Simplified Solar Permitting Guidelines

Improving Permit Review and Inspection for Small Solar Systems

Delaware Valley Regional Planning Commission Training

Bill Brooks, Principal, Brooks Engineering
SIMPLIFIED PV PERMIT GUIDELINES

- The information in these guidelines are intended to provide a format whereby local jurisdictions and contractors can permit simple PV system installations where only a basic review is necessary.

- It is likely that most residential and some small commercial PV systems will comply with these simple criteria that address the requirements for PV systems in the building, electrical, and fire codes.
Guideline Contents

1. **Eligibility List** – Defines the size, electrical, structural, and fire safety requirements for solar installations to qualify for simplified permitting.

2. **Structural Review** – Enable applicants to “fill in the blanks” to explain the structural details of a rooftop solar PV system.

3. **Electrical Review** – Enable applicants to “fill in the blanks” to explain the electrical configuration of a solar PV system.
This Guideline is not intended to create, explicitly or implicitly, any new requirements.

- 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
Required Information for Permit:

1. Permit application required by the local jurisdiction. Permit applications normally include information about the project scope, project location, and the installer.

2. Site plan showing location of major components on the property. This drawing need not be exactly to scale, but it 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).
Required Information for Permit (cont.):

3. Electrical worksheets showing PV array configuration, wiring system, overcurrent protection, inverter, disconnects, required signs, and ac connection to building (see supplied standard electrical diagram).

4. 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.
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.
The “Box” to Qualify Simple Permits

- PV system no larger than 15.36kW
- One- and two-family rooftop installations or structure of same construction.
- String inverter, dc converter, or microinverter
- Complies with eligibility checklist
Overall Limitations of Location

- Snow load no greater than 60 PSF (pounds per square foot).
- Wind load no greater than 150 MPH.
Guidelines Cover Most of 48 States

60 PSF
150 MPH
Guidelines Cover Most of 48 States

60 PSF & Case Study
150 MPH
Wind Case Study

www.solsmart.org
Member Attached Limitations

• Snow load no greater than 60 PSF (pounds per square foot).
• Wind load no greater than 150 MPH
• Not Exposure D (waterfront)
• Not on steep hill (5% grade)
• Roof mean height 40’ or less
• Roof structure meets IRC
• No structural damage
Member-Attached PV 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.
ELIGIBILITY CHECKLIST FOR SIMPLIFIED PV PERMITTING

Member-Attached PV Array Requirements (cont):

- 5. Mounting rail orientation or rail-less module long edges:
  - a. run perpendicular to rafters or trusses, and attached to them

- 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 PV 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.
1. Houses that were built in compliance with building structural codes, can support PV.

2. Single layer of roofing (no second layer of comp).

3. PV modules mounted within 2” and 10” of roof deck.

4. PV array distributed weight less than 4 lb/ft$^2$

5. Typical rafter with supports 48” apart or closer (each anchor row mounted on alternating trusses) meet structural code requirements (represents most of housing stock).
Options for Low Snow and Wind
Member-Attached PV Array Requirements (cont):

☐ 5. Mounting rail orientation or rail-less module long edges:

☐  b. run parallel to rafters and are spaced no more than 4’-0” apart, Ground Snow Load is no greater than 10 psf, and Design Wind Speed does not exceed 120 mph.

☐ 6. 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 (see Figure), 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 Limitations

- Snow load no greater than 60 PSF
- Wind load no greater than 140 MPH
- Not Exposure D (waterfront)
- Not on steep hill (5% grade)
- Roof mean height 30’ or less
- Roof structure meets IRC
- Mfg Truss or Kiln Dry Rafters
- No structural damage
- Tributary area matters
Options for Sheathing Attached
BANDS OF STRENGTH—Middle 16” of Sheet
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.
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.
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.

GENERAL STATEMENT FOR CHECKLIST:

*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.*
Step 2: Electrical PV System Requirements Checklist

For a simplified PV permit, following are the electrical 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 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.
ELIGIBILITY CHECKLIST FOR SIMPLIFIED PV PERMITTING

☐ 4. Field Installed PV array wiring meets the following requirements (all boxes must be checked):
   ☐ a. All exposed PV source circuit wiring is no smaller than 12 AWG PV Wire or MFG Cable.
   ☐ b. All PV source circuit wiring in raceway is no smaller than 12 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(B) where installed on the load side of the service disconnecting means (complies with Table 705.12 in the Electrical Commentary). (choose one below)
   ☐ Load-side connection complying with Table 705.12(B)
   ☐ Supply-side connection complying with 705.12(A)
ELIGIBILITY CHECKLIST FOR SIMPLIFIED PV PERMITTING

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
ELIGIBILITY CHECKLIST FOR SIMPLIFIED PV PERMITTING

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
ELIGIBILITY CHECKLIST FOR SIMPLIFIED PV PERMITTING

7. One of the standard electrical diagrams (E1.1a, E1.1b, E1.1c, or E1.1d) 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.
Central/String Inverter Standard Plans

- Use this plan ONLY for central/string inverter systems with or without dc converters not exceeding 15.36kW on the roof of a one- or two-family dwelling or similar structure.

- 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).
Example 1—7.5kW Central Inverter PV System

PV System Components

PV Modules
- Qty. 30, 285W, American Solar AS285

Inverter
- Qty. 1, 7.5 kW, American Inverter AI-7500

Mounting System
- OmniRack ModMount 5.0; sheathing attached;

House
Form Fill-Out Demonstration

Compliance Document
Standard Plan—Simplified Central Inverter
Structural Criteria—compliant
Sheathing Attached System

**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

30 American Solar AS 285 Modules in 3 Series Strings of 10 Modules Each on Existing Roof Structure

Existing All-in-One Service Equipment with 40-Amp PV Breaker as AC Disconnect

Inverter with Supplied Combiner and DC Disconnect

Rooftop J-Box Under Movable PV Module to Transition Exposed PV Wire to THWN-2 Conductors in 3/4" EMT

Roof Access

www.solsmart.org
Contractor Name, Address and Phone:
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

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

For Unused Series Strings
Put "N/A" in Blank Above

Disregard if Disconnect/Combiner provided with inverter

Equipment Schedule

<table>
<thead>
<tr>
<th>TAG</th>
<th>DESCRIPTION</th>
<th>PART NUMBER</th>
<th>NOTES (N/A IF NOT USED)</th>
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<tbody>
<tr>
<td>1</td>
<td>SOLAR PV MODULE</td>
<td>AS 285</td>
<td>AMERICAN SOLAR, QUANTITY - 30 (SEE NOTES SHEET FOR DETAILS)</td>
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<tr>
<td>2</td>
<td>DC-DC CONVERTER</td>
<td>N/A</td>
<td></td>
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<tr>
<td>3</td>
<td>PV ARRAY OUTPUT 1</td>
<td>2 STRINGS WITH 10 MODULES PER SERIES STRING</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>PV ARRAY OUTPUT 2</td>
<td>1 STRING WITH 10 MODULES PER SERIES STRING</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>PV ARRAY OUTPUT 3</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>J-BOX</td>
<td>6&quot;x6&quot;x4&quot; NEMA 4, PVC JUNCTION BOX</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>ROOFTOP RSD SWITCH</td>
<td>AI-RSD-3</td>
<td>THREE STRING RAPID SHUTDOWN SWITCH FOR AI-7500</td>
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<tr>
<td>8</td>
<td>DC DISCONNECT</td>
<td>MFR-supplied</td>
<td>LISTED WITH INVERTER, 600VDC</td>
</tr>
<tr>
<td>9</td>
<td>DC/AC INVERTER</td>
<td>AI-7500</td>
<td>7500 WATT, SINGLE PHASE (SEE NOTES SHEET FOR DETAILS)</td>
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<tr>
<td>10</td>
<td>GEN METER</td>
<td>FORM 2S</td>
<td>4-JAW, 240V CYCLOMETER REGISTER KWH METER IN 100-A BASE</td>
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<tr>
<td>11</td>
<td>AC DISCONNECT</td>
<td>N/A</td>
<td></td>
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<tr>
<td>12</td>
<td>SERVICE PANEL</td>
<td>SQ.D 200D</td>
<td>240 VAC, 200 A MAIN, 200 A BUS, 40 A INVERTER OCPD</td>
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Conduit and Conductor Schedule

<table>
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<tr>
<th>TAG</th>
<th>DESCRIPTION OR CONDUCTOR TYPE</th>
<th>COND. GAUGE</th>
<th>NUMBER OF CONDUCTORS</th>
<th>CONDUIT SIZE</th>
<th>CONDUIT TYPE</th>
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<tbody>
<tr>
<td>1</td>
<td>USE-2 or PV WIRE</td>
<td>10</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>2</td>
<td>BARE COPPER EGC, GRD. COND. (EGC)</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>3</td>
<td>THWN-2 or XHHW-2 or RHW-2</td>
<td>6</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>THWN-2 or XHHW-2 or RHW-2</td>
<td>6</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>INSULATED EGC</td>
<td>10</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>THWN-2 or XHHW-2 or RHW-2</td>
<td>N/A</td>
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<tr>
<td>7</td>
<td>INSULATED EGC</td>
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PV MODULE RATINGS @ STC (Guide Section 7)

<table>
<thead>
<tr>
<th>MODULE MAKE</th>
<th>AMERICAN SOLAR</th>
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<tbody>
<tr>
<td>MODULE MODEL</td>
<td>A5-285</td>
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<tr>
<td>MAX POWER-POINT CURRENT (I_{MP})</td>
<td>9.20 A</td>
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<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>
</tr>
<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_{OC})</td>
<td>1000 V</td>
</tr>
</tbody>
</table>

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)

<table>
<thead>
<tr>
<th>CONVERTER MAKE</th>
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<tbody>
<tr>
<td>CONVERTER MODEL</td>
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</tr>
<tr>
<td>MAX CURRENT</td>
<td>A</td>
</tr>
<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_{OC})</td>
<td>V</td>
</tr>
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</table>

INVERTER RATINGS (Guide Section 4)

<table>
<thead>
<tr>
<th>INVERTER MAKE</th>
<th>AMERICAN INVERTER</th>
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<tbody>
<tr>
<td>INVERTER MODEL</td>
<td>AI-7500</td>
</tr>
<tr>
<td>MAX DC VOLT RATING</td>
<td>600 V</td>
</tr>
<tr>
<td>MAX POWER @ 40°C</td>
<td>7500 W</td>
</tr>
<tr>
<td>NOMINAL AC VOLTAGE</td>
<td>240 V</td>
</tr>
<tr>
<td>MAX AC CURRENT</td>
<td>31.25 A</td>
</tr>
<tr>
<td>MAX OCPD RATING</td>
<td>40 A</td>
</tr>
</tbody>
</table>

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

| Site Name: __________________________ |
| Site Address: _______________________ |
| System AC Size: ____________________ |

Drawn By: ____________________________  
Checked By: __________________________

E1.2a

Scale: NTS  Date: SHEET

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
Microinverter Standard Plans--Scope

- 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/microinverter, installed on the roof of a one- or two-family dwelling or similar structure.

- The PV system must interconnect to the load side of a 120/240Vac, service panel rated 400A or less (80-amp breaker or less).
Example 2— 7.5kW Microinverter PV System

- PV System Components
  - PV Modules
    - Qty. 30, 285W, American Solar AS285
  - Inverters
    - Qty. 30, 250W, American Inverter AI-250
  - Mounting System
    - OmniRack ModMount 4.0; Maximum span 72”;
  - House
Form Fill-Out Demonstration

Compliance Document
Standard Plan—Simplified Microinverter
Structural Criteria (compliant)
Member Attached System

125-AMP AC SUB PANEL 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)

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

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
## Equipment Schedule

<table>
<thead>
<tr>
<th>TAG</th>
<th>Description</th>
<th>Part Number</th>
<th>Notes</th>
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<tbody>
<tr>
<td>1</td>
<td>PV DC or AC Module</td>
<td>AS 28E</td>
<td>AMERICAN SOLAR, QUANTITY = 20 (SEE NOTES SHEET FOR DETAILS)</td>
</tr>
<tr>
<td>2</td>
<td>DC/AC Inverter (MICRC)</td>
<td>A-290</td>
<td>250 WATT, SINGLE PHASE (SEE NOTES SHEET FOR DETAILS)</td>
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<tr>
<td>3</td>
<td>J-Box (If Used)</td>
<td>6&quot;x8&quot;x4&quot; NEMA 4, PVC JUNCTION BOX</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>PV ARRAY</td>
<td>N/A</td>
<td>220-V AC CIRCUIT W/ 15 MICROINVERTERS PER CIRCUIT</td>
</tr>
<tr>
<td>5</td>
<td>AC COMB. PANEL (If UseC)</td>
<td>SC125SL</td>
<td>240VAC, 125-A MAIN LUG PANEL W/ 40-A BREAKER AS MAIN</td>
</tr>
<tr>
<td>6</td>
<td>GEN METER (If UseC)</td>
<td>FORM 2S</td>
<td>4-JAW, 240V CYCLOMETER REGISTER KWH METER IN 100-A BASE</td>
</tr>
<tr>
<td>7</td>
<td>AC DISCONNECT (If UseC)</td>
<td>D222NRB</td>
<td>240VAC, 30-A AMP UNFUSED (SEE GUIDE APPENDIX C)</td>
</tr>
<tr>
<td>8</td>
<td>SERVICE PANEL</td>
<td>SC200SL</td>
<td>240VAC, 200-A MAIN, 200-A BUS, 30-A INVERTER OCPD</td>
</tr>
</tbody>
</table>

(SEE NOTE 5 FOR INVERTER OCPDs. ALSO SEE GUIDE SECTION 9)

## Conduit and Conductor Schedule

<table>
<thead>
<tr>
<th>TAG</th>
<th>Description or Conductor Type</th>
<th>Cond.</th>
<th>Number of Conductors</th>
<th>Conduit</th>
<th>Conduit</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>USE-2 or PV Wire</td>
<td>MFG</td>
<td>MFG</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>GEC X all that apply</td>
<td>8 AWG</td>
<td>1 BARE CU</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>EXTERIOR CABLE LISTED W/ NV.</td>
<td>MFG</td>
<td>MFG Cable</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>4</td>
<td>THWN-2 or XHHW-2 or RHW-2</td>
<td>12 AWG</td>
<td>2-B, 2-R, 2-W EMG</td>
<td>3/4&quot;</td>
<td>SAME</td>
</tr>
<tr>
<td>5</td>
<td>NO DC GEC IF 69C.35 SYSTEM</td>
<td>8 AWG</td>
<td>1 GREEN</td>
<td>SAME</td>
<td>SAME</td>
</tr>
</tbody>
</table>

## One-Line Standard Electrical Diagram for Micro-Inverter or AC Module PV Systems

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

**Site Name:** John and Jane Homeowner
***Site Address:** 123 Sunnyside St., Boston, MA

**System AC Size:** 4.0 kW

**Drawn By:** Bill
**Checked By:** Ted
**Date:**

---

**Drawing Information:**

**Size:**

**From NO:**

**Dwg NO:**

**Rev:** 0

**Scale:**

**NTS:** Sheet
**NOTES FOR ALL DRAWINGS:**

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

---

**PV MODULE RATINGS @ STC (Guide Section 7)**

<table>
<thead>
<tr>
<th>MODULE MAKE</th>
<th>AMERICAN SOLAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODULE MODEL</td>
<td>AS-285</td>
</tr>
<tr>
<td>MAX POWER-POINT CURRENT (I_{mp})</td>
<td>9.20 A</td>
</tr>
<tr>
<td>MAX POWER-POINT VOLTAGE (V_{mp})</td>
<td>31.3 V</td>
</tr>
<tr>
<td>OPEN-CIRCUIT VOLTAGE (V_{oc})</td>
<td>39.7 V</td>
</tr>
<tr>
<td>SHORT-CIRCUIT CURRENT (I_{sc})</td>
<td>9.84 A</td>
</tr>
<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>
</tbody>
</table>

---

**DC-TO-DC CONVERTER RATINGS (if used)**

<table>
<thead>
<tr>
<th>CONVERTER MAKE</th>
<th>CONVERTER MODEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX CURRENT</td>
<td>A</td>
</tr>
<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>
</tr>
</tbody>
</table>

---

**INVERTER RATINGS (Guide Section 4)**

<table>
<thead>
<tr>
<th>INVERTER MAKE</th>
<th>AMERICAN INVERTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>INVERTER MODEL</td>
<td>AI-250</td>
</tr>
<tr>
<td>MAX DC VOLT RATING</td>
<td>60 V</td>
</tr>
<tr>
<td>MAX POWER @ 40°C</td>
<td>250 W</td>
</tr>
<tr>
<td>NOMINAL AC VOLTAGE</td>
<td>240 V</td>
</tr>
<tr>
<td>MAX AC CURRENT</td>
<td>1.04 A</td>
</tr>
<tr>
<td>MAX OCPD RATING</td>
<td>20 A</td>
</tr>
</tbody>
</table>

---

**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**

---

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

**SITE NAME:** __________________________

**SITE ADDRESS:** ________________________

**SYSTEM AC SIZE:** ______________________

---

**Drawn By:** ____________________________

**Checked By:** __________________________

---

**CONTRACTOR NAME:** ______________________

**ADDRESS AND PHONE:** ______________________

---

**SIZE** | **FSCM NO** | **DWG NO** | **REV**
---|---|---|---
E1.2a | | | |

**SCALE** | **NTS** | **DATE** | **SHEET**
---|---|---|---

---

**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**

---

**NOTES:**

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