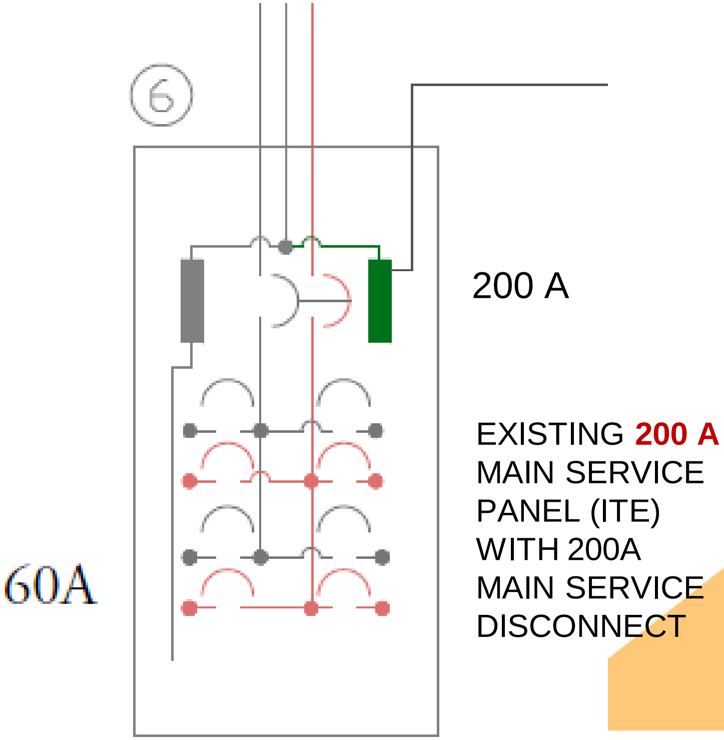
THWN & SJO/SJOW Cord – NO!

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



OK!



NO!

Images: IREC

13. Overcurrent protection devices are the type and size according to the approved plan

Photos: Brooks Engineering

600V 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!

Photos: Brooks Engineering

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

15. Inverter output circuit breaker is located at opposite end of bus from utility supply

Photo: IREC

16. PV System markings, labels, and signs installed according to approved plan

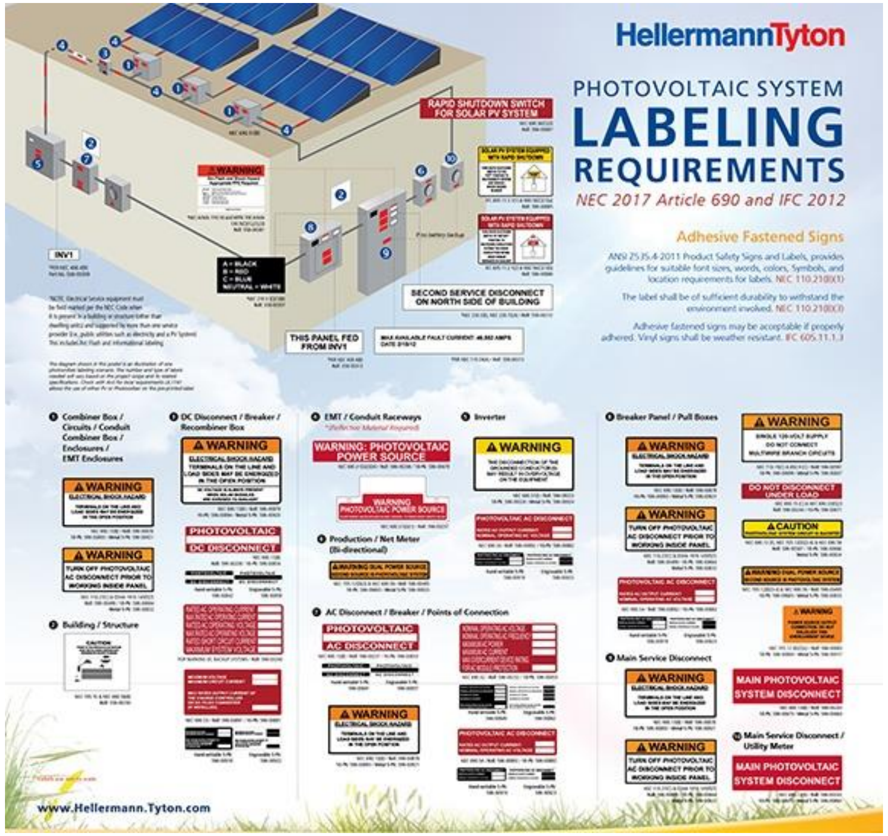


Image: HellermanTyton

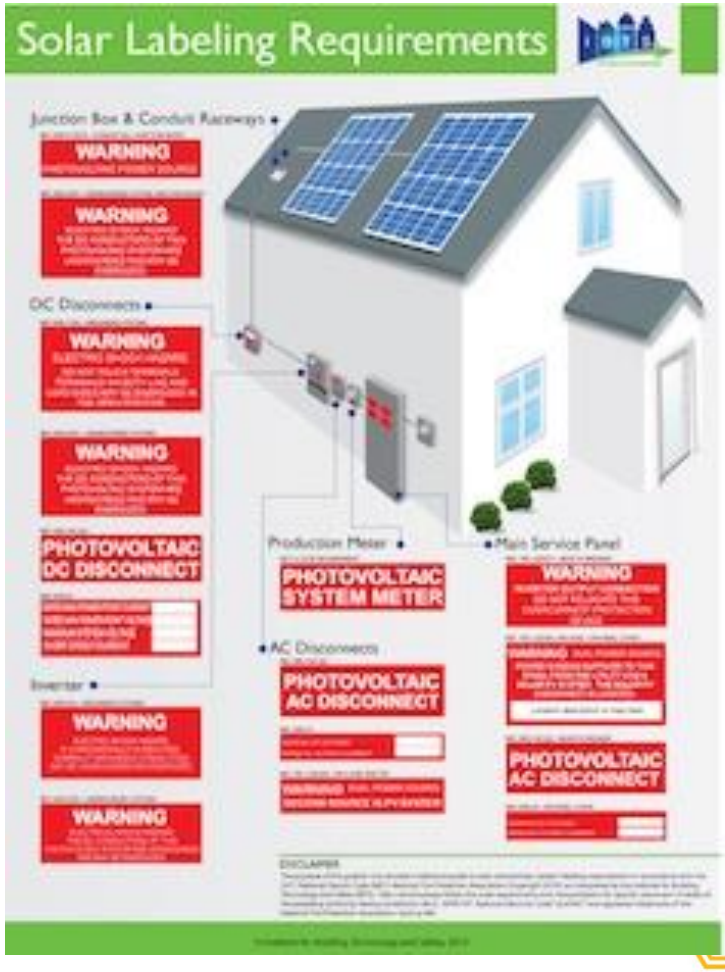


Image: IBTS

17. Connection of the PV system to the grounding electrode system according to approved plan

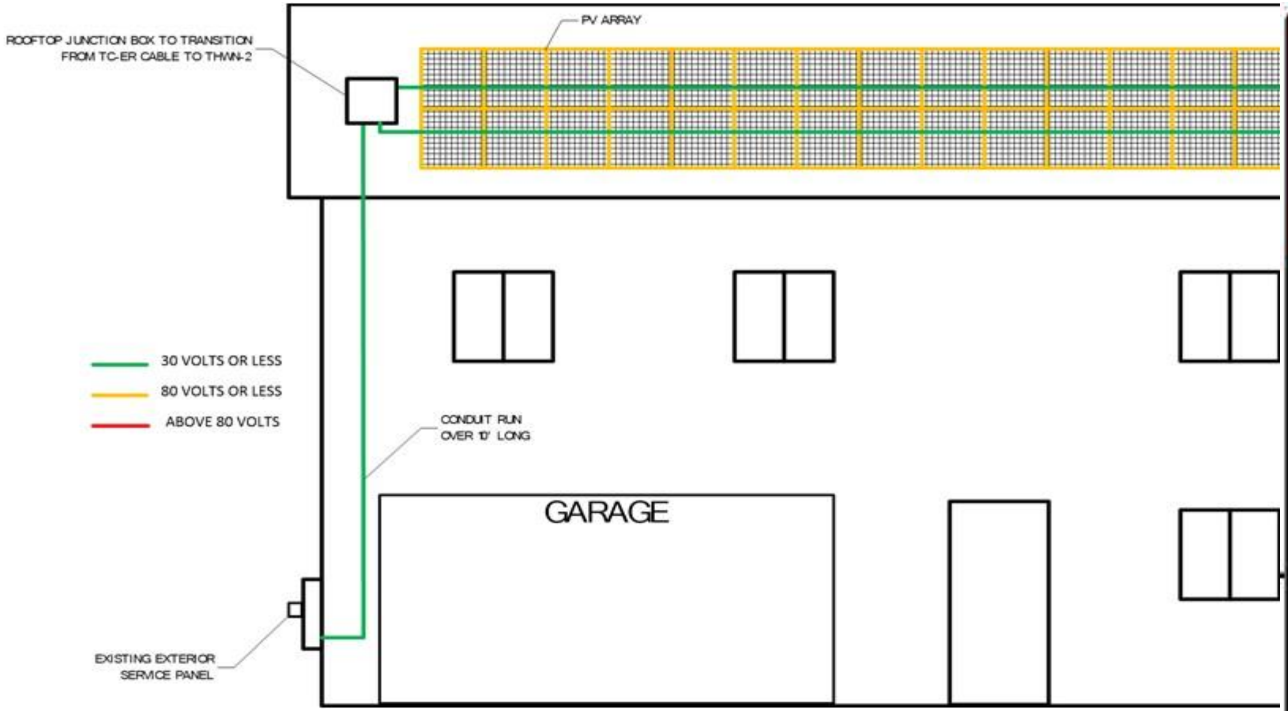
Photo: Cadmus Group

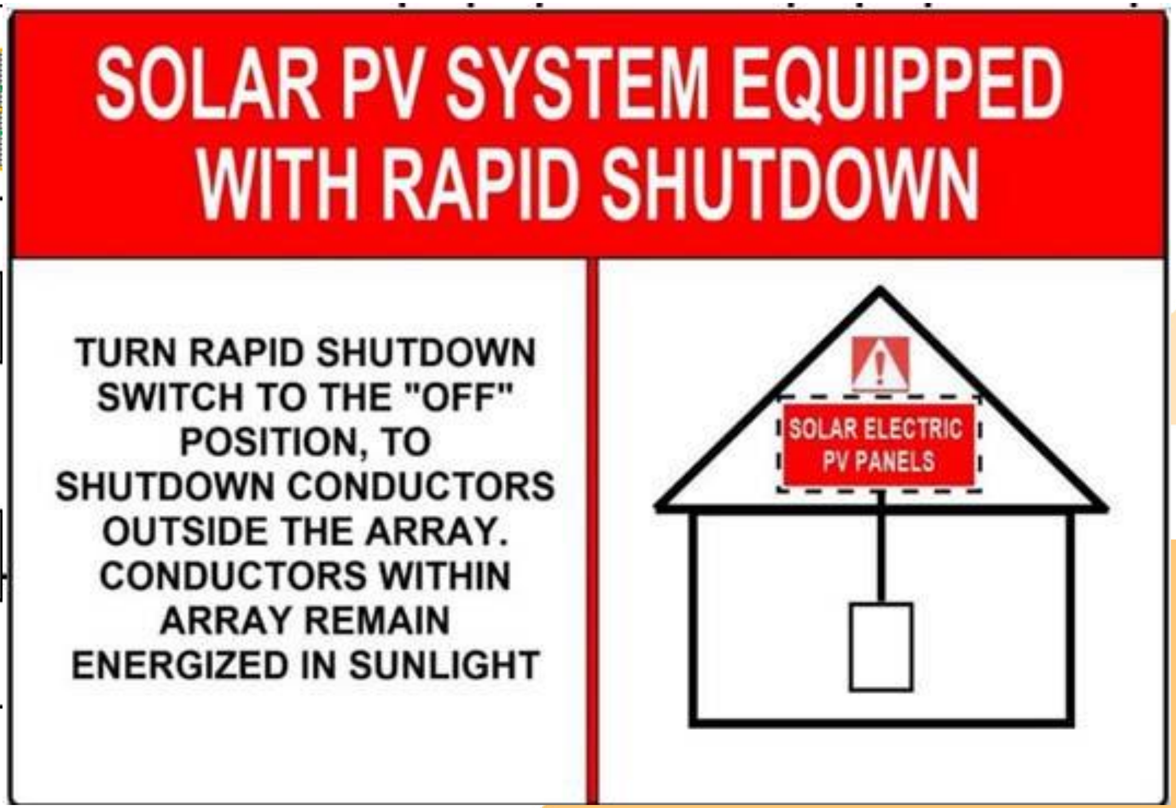
Photo: Brooks Engineering

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:
IREC: irecusa.org/publications/plan-review-and-inspection-guidelines-model-inspection-checklist-for-residential-rooftop-pv/
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:
International Solar Energy Provisions (ISEP), International Code Council
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!

SOLSMART NATIONALLY DISTINGUISHED. LOCALLY POWERED.

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.

Photo: Cadmus Group

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

The SOLAR FOUNDATION for a bright future

ICMA Leaders at the Core of Better Communities

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

David Golembeski

Program and Communications Specialist
The Solar Foundation

T: 202-866-0923
dgolembeski@solarfound.org
www.thesolarfoundation.org | www.solsmart.org
1110 Vermont Ave NW, Suite 930,
Washington, D.C. 20005

Richard Lawrence

Program Director
The Solar Foundation

rlawrence@solarfound.org
TheSolarFoundation.org
1899 L Street, NW, Suite 850
Washington, DC 20036

SOLSMART
NATIONALLY DISTINGUISHED. **LOCALLY POWERED.**

The SOLAR FOUNDATION™
for a bright future

Jon-Paul d'Aversa, AICP

Senior Energy Planner
Mid-Ohio Regional Planning Commission

T: 614.233.4137 | M: 518.429.8889
jpdaversa@morpc.org
111 Liberty Street, Suite 100
Columbus, OH 43215

MID-OHIO REGIONAL
MORPC
PLANNING COMMISSION