DVRPC Solar Permitting Guide (Draft)

This guide references material from the following Solar PV Permitting Guidebooks:

Connecticut Rooftop Solar PV Permitting Guide. Energize Connecticut. 2014.
http://www.energizect.com/sites/default/files/uploads/%281%29%20CT%20Rooftop%20Solar%20PV%20Permitting%20Guide%20v1.0.pdf

Zoning and Permitting Solar in Your Municipality. PennFuture. 2012.
http://www.pennfuture.org/SunShot/SunSHOT_Guide.pdf

Recommended Model Permitting Processes and Structural Review Guidance for Rooftop Solar PV in Massachusetts. Massachusetts Department of Energy Resources. 2013.
http://www.mass.gov/eea/docs/doer/renewables/solar/recommended-model-permitting.pdf

Expedited Permit Process for Solar PV Systems. Solar America Board of Codes and Standards. 2012.
http://www.solarabcs.org/about/publications/reports/expedited-permit/pdfs/Expermitprocess.pdf

Step-by-Step Application process:

The following step-by-step application process outlines useful information, checklists, templates, and other materials that municipalities can use to supplement and enhance existing solar PV processes in a way that will make the process easier for the municipality and the applicant. The information in this guide is not intended to wholly replace existing permitting processes – and in many cases provides information that applicants will submit in addition to an existing building/electrical permit application. The recommended submittals for applicants who wish to obtain a permit for small scale solar PV include:

1. Municipalities existing permit application
2. Questionnaire for Additional Information (system information (basic site, and electrical information), property information, information not typically gathered in standard application).
3. Site Plan
4. Electrical diagram
5. Roof Mounted attachments?
6. Structural Questionnaire (for municipalities that wish to streamline the process).
7. Specification Sheets for PV panels, inverters, and all manufactured equipment.
8. Pole Mount or Ground Mount Information (if applicable):*

This section of the Guide explains each step in detail, provides template application materials and fill-in diagrams, and for the structural questionnaire provides detail on how to review an applicant's responses.

Prerequisite: Municipalities will need to determine

1. whether they wish to streamline the building and electrical permits for installations that meet certain requirements; or
2. allow prescriptive review of structural integrity for installations that meet certain requirements

Proposed outline for Step-by-Step Application process (In order to complete the permit package, the applicant is required to provide the following):

1.The municipality's existing permit application(s), completed (electrical and building, if required).

Applicants should be required to complete the municipality's existing permit application. If the municipality decides to streamline the building and electrical permit process, the municipality can provide a flowchart for applicants to determine whether their project will be eligible for a streamlined building and electrical permit, or whether separate permit applications (building and electrical) will be necessary.

Additional material will be required for applicants to be approved for a building or electrical permit for a solar PV system. Municipalities will need to reference these additional requirements in addendums to the application, similar to how a municipality may reference additional requirements for a roof deck or in-ground pool. Language for how municipalities can reference this additional material is provided below:

2. **Additional information about the applicant and the project.** This two-page addendum to the application will ask for important information relevant to a solar PV system that is not typically asked for in a municipality's standard electric or building permit application. This information includes system information (basic site, and electrical information), property information, information not typically gathered in standard application.

Brief System Description (eg, number and power rating of panels; total combined power rating of system; panel and inverter manufacturer; inverter/microinverter output, location of system on property)

_____
_____
_____

Address of Project _____

Property Owner
Name:_____
Address: _____
Phone: _____
E-mail _____

Owner of Solar PV System
Name_____
Address: _____
Phone: _____
E-mail _____

Installation company The System must be installed by a contractor licensed by the Commonwealth of Pennsylvania
Name_____
Address: _____
Phone: _____
E-mail _____
HIC# _____

Installer Qualifications
□ NABCEP certified solar equipment installer
□ UL certified solar equipment installer
□ Electrical contractor with a license accepted by the municipality
Installer Name

Building Information (For Roof-Mounted Systems Only)

Building Type (e.g. house, shed, barn, slab):_____
Building Height (in feet):_____
Is the building permitted? Yes No NA
If no, reason:_____
Are there other permits associated with this application? Yes No
Describe:_____

Electrical Description

Size (amps) and type (phase, voltage) of electrical service: _____

Amperage of main breaker:_____

Will the value of main breaker change? Yes No To:_____

Rated amperage of the bus bar in the main panel:_____

Type of interconnection (e.g. breaker-load side, supply-side interconnect):_____

Electrical panel location:_____

If load-side interconnect, will solar intertie into a subpanel? Yes No

If yes, rated amperage of the subpanel bus bar?_____

Value of breaker protecting subpanel bus bar?_____

Attachments for application (See Instructions on the next page, followed by Example Attachments)

1. Additional Subcontractors and Information
2. One-Line Electrical Drawing
3. One-Line Site Plan Drawing
4. Attachment Details (Line Drawing)*
5. Solar PV Module Specification Sheets From Manufacturer
6. Inverter Specification Sheets From Manufacturer
7. Pole or Ground Mount Information (if applicable)*
8. Structural Review Worksheet (if applicable)
9. Additional Information for Large Solar PV Systems (as Specified by the Municipality)

* **NOTE:** Applicants should submit either Attachment 4 for roof-mounted systems OR Attachment 7 for pole/ground-mounted systems, not both.

3. **Site plan.** A site plan must be submitted showing location of major components on the property. This drawing need not be to scale, but it should represent relative location of components at site. (see supplied example site plan).
   Explanation: This is a simple diagram to show where the equipment is located on the property. This can be a zone-clearance plot plan with the equipment clearly shown and identified on the plan. If PV array is ground-mounted, clearly show that system will be mounted within allowable zoned setbacks. See site plan example drawing in permit process for reference

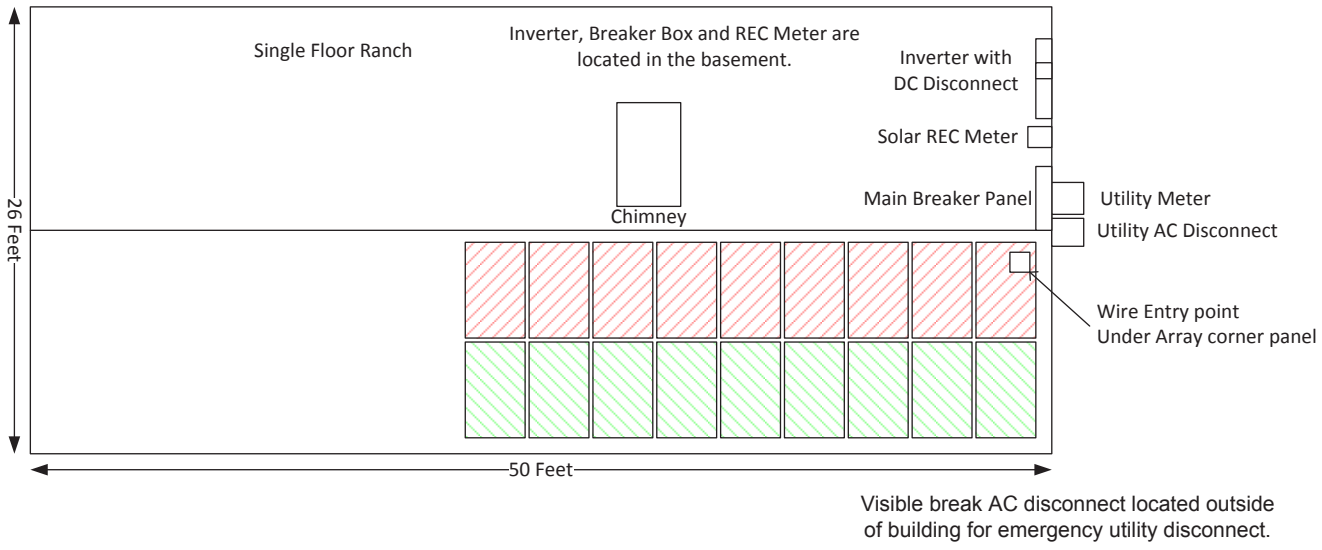
   One-Line Site Plan Drawing Must Show:

   - Location of solar panels
   - Location of Inverters and major equipment
   - Location of roof obstructions (Vents, Chimneys, etc.)
   - Location of Main Breaker Panel
   - Location of Utility Meter
   - Location of AC disconnect
   - Location of batteries and/or charge controllers (If Appropriate)
   - Location of solar metering (If Appropriate)
   - Planned conduit path (Encouraged, Not Required)
   - Gross dimensions of structure (If Appropriate)
   - Approximate layout of building or other structure (If Appropriate)
   - Property lines, zoning, and setback considerations (If Appropriate)
   - Trenching details: Location, Depth and Length of Trench (If Appropriate)
   - A notation indicating scale —or not to scale (Both are Acceptable)

See sample One Line Site Plan on the following page.

Source: Connecticut Rooftop Solar PV Permitting Guide:
http://www.energizect.com/sites/default/files/uploads/%281%29%20CT%20Rooftop%20Solar%20PV%20Permitting%20Guide%20v1.0.pdf

Sample Solar PV
One Line Site Plan



Visible break AC disconnect located outside of building for emergency utility disconnect.

S

Installion Company Name **Contact Name** **Phone** **860 123-4567** **Installer Address** **Town, CT**	Property Owner Street Address Town, CT
	Drawing Number 101 Revision 1
	Month Day, Year Drawn By Name of Designer

4. **Electrical diagram** showing PV array configuration, wiring system, overcurrent protection, inverter, disconnects, required signs, and ac connection to building (see supplied standard electrical diagram). *Must show:*
    a. Size of electrical service
        i. Size of Main Breaker
        ii. Size of Bus Bar (If Known)
    b. Type of electrical service
    c. If interconnection point is a subpanel
        i. Size of Subpanel Main Breaker
        ii. Size of Subpanel Bus Bar (If Known)
    d. Nominal power of solar system (Watts)
        i. DC Capacity: Nameplate "STC" Value of all panels, watts
        ii. AC Capacity: Total AC capacity of Inverters, watts
    e. Batteries (If Present): Type, Quantity, Nominal Voltage, Capacity kWh
        i. H_2 mitigation methods (If Necessary)
    f. Interconnection method
        i. Size of overcurrent protection
    g. Number, type and electrical configuration of solar panels
    h. Number and type of Inverters
    i. Values for source stickers: NEC 690.53; NEC 690.54 (Encouraged, Not Required)
    j. Wiring methods
        i. Wire Type(s), Size
        ii. Conduit Type(s), Size
    k. Solar metering (If Appropriate)
    l. Electrical current contribution from all PV sources
        i. • Electrical grounding details: Wire Type, Size, GEC

Municipalities should determine whether they are willing to accept a 3-line diagram, or require a 1-line diagram. Several templates will need to be provided - 1 line, 3 line, systems with use of microinverters. Explanation: The cornerstone of a simplified permit process is the ability to express the electrical design with a generic electrical diagram. This diagram has been designed to accurately represent the majority of single-phase, residential-sized PV systems. PV systems may vary dramatically in PV array layout and inverter selection. However, the majority of small-scale, residential-sized PV systems can be accurately represented by this diagram. This diagram must be fully completed filled out in order for the permit package to be submitted.

See sample Electrical Diagrams on the following eight pages. Notes pages and template diagrams included for:

1. Standard String

2. Micro inverter

3. AC systems

4. Supply side systems

Source:

Expedited Permit Process for Solar PV Systems. Solar America Board of Codes and Standards. 2012. http://www.solarabcs.org/about/publications/reports/expedited-permit/pdfs/Expermitprocess.pdf

NOTES FOR STANDARD STRING SYSTEM ELECTRICAL DIAGRAM

PV MODULE RATINGS @ STC (Guide Section 5)

MODULE MAKE	
MODULE MODEL	
MAX POWER-POINT CURRENT (I_{MP})	A
MAX POWER-POINT VOLTAGE (V_{MP})	V
OPEN-CIRCUIT VOLTAGE (V_{OC})	V
SHORT-CIRCUIT CURRENT (I_{SC})	A
MAX SERIES FUSE (OCPD)	A
MAXIMUM POWER (P_{MAX})	W
MAX VOLTAGE (TYP 600V_{DC})	V
VOC TEMP COEFF (mV/°C☐ or %/°C☐)	
IF COEFF SUPPLIED, CIRCLE UNITS	

NOTES FOR ALL DRAWINGS:

OCPD = OVERCURRENT PROTECTION DEVICE

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

INVERTER RATINGS (Guide Section 4)

INVERTER MAKE	
INVERTER MODEL	
MAX DC VOLT RATING	V
MAX POWER @ 40°C	W
NOMINAL AC VOLTAGE	V
MAX AC CURRENT	A
MAX OCPD RATING	A

SIGNS–SEE GUIDE SECTION 7

SIGN FOR DC DISCONNECT

PHOTOVOLTAIC POWER SOURCE	
RATED MPP CURRENT	A
RATED MPP VOLTAGE	V
MAX SYSTEM VOLTAGE	V
MAX CIRCUIT CURRENT	A
WARNING: ELECTRICAL SHOCK HAZARD–LINE AND LOAD MAY BE ENERGIZED IN OPEN POSITION	

SIGN FOR INVERTER OCPD AND AC DISCONNECT (IF USED)

SOLAR PV SYSTEM AC POINT OF CONNECTION	
AC OUTPUT CURRENT	A
NOMINAL AC VOLTAGE	V
THIS PANEL FED BY MULTIPLE SOURCES (UTILITY AND SOLAR)	

NOTES FOR ARRAY CIRCUIT WIRING (Guide Section 6 and 8 and Appendix D):

1.) LOWEST EXPECT AMBIENT TEMPERATURE BASED ON ASHRAE MINIMUM MEAN EXTREME DRY BULB TEMPERATURE FOR ASHRAE LOCATION MOST SIMILAR TO INSTALLATION LOCATION. LOWEST EXPECTED AMBIENT TEMP _____°C

2.) HIGHEST CONTINUOUS AMBIENT TEMPERATURE BASED ON ASHRAE HIGHEST MONTH 2% DRY BULB TEMPERATURE FOR ASHRAE LOCATION MOST SIMILAR TO INSTALLATION LOCATION. HIGHEST CONTINUOUS TEMPERATURE _____°C

2.) 2005 ASHRAE FUNDEMENTALS 2% DESIGN TEMPERATURES DO NOT EXCEED 47°C IN THE UNITED STATES (PALM SPRINGS, CA IS 44.1°C). FOR LESS THAN 9 CURRENT-CARRYING CONDUCTORS IN ROOF-MOUNTED SUNLIT CONDUIT AT LEAST 0.5" ABOVE ROOF AND USING THE OUTDOOR DESIGN TEMPERATURE OF 47°C OR LESS (ALL OF UNITED STATES),

a) 12 AWG, 90°C CONDUCTORS ARE GENERALLY ACCEPTABLE FOR MODULES WITH Isc OF 7.68 AMPS OR LESS WHEN PROTECTED BY A 12-AMP OR SMALLER FUSE.
b) 10 AWG, 90°C CONDUCTORS ARE GENERALLY ACCEPTABLE FOR MODULES WITH Isc OF 9.6 AMPS OR LESS WHEN PROTECTED BY A 15-AMP OR SMALLER FUSE.

NOTES FOR INVERTER CIRCUITS (Guide Section 8 and 9):

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 PHOTOVOLTAIC POWER SOURCE (DC) CONDUCTORS BASED ON MAX CURRENT ON NEC 690.53 SIGN OR OCPD RATING AT DISCONNECT

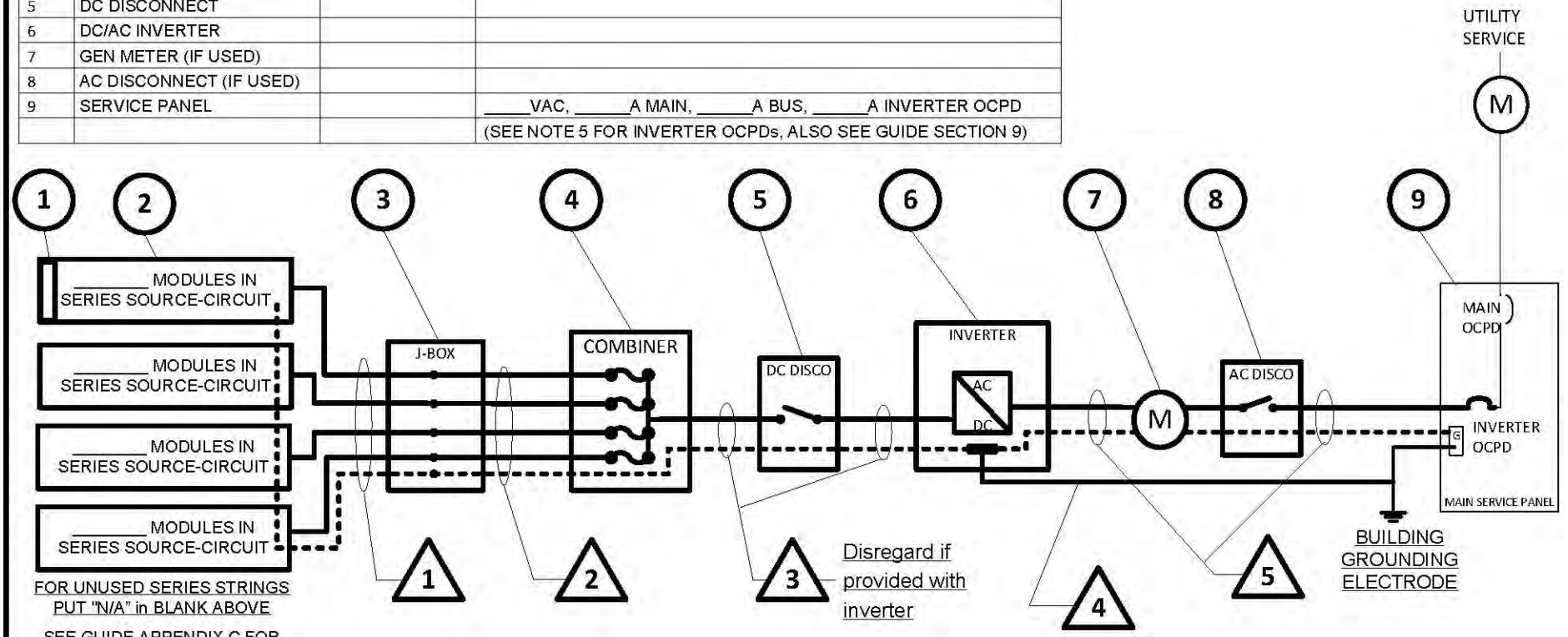
4) SIZE INVERTER OUTPUT CIRCUIT (AC) CONDUCTORS ACCORDING TO INVERTER OCPD AMPERE RATING. (See Guide Section 9)

5) TOTAL OF _____ INVERTER OCPD(s), ONE FOR EACH INVERTER. DOES TOTAL SUPPLY BREAKERS COMPLY WITH 120% BUSBAR EXCEPTION IN 690.64(B)(2)(a)? YES ☐ NO ☐

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	REV
Checked By:	SCALE NTS	Date:	SHEET	

STANDARD STRING SYSTEM SYSTEM ELECTRICAL DIAGRAM

EQUIPMENT SCHEDULE			
TAG	DESCRIPTION	PART NUMBER	NOTES
1	SOLAR PV MODULE		
2	PV ARRAY		
3	J-BOX (IF USED)		
4	COMBINER (IF USED)		
5	DC DISCONNECT		
6	DC/AC INVERTER		
7	GEN METER (IF USED)		
8	AC DISCONNECT (IF USED)		
9	SERVICE PANEL		_____VAC, _____A MAIN, _____A BUS, _____A INVERTER OCPD
			(SEE NOTE 5 FOR INVERTER OCPDs, ALSO SEE GUIDE SECTION 9)



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

SEE GUIDE APPENDIX C FOR INFORMATION ON MODULE AND ARRAY GROUNDING

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

Contractor Name, Address and Phone:

_____
_____
_____
_____

Drawn By:

Checked By:

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

Site Name: _____

Site Address: _____

System AC Size: _____

SIZE	FSCM NO	DWG NO	REV

SCALE NTS | Date: | SHEET

NOTES FOR MICRO-INTVERTER ELECTRICAL DIAGRAM

PV MODULE RATINGS @ STC (Guide Section 5)

MODULE MAKE	
MODULE MODEL	
MAX POWER-POINT CURRENT (I_{MP})	
MAX POWER-POINT VOLTAGE (V_{MP})	
OPEN-CIRCUIT VOLTAGE (V_{OC})	
SHORT-CIRCUIT CURRENT (I_{SC})	
MAX SERIES FUSE (OCPD)	
MAXIMUM POWER (P_{MAX})	
MAX VOLTAGE (TYP 600V_{DC})	
VOC TEMP COEFF (mV/°C ☐ or %/°C ☐)	
IF COEFF SUPPLIED, CIRCLE UNITS	

NOTES FOR ALL DRAWINGS:

OCPD = OVERCURRENT PROTECTION DEVICE

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

INVERTER RATINGS (Guide Section 4)

INVERTER MAKE	
INVERTER MODEL	
MAX DC VOLT RATING	
MAX POWER @ 40°C	
NOMINAL AC VOLTAGE	
MAX AC CURRENT	
MAX OCPD RATING	

SIGNS–SEE GUIDE SECTION 7

SIGN FOR DC DISCONNECT

No sign necessary since 690.51 marking on PV module covers needed information

SIGN FOR INVERTER OCPD AND AC DISCONNECT (IF USED)

SOLAR PV SYSTEM AC POINT OF CONNECTION	
AC OUTPUT CURRENT	
NOMINAL AC VOLTAGE	
THIS PANEL FED BY MULTIPLE SOURCES (UTILITY AND SOLAR)	

NOTES FOR ARRAY CIRCUIT WIRING (Guide Section 6 and 8 and Appendix E):

1.) LOWEST EXPECT AMBIENT TEMPERATURE BASED ON ASHRAE MINIMUM MEAN EXTREME DRY BULB TEMPERATURE FOR ASHRAE LOCATION MOST SIMILAR TO INSTALLATION LOCATION. LOWEST EXPECTED AMBIENT TEMP ____°C

2.) HIGHEST CONTINUOUS AMBIENT TEMPERATURE BASED ON ASHRAE HIGHEST MONTH 2% DRY BULB TEMPERATURE FOR ASHRAE LOCATION MOST SIMILAR TO INSTALLATION LOCATION. HIGHEST CONTINUOUS TEMPERATURE ____°C

2.) 2009 ASHRAE FUNDAMENTALS 2% DESIGN TEMPERATURES DO NOT EXCEED 47°C IN THE UNITED STATES (PALM SPRINGS, CA IS 44.1°C). FOR LESS THAN 9 CURRENT-CARRYING CONDUCTORS IN ROOF-MOUNTED SUNLIT CONDUIT AT LEAST 0.5" ABOVE ROOF AND USING THE OUTDOOR DESIGN TEMPERATURE OF 47°C OR LESS (ALL OF UNITED STATES),

a) 12 AWG, 90°C CONDUCTORS ARE GENERALLY ACCEPTABLE FOR MODULES WITH Isc OF 7.68 AMPS OR LESS WHEN PROTECTED BY A 12-AMP OR SMALLER FUSE.
b) 10 AWG, 90°C CONDUCTORS ARE GENERALLY ACCEPTABLE FOR MODULES WITH Isc OF 9.6 AMPS OR LESS WHEN PROTECTED BY A 15-AMP OR SMALLER FUSE.

NOTES FOR INVERTER CIRCUITS (Guide Section 8 and 9):

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 PHOTOVOLTAIC POWER SOURCE (DC) CONDUCTORS BASED ON MAX CURRENT ON NEC 690.53 SIGN OR OCPD RATING AT DISCONNECT

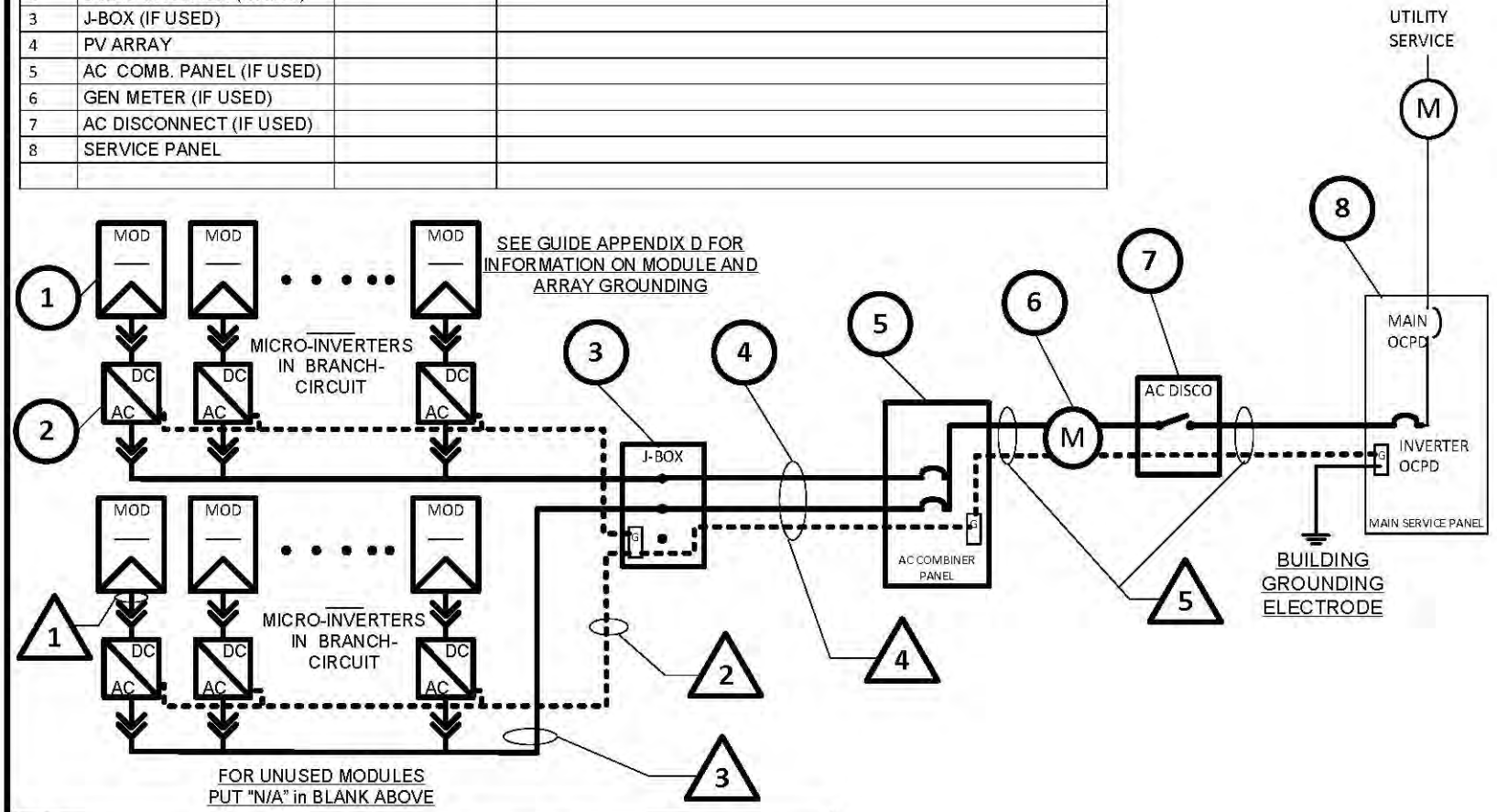
4) SIZE INVERTER OUTPUT CIRCUIT (AC) CONDUCTORS ACCORDING TO INVERTER OCPD AMPERE RATING. (See Guide Section 9)

5) TOTAL OF _____ INVERTER OUTPUT CIRCUIT OCPD(s), ONE FOR EACH MICRO-INVERTER CIRCUIT. DOES TOTAL SUPPLY BREAKERS COMPLY WITH 120% BUSBAR EXCEPTION IN 690.64(B)(2)(a)? YES☐ NO☐

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	PSCM NO	DWG NO	REV
Checked By:	SCALE NTS	Date:	SHEET	

MICRO-INVERTER ELECTRICAL DIAGRAM

EQUIPMENT SCHEDULE			
TAG	DESCRIPTION	PART NUMBER	NOTES
1	PV DC or AC MODULE		
2	DC/AC INVERTER (MICRO)		
3	J-BOX (IF USED)		
4	PV ARRAY		
5	AC COMB. PANEL (IF USED)		
6	GEN METER (IF USED)		
7	AC DISCONNECT (IF USED)		
8	SERVICE PANEL		



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			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 ☐				
	GEC ☐ EGC ☐ X ALL THAT APPLY			SAME	SAME
	NO DC GEC IF 690.35 SYSTEM				
5	THWN-2 ☐ or XHHW-2 ☐ or RHW-2 ☐				
	GEC ☐ EGC ☐ X ALL THAT APPLY			SAME	SAME

Contractor Name, Address and Phone:	One-Line Standard Electrical Diagram for Micro-Inverter PV Systems
	Site Name:
	Site Address:
	System AC Size:
Drawn By:	SIZE / FSCM NO / DWG NO / REV
Checked By:	SCALE: NTS / Date: / SHEET

NOTES FOR AC MODULE DIAGRAM

NOTES FOR ALL DRAWINGS:

OCPD = OVERCURRENT PROTECTION DEVICE

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

AC MODULE RATINGS (Guide Appendix C)

AC MODULE MAKE	
AC MODULE MODEL	
NOMINAL OPERATING AC VOLTAGE	
NOMINAL OPERATING AC FREQUENCY	
MAXIMUM AC POWER	
MAXIMUM AC CURRENT	
MAXIMUM OCPD RATING	

SIGNS–SEE GUIDE SECTION 7

SIGN FOR DC DISCONNECT

N/A since no dc wiring

SIGN FOR INVERTER OCPD AND AC DISCONNECT (IF USED)

SOLAR PV SYSTEM AC POINT OF CONNECTION	
AC OUTPUT CURRENT	
NOMINAL AC VOLTAGE	
THIS PANEL FED BY MULTIPLE SOURCES (UTILITY AND SOLAR)	

NOTES FOR ARRAY CIRCUIT WIRING (Guide Section 6 and 8 and Appendix F):

1.) LOWEST EXPECT AMBIENT TEMPERATURE BASED ON ASHRAE MINIMUM MEAN EXTREME DRY BULB TEMPERATURE FOR ASHRAE LOCATION MOST SIMILAR TO INSTALLATION LOCATION. LOWEST EXPECTED AMBIENT TEMP ____°C

2.) HIGHEST CONTINUOUS AMBIENT TEMPERATURE BASED ON ASHRAE HIGHEST MONTH 2% DRY BULB TEMPERATURE FOR ASHRAE LOCATION MOST SIMILAR TO INSTALLATION LOCATION. HIGHEST CONTINUOUS TEMPERATURE ___°C

2.) 2009 ASHRAE FUNDAMENTALS 2% DESIGN TEMPERATURES DO NOT EXCEED 47°C IN THE UNITED STATES (PALM SPRINGS, CA IS 44.1°C). FOR 6 OR LESS CURRENT-CARRYING CONDUCTORS IN ROOF-MOUNTED SUNLIT CONDUIT AT LEAST 0.5" ABOVE ROOF AND USING THE OUTDOOR DESIGN TEMPERATURE OF 47°C OR LESS (ALL OF UNITED STATES),

a) 12 AWG, 90°C CONDUCTORS ARE GENERALLY ACCEPTABLE FOR AC MODULES INVERTER OUTPUT CIRCUITS WITH 12 AMPS OR LESS WHEN PROTECTED BY A 15-AMP OR SMALLER OCPD.

b) 10 AWG, 90°C CONDUCTORS ARE GENERALLY ACCEPTABLE FOR AC MODULES INVERTER OUTPUT CIRCUITS WITH 16 AMPS OR LESS WHEN PROTECTED BY A 20-AMP OR SMALLER OCPD.

NOTES FOR INVERTER CIRCUITS (Guide Section 8 and 9):

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 PHOTOVOLTAIC POWER SOURCE (DC) CONDUCTORS BASED ON MAX CURRENT ON NEC 690.53 SIGN OR OCPD RATING AT DISCONNECT (N/A)

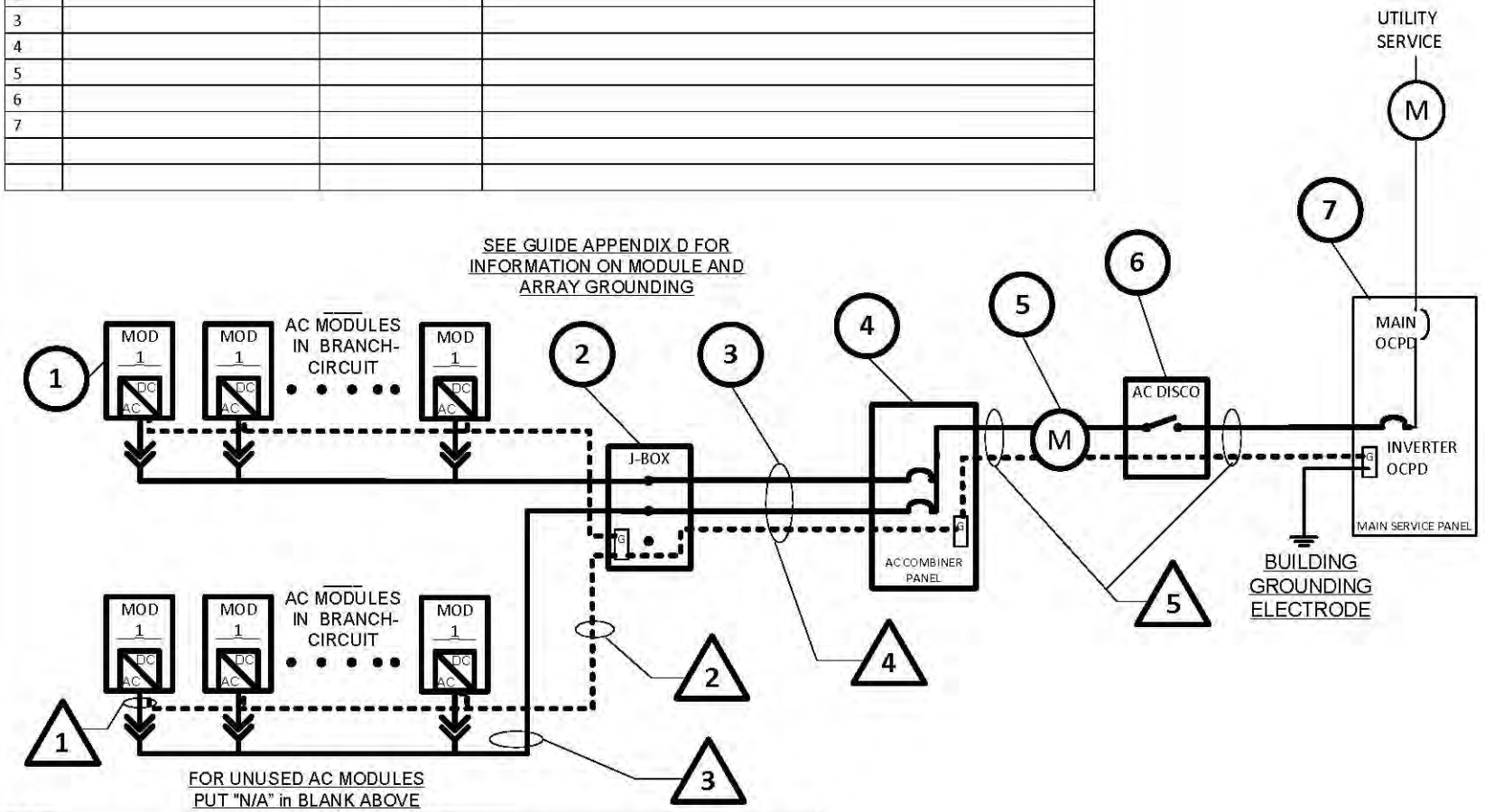
4) SIZE INVERTER OUTPUT CIRCUIT (AC) CONDUCTORS ACCORDING TO INVERTER OCPD AMPERE RATING. (See Guide Section 9)

5) TOTAL OF _____ INVERTER OUTPUT CIRCUIT OCPD(s), ONE FOR EACH AC MODULE CIRCUIT. DOES TOTAL SUPPLY BREAKERS COMPLY WITH 120% BUSBAR EXCEPTION IN 690.64(B)(2)(a)? YES ☐ NO ☐

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	REV
Checked By:	SCALE NTS	Date:	SHEET	

AC MODULE ELECTRICAL DIAGRAM

EQUIPMENT SCHEDULE			
TAG	DESCRIPTION	PART NUMBER	NOTES
1			
2			
3			
4			
5			
6			
7			



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			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 ☐				
	GEC ☐ EGC ☐ X ALL THAT APPLY				
	NO DC GEC IF 690.35 SYSTEM				
5	THWN-2 ☐ or XHHW-2 ☐ or RHW-2 ☐				
	GEC ☐ EGC ☐ X ALL THAT APPLY				

Contractor Name, Address and Phone:	One-Line Standard Electrical Diagram for AC Module PV Systems
	Site Name:
	Site Address:
	System AC Size:
Drawn By:	SIZE / FSCM NO / DWG NO / REV
Checked By:	SCALE NTS / Date: / SHEET

NOTES FOR SUPPLY-SIDE CONNECTION ELECTRICAL DIAGRAM

PV MODULE RATINGS @ STC (Guide Section 5)

MODULE MAKE	
MODULE MODEL	
MAX POWER-POINT CURRENT (I_{MP})	A
MAX POWER-POINT VOLTAGE (V_{MP})	V
OPEN-CIRCUIT VOLTAGE (V_{OC})	V
SHORT-CIRCUIT CURRENT (I_{SC})	A
MAX SERIES FUSE (OCPD)	A
MAXIMUM POWER (P_{MAX})	W
MAX VOLTAGE (TYP 600V_{DC})	V
VOC TEMP COEFF (mV/°C☐ or %/°C☐)	
IF COEFF SUPPLIED, CIRCLE UNITS	

NOTES FOR ALL DRAWINGS:

OCPD = OVERCURRENT PROTECTION DEVICE

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

INVERTER RATINGS (Guide Section 4)

INVERTER MAKE	
INVERTER MODEL	
MAX DC VOLT RATING	V
MAX POWER @ 40°C	W
NOMINAL AC VOLTAGE	V
MAX AC CURRENT	A
MAX OCPD RATING	A

SIGNS–SEE GUIDE SECTION 7

SIGN FOR DC DISCONNECT

PHOTOVOLTAIC POWER SOURCE	
RATED MPP CURRENT	A
RATED MPP VOLTAGE	V
MAX SYSTEM VOLTAGE	V
MAX CIRCUIT CURRENT	A
WARNING: ELECTRICAL SHOCK HAZARD–LINE AND LOAD MAY BE ENERGIZED IN OPEN POSITION	

SIGN FOR INVERTER OCPD AND AC DISCONNECT (IF USED)

SOLAR PV SYSTEM AC POINT OF CONNECTION	
AC OUTPUT CURRENT	A
NOMINAL AC VOLTAGE	V
THIS PANEL FED BY MULTIPLE SOURCES (UTILITY AND SOLAR)	

NOTES FOR ARRAY CIRCUIT WIRING (Guide Section 6 and 8 and Appendix D):

1.) LOWEST EXPECT AMBIENT TEMPERATURE BASED ON ASHRAE MINIMUM MEAN EXTREME DRY BULB TEMPERATURE FOR ASHRAE LOCATION MOST SIMILAR TO INSTALLATION LOCATION. LOWEST EXPECTED AMBIENT TEMP _____°C

2.) HIGHEST CONTINUOUS AMBIENT TEMPERATURE BASED ON ASHRAE HIGHEST MONTH 2% DRY BULB TEMPERATURE FOR ASHRAE LOCATION MOST SIMILAR TO INSTALLATION LOCATION. HIGHEST CONTINUOUS TEMPERATURE _____°C

2.) 2005 ASHRAE FUNDEMENTALS 2% DESIGN TEMPERATURES DO NOT EXCEED 47°C IN THE UNITED STATES (PALM SPRINGS, CA IS 44.1°C). FOR LESS THAN 9 CURRENT-CARRYING CONDUCTORS IN ROOF-MOUNTED SUNLIT CONDUIT AT LEAST 0.5" ABOVE ROOF AND USING THE OUTDOOR DESIGN TEMPERATURE OF 47°C OR LESS (ALL OF UNITED STATES),

a) 12 AWG, 90°C CONDUCTORS ARE GENERALLY ACCEPTABLE FOR MODULES WITH Isc OF 7.68 AMPS OR LESS WHEN PROTECTED BY A 12-AMP OR SMALLER FUSE.
b) 10 AWG, 90°C CONDUCTORS ARE GENERALLY ACCEPTABLE FOR MODULES WITH Isc OF 9.6 AMPS OR LESS WHEN PROTECTED BY A 15-AMP OR SMALLER FUSE.

NOTES FOR INVERTER CIRCUITS (Guide Section 8 and 9):

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 PHOTOVOLTAIC POWER SOURCE (DC) CONDUCTORS BASED ON MAX CURRENT ON NEC 690.53 SIGN OR OCPD RATING AT DISCONNECT

4) SIZE INVERTER OUTPUT CIRCUIT (AC) CONDUCTORS ACCORDING TO INVERTER OCPD AMPERE RATING. (See Guide Section 9)

5) TOTAL OF _____ INVERTER OCPD(s), ONE FOR EACH INVERTER. DOES TOTAL SUPPLY BREAKERS COMPLY WITH 120% BUSBAR EXCEPTION IN 690.64(B)(2)(a)? YES ☐ NO ☐

Contractor Name,
Address and Phone:

_____
_____
_____
_____

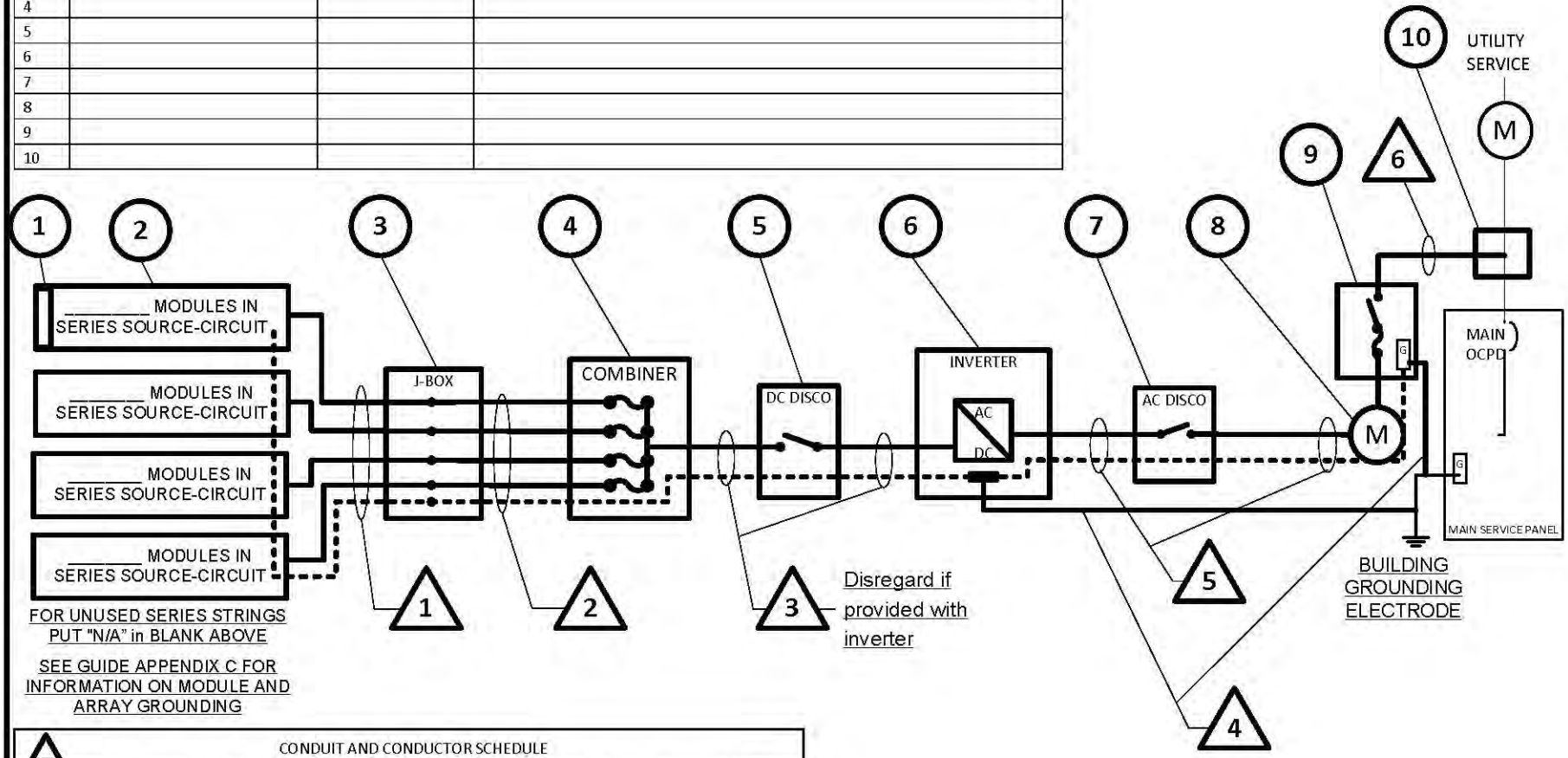
Notes for One-Line Standard Electrical Diagram for Single-Phase PV Systems

Site Name: _____
Site Address: _____
System AC Size: _____

Drawn By:	SIZE	FSCM NO	DWG NO	REV
Checked By:	SCALE NTS	Date:	SHEET	

SUPPLY-SIDE CONNECTION ELECTRICAL DIAGRAM

EQUIPMENT SCHEDULE			
TAG	DESCRIPTION	PART NUMBER	NOTES
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			



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

SEE GUIDE APPENDIX C FOR INFORMATION ON MODULE AND ARRAY GROUNDING

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

Contractor Name, Address and Phone:	One-Line Electrical Diagram for Supply-Side Connected Single-Phase PV Systems
	Site Name:
	Site Address:
	System AC Size:
Drawn By:	SIZE / FSCM NO / DWG NO / REV
Checked By:	SCALE: NTS / Date: / SHEET

5. Attachment Details for Roof-Mounted Systems (Line Drawing) Must Show:*

- Racking System
  - – Manufacturer of racking structure
  - – Model
  - – Type
- Flashing description
- Fastener detail
  - – Type of fasteners, e.g. Lag Screws, Seam Clamps, Ballast

  If Lag Screws include: **(1)** Type (e.g. Zinc, Stainless steel) **(2)** Size of Lag **(3)** Depth of Thread Penetration **(4)** Type of Sealant (e.g. caulk)
- Mitigation of Dissimilar Metals
  - – Describe how any dissimilar metals will be isolated

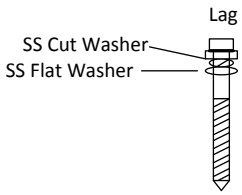
See sample Attachment Detail with Line Drawing on the following page.

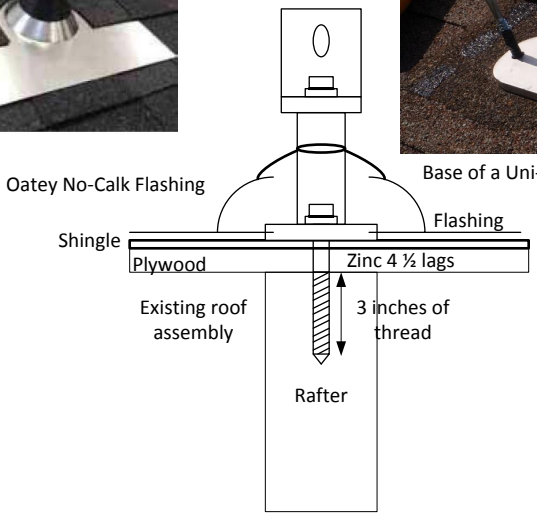
Source:

Connecticut Rooftop Solar PV Permitting Guide. Energize Connecticut. 2014.
http://www.energizect.com/sites/default/files/uploads/%281%29%20CT%20Rooftop%20Solar%20PV%20Permitting%20Guide%20v1.0.pdf

Sample Solar PV Attachment Details

Base of a Uni-rac two piece foot





Racking system is Uni-Rac, Solarmount with standard size rail.

Uni-rac supplies the lag screws and SS hardware necessary to ensure dissimilar metal compliance. Nowhere does the aluminum touch steel directly.

Type of sealant

All penetrations are sealed with an appropriate roofing sealant.

OSI RF-140 Black Magic Roofing & Flashing Sealant or equivalent.

An Oatey No-Calk Flashing will be installed to cover the mounting.

Installion Company Name **Contact Name** **Phone** **860 123-4567** **Installer Address** **Town, CT**	Property Owner Street Address Town, CT
	Drawing Number 101 Revision 1
	Month Day, Year Drawn By Name of Designer

6. **Specification sheets and installation manuals** (if available) for all manufactured components including, but not limited to, PV modules, inverter(s), combiner box, disconnects, and mounting system. *Explanation: At a minimum, specification sheets must be provided for all major components. In addition to the components listed, other important components may be specialty fuses, circuit breakers, or any other unique product that may need to be reviewed by the local jurisdiction. Installation manuals are also listed in this item. This is referring to the brief versions of manuals that are reviewed by the listing agency certifying the product. Some detailed installation manuals can be several dozens or hundreds of pages. If the local jurisdiction feels it is necessary to review these large documents, a good alternative would be for the documents to be supplied electronically, rather than in print.*

Source:

Connecticut Rooftop Solar PV Permitting Guide. Energize Connecticut. 2014. http://www.energizect.com/sites/default/files/uploads/%281%29%20CT%20Rooftop%20Solar%20PV%20Permitting%20Guide%20v1.0.pdf

ENGINEERING EXCELLENCE

- Built exclusively with **Suniva's premium ARTisun Select cells**, providing one of the highest power outputs per square meter at an affordable price
- **Suniva is a U.S. based company** spun out from the Georgia Tech University Center of Excellence in Photovoltaics; one of only two such research centers in the U.S.
- Suniva's state-of-the art manufacturing and module lab facilities feature the most advanced equipment and technology

QUALITY & RELIABILITY

- Suniva Optimus modules are manufactured and warranted to our specifications assuring consistent high performance and high quality.
- Rigorous in-house quality management tests beyond standard UL and IEC standards
- Produced in an ISO 9001: 2008 certified facility
- Performance longevity with advanced polymer backsheet
- Passed the most stringent salt spray tests based on IEC 61701
- Passed enhanced stress tests[1] based on IEC 61215 conducted at Fraunhofer ISE
- Certified PID free by PV Evolution Labs (PVEL)
- PAN files are independently validated

Suniva

SUNIVA OPTIMUS® SERIES MONOCRYSTALLINE SOLAR MODULES

OPT SERIES: OPT 60 CELL MODULES (SILVER FRAME)

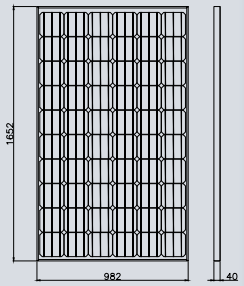
Optimus® modules are known for their superior quality and long-term reliability. These high-powered modules consist of Suniva's premium ARTisun® Select cell technology and are designed and manufactured in the U.S.A. using our pioneering ion implantation technology. Suniva's high power-density Optimus modules provide excellent performance and value.

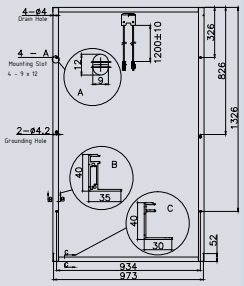
FEATURES

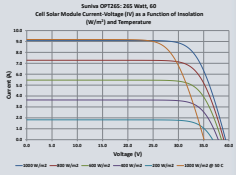
- Contains premium ARTisun Select cell technology - over 19%
- Extensive materials testing and certifications safeguard reliability
- Positive only tolerance ensures predictable output
- Marine grade aluminum frame with hard anodized coating
- Buy America-compliant upon request
- Qualifies for U.S. EXIM financing
- System and design services available
- Industry leading linear warranty: 10 year warranty on workmanship and materials; 25 year linear performance warranty delivering 80% power at STC

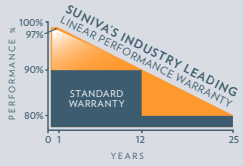
CERTIFICATIONS

AS5033 Compliant









PLEASE RECYCLE

JANUARY 17, 2014 (REV. 19) [SAMD_0010]

OPTIMUS SERIES: OPT 60 CELL MODULES

ELECTRICAL DATA (NOMINAL)

The rated power may only vary by -0/+3% and all other electrical parameters by ± 5%

Model Number	OPT 260-60-4-100	OPT 265-60-4-100	OPT 270-60-4-100
Power Classification (Pmax)	260 W	265 W	270 W
Module Efficiency (%)	16.02%	16.33%	16.60%
Voltage at Max. Power Point (Vmp)	30.20 V	30.70 V	31.20 V
Current at Max. Power Point (Imp)	8.60 A	8.64 A	8.68 A
Open Circuit Voltage (Voc)	38.10 V	38.30 V	38.50 V
Short Circuit Current (Isc)	9.08 A	9.12 A	9.15 A

The electrical data apply to standard test conditions (STC): Irradiance of 1000 W/m² with AM 1.5 spectra at 25°C.

CHARACTERISTIC DATA

Type of Solar Cell	High-efficiency ARTisun Select cells of 156 x 156 mm (6 in.)
Frame	Silver anodized aluminum alloy
Glass	Tempered (low-iron), anti-reflective coating
Junction Box	NEMA IP67 rated; 3 internal bypass diodes
Cable & Connectors	12 AWG (4 mm²) PV Wire cable with multiple connector options available; cable length 1200 mm

MECHANICALS

Cells / Module	60 (6 x 10)
Module Dimensions	1652 x 982 mm (65.04 x 38.66 in.)
Module Thickness (Depth)	40 mm (1.57 in.)
Approximate Weight	17.9 +/- 0.25 kg. (39.5 +/- 0.5 lb.)

TEMPERATURE COEFFICIENTS

Voltage	ß, Voc (%/°C)	-0.335
Current	α, Isc (%/°C)	+0.047
Power	γ, Pmax (%/°C)	-0.420
NOCT Avg	(+/- 2 °C)	46.0

LIMITS

Max. System Voltage	1000 VDC for IEC, 1000 VDC for UL
Max Series Fuse Rating	15 Amps
Operating Module Temperature	-40°C to +85°C (-40°F to +185°F)
Storm Resistance/Static Load	Tested to IEC 61215 for loads of 5400 Pa (113 psf); hail and wind resistant

Suniva® reserves the right to change the data at any time. View manual at suniva.com.
[1]UV 90 kWh, TC 400, DH 2000.

Please read installation manual before installing or working with module.

Product	Modules per pallet	Pallets per Container	Total Modules
OPT - 60 cell (silver and black)	25	28	700

HEADQUARTERS
5765 Peachtree Industrial Blvd.,
Norcross, Georgia 30092 USA
Tel: +1 404 477 2700
www.suniva.com

Suniva® The Brilliance of Solar Made Sensible®

SOLECTRIA RENEWABLES

TRANSFORMERLESS
STRING INVERTERS

PVI **3800TL**
PVI **5200TL**
PVI **6600TL**
PVI **7600TL**

FEATURES

- 600 VDC
- Highest industry peak and CEC efficiencies
- Lightweight, compact design - smallest in the industry
- Quick and easy installation
- Wide operating voltage range
- DC disconnect

OPTIONS

- Web-based monitoring
- Revenue grade monitoring
- DC arc-fault detection and interrupt

TRANSFORMERLESS STRING INVERTERS

Solectria Renewables' PVI 3800TL, 5200TL, 6600TL and 7600TL are compact, transformerless, single-phase inverters with the highest peak and CEC efficiencies in the industry. These inverters come standard with an integrated DC disconnect, optional DC arc-fault detection and interrupt, 1 or 2 MPP tracker(s), and a user-interactive LCD and keypad. Its small and lightweight design make for quick and easy installation and maintenance. These inverters include an enhanced DSP control, comprehensive protection functions, and advanced thermal design enabling highest reliability and uptime. They also come with a standard 10 year warranty with options for 15 and 20 years.

Built for the real world

COMING SOON

SPECIFICATIONS		PVI 3800TL	PVI 5200TL	PVI 6600TL	PVI 7600TL
DC Input					
Absolute Maximum Open Circuit Voltage			600 VDC		
Operating Voltage Range			120-550 VDC		
MPPT Input Voltage Range			200-500 VDC		
MPP Trackers		1	2		
Maximum Operating Input Current		20 A	15 A per MPP tracker	18 A per MPP tracker	20 A per MPP tracker
AC Output					
Nominal Output Voltage			208 or 240 VAC, 1-Ph		
AC Voltage Range			-12%/+10%		
Continuous Output Power	208 VAC	3300 W	5200 W	6600 W	6600 W
	240 VAC	3800 W	5200 W	6600 W	7600 W
Continuous Output Current	208 VAC	15.8 A	25 A	31.7 A	31.7 A
	240 VAC	15.8 A	21.6 A	27.5 A	31.7 A
Maximum Backfeed Current			0 A		
Nominal Output Frequency			60 Hz		
Output Frequency Range			59.3-60.5 Hz		
Power Factor			Unity, > 0.99		
Total Harmonic Distortion (THD)			< 3%		
Efficiency					
Peak Efficiency			98%		
CEC Efficiency			97.5%		
Tare Loss			<1 W		
Temperature					
Ambient Temperature Range (full power)			-13°F to +122°F (-25°C to +50°C)		
Storage Temperature Range			-40°F to +185°F (-40°C to +85°C)		
Relative Humidity (non-condensing)			0-100%		
Data Monitoring					
Optional SolrenView Web-based Monitoring			External		
Optional Revenue Grade Monitoring			External		
External Communication Interface			RS485		
Testing & Certifications					
Safety Listings & Certifications			UL 1741/IEEE 1547, UL1699B, CSA C22.2#107.1, FCC part 15 A&B		
Testing Agency		ETL	CSA		
Warranty					
Standard			10 year		
Optional			15, 20; extended service agreement		
Enclosure					
DC Disconnect			Standard, fully-integrated		
Dimensions (H x W x D)		17.5 x 15.8 x 8.5 in. (445 x 401 x 216 mm)	26.8 x 15.8 x 8.5 in. (680 x 401 x 216 mm)		
Weight		43 lbs (19.5 kg)	65 lbs (29.5 kg)		
Enclosure Rating			Type 4		
Enclosure Finish			Aluminum		

SOLECTRIA RENEWABLES www.solectria.com | inverters@solectria.com | 978.683.9700

7. Structural review questionnaire

This guide will include a questionnaire to help municipalities determine what type of structural review will be required for an applicant to receive a building permit. Municipalities have three options for structural review:

1. **Always require a "wet-stamped" structural analysis of a roof prior to issuing a building permit.**
2. **Require a "wet-stamped" structural analysis on in cases where roofs do not meet a certain set of criteria.**
3. **Never require a "wet-stamped" structural analysis.**

Rooftop solar PV systems typically weigh less than a second layer of roof shingles, and most roofs will be able to support a standard small-scale solar PV system. Since wet-stamp approvals can be costly and time consuming, allowing applicants who have projects that meet certain structural requirements to obtain a permit without receiving a wet stamp will save applicants time and money on obtaining a permit. Below are several examples of structural questionnaires that can be used to help determine whether a solar PV system will require a wet stamp and a building permit.

The following pages include several examples of structural review, from the CT Guide, The MA Guide, and PennFuture's SunShot Guide. DVRPC will work with stakeholders to determine if a review process modeled after these can be developed for the region.

USAGE GUIDE FOR STRUCTURAL REVIEW WORKSHEET

This Structural Review Worksheet can be used to evaluate the integrity of a roof's framing for a proposed solar PV system. To use this Worksheet in an official capacity, you will need permission from the municipal building department. The Worksheet identifies structural conditions in a home's roof framing that may raise concerns with the installation of solar PV, including increased dead load and wind uplift.

This worksheet only applies to installations that meet the following basic criteria, as well as the more detailed criteria below and elsewhere in the Worksheet:

- Installation on one or two family home built after 1900
- Installation on home with regular, stick-built framing (not home with trusses)
- Installation on home with asphalt shingle or standing metal seam roof
- Solar PV panels are flush mounted (i.e., installed parallel to the roof)

User Qualifications for the Structural Review Worksheet

Users of this worksheet should have demonstrable knowledge of typical residential roof framing systems. A number of certification programs may be acceptable evidence of qualifications, if approved by the local jurisdiction, for example:

- Registered Design Professional (Professional Engineer or Architect)
- Licensed Home Inspector
- Engineer-in-Training (EIT)
- North American Board of Certified Energy Practitioners (NABCEP) PV Installation Professional certification
- Other approved certifications that require training in structural inspection of residential framing systems.

Visibility Requirements

Worksheet users must be able to view the roof framing to evaluate its strength. Enough of the framing must be exposed to be able to determine at a minimum:

- Rafter size and spacing
- Ridge board versus ridge beam
- Configuration of rafter cross-ties (e.g. attic floor, collar ties), including size and spacing
- Existence of framing irregularities (e.g. skylights, dormers) in the vicinity of the proposed PV panels
- Type of roof sheathing (e.g. plywood, oriented strand board (OSB), straight board sheathing)

If the framing is concealed by finishes, such as in spaces with cathedral ceilings, a Registered Design Professional should investigate the framing and review the proposed installation. Openings may be required in the finishes to observe the framing and document the construction details listed above.

Anchorage to Structure

Use of this worksheet is contingent upon fastening the PV system directly to the rafters. If the installer wishes to attach to the sheathing between the rafters, a registered design professional should evaluate the proposed design and confirm the available sheathing capacity. If the sheathing alone is not adequate to resist downward gravity and wind uplift forces, the addition of blocking between the rafters at the attachment locations may be a possible solution.

Structural Information

(To be used as a standalone supplemental form or in conjunction with the Structural Evaluation portion of this Worksheet on the following pages, 3-4)

Please fill in the following Roof Description Information

ROOF DESCRIPTION:

Wind Exposure Category (B / C / D):[1] _____

Roofing Type (e.g. asphalt shingle, slate, clay tile, cedar shake, metal seam, single-ply membrane, built-up): _____

_____

Age of roof:_____Number of Layers: _____

Roof Type (e.g. gable, hipped, flat):_____

Framing Type (e.g. stick-built, trusses): _____

If trusses, list manufacturer, if known:_____

Rafter Material (wood, steel, etc.; if wood, specify rafter species[2]): _____

Rafter Size (e.g. 2x6): _____Rafter Spacing (e.g. 16"): _____

Maximum unsupported rafter span: _____ Feet _____ Inches

Ceiling joist or rafter tie size and spacing (e.g. 2x6@16"):_____

Ceiling joist or rafter tie orientation (relative to rafters): ☐ parallel ☐ perpendicular

Height of ceiling joist or rafter tie measured vertically above top of rafter support walls (enter "0" if ceiling joists are located at the top of the support walls): _____

Height of roof ridge measured vertically above top of rafter support walls:_____

Ridge type (beam or board): _____

Framing Irregularities in vicinity of proposed panel installation (e.g. modifications, skylights, dormers that interrupt rafter spans): _____

Heavy equipment or unusual loads suspended from rafters in the vicinity of proposed panel installation:_____

_____

Other information/Comments: _____

_____

[1] http://publicecodes.cyberregs.com/icod/irc/2009/icod_irc_2009_3_par010.htm

[2] Obtain species from grade stamps on the rafters. If no grade stamps, assume Spruce-Pine-Fir #2.

Please perform the following Roof Load Calculations

ROOF LOAD CALCULATIONS:

a. Total weight of PV modules, rails, mountings, hardware and wiring	_____	Lbs
b. Total number of attachments (mountings)	_____	Mountings
c. Weight per attachment point (mounting) a÷b	_____	**Lbs/Attachment**
d. Maximum spacing between adjacent attachment (mounting) points	_____	Feet-Inches
e. Total surface area of PV modules (square feet)	_____	Ft^2
f. Distributed weight of PV modules a÷e	_____	**Lbs/ft^2**

Structural Evaluation

Please answer the questions in the Maximum Rafter Span Table Qualifier

MAXIMUM RAFTER SPAN TABLE QUALIFIER:

1. Was the house built after 1900?	☐ Yes	☐ No
2. Does the roof have only one layer of asphalt roofing shingles or standing metal seam?	☐ Yes	☐ No
3. Does the roof have a slope of 4:12 or greater?	☐ Yes	☐ No
4. Is roof framing stick-built wood framing?	☐ Yes	☐ No
5. Are rafters continuously tied with ceiling framing from one supporting wall to the other at the eave level, noting that the ceiling framing must match the rafter spacing and direction?	☐ Yes	☐ No
6. Is the framing in the vicinity of the solar array free of irregularities (see Roof Description for examples)?	☐ Yes	☐ No
7. Is the framing in the vicinity of the solar array free of heavy equipment or unusual loads?	☐ Yes	☐ No
8. Is the roof framing free of visible indications of distress (e.g. ridge sagging, walls out of plumb, significant ceiling cracks, split rafters)?	☐ Yes	☐ No
9. Is the roof framing free of signs or knowledge of previous damage (e.g. water incursion, fire damage, impact from an object, termite damage, etc.)?	☐ Yes	☐ No
10. Is the new PV system flush mounted, with a maximum angle of 5 degrees relative to the roof line and a maximum gap of 6" between the roof surface and the solar panels?	☐ Yes	☐ No
11. Is the maximum weight of PV modules less than or equal to 4 lbs/ft^2 (see "Roof Load Calculations" p. 2)?	☐ Yes	☐ No
12. Is the "weight per attachment point" less than 45 lbs (see "Roof Load Calculations" p. 2)?	☐ Yes	☐ No

If all answers are "Yes," proceed to Rafter Span Verification. If any answer is "No," enter "NA" for your answer to Question 13 on the next page and employ a Registered Design Professional to evaluate the roof structure.

Structural Evaluation

RAFTER SPAN VERIFICATION

Refer to the Rafter Span Table below to determine whether the "Maximum Unsupported Span" (provided in the "Roof Description" on page 2) is less than the maximum allowed rafter span. *(Consider wood species, rafter size, and rafter spacing in your assessment)*

MAXIMUM RAFTER SPANS

Ground snow load = 30 psf

Maximum Dead Load Including PV Panels = 14 psf

Ceiling not attached to rafters (deflection ≤ L/180)

		Rafter Size				
		2x4	2x6	2x8	2x10	2x12
Rafter Spacing	Species and Grade	Maximum Rafter Spans (ft-in)				
12"	Spruce-Pine-Fir #2	8'-4"	12'-4"	15'-8"	19'-1"	22'-2"
	Douglas Fir-Larch #2	8'-10"	12'-11"	16'-5"	20'-0"	23'-3"
	Hem-Fir #2	8'-10"	12'-11"	16'-5"	20'-0"	23'-3"
16"	Spruce-Pine-Fir #2	7'-4"	10'-8"	13'-7"	16'-7"	19'-2"
	Douglas Fir-Larch #2	7'-8"	11'-2"	14'-2"	17'-4"	20'-1"
	Hem-Fir #2	7'-8"	11'-2"	14'-2"	17'-4"	20'-1"
19.2"	Spruce-Pine-Fir #2	6'-8"	9'-9"	12'-4"	15'-1"	17'-6"
	Douglas Fir-Larch #2	7'-0"	10'-3"	12'-11"	15'-10"	18'-4"
	Hem-Fir #2	7'-0"	10'-3"	12'-11"	15'-10"	18'-4"
24"	Spruce-Pine-Fir #2	6'-0"	8'-9"	11'-1"	13'-6"	15'-8"
	Douglas Fir-Larch #2	6'-3"	9'-2"	11'-7"	14'-2"	16'-5"
	Hem-Fir #2	6'-3"	9'-2"	11'-7"	14'-2"	16'-5"

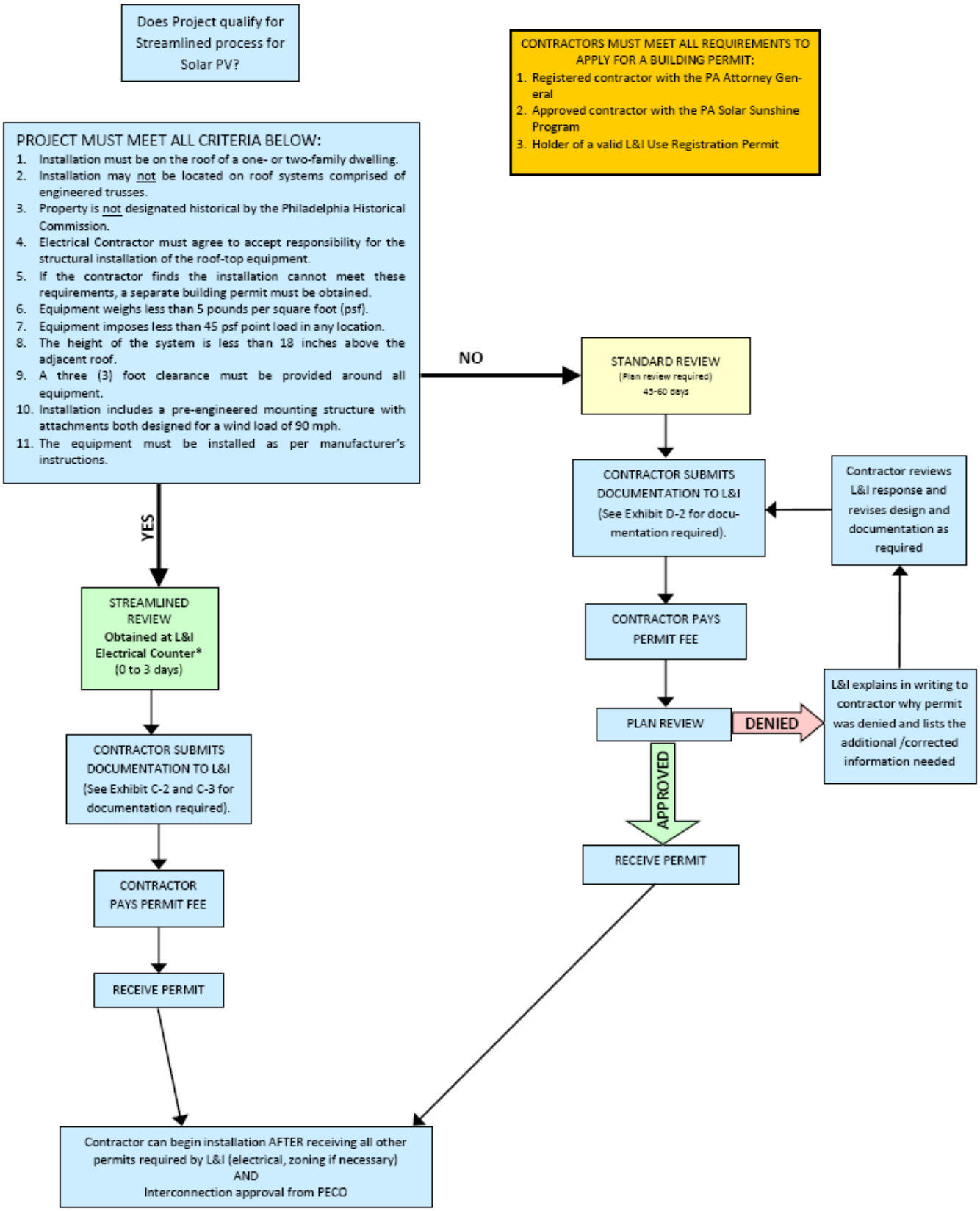
13. According to the Rafter Span Table, is the observed "Maximum Unsupported Span" less than the "Maximum Rafter Span" listed in the table? ☐ Yes ☐ No ☐ NA

STRUCTURAL REVIEW WORKSHEET CONCLUSION:

If your answer to Question 13 is "*Yes*," you do not need to employ a Registered Design Professional to evaluate the roof structure unless required to do so by the local jurisdiction.

Disclaimer:
This worksheet should not be used to replace a Jurisdiction's requirement that a registered design professional perform a structural analysis for a roof-mounted solar PV installation, unless a municipal building department specifically authorizes its use for that purpose.

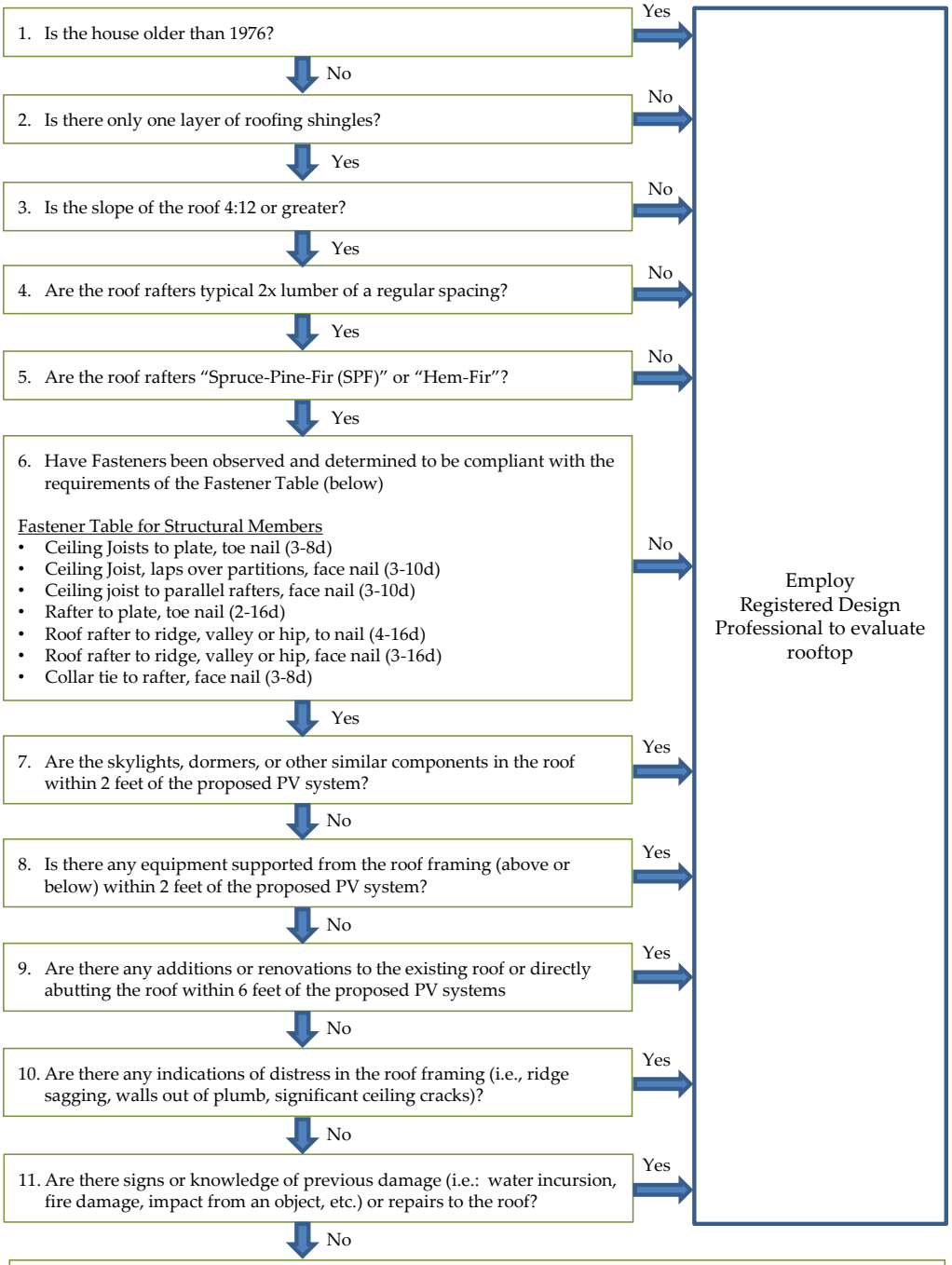
EXHIBIT D-1 Building Permit Process Flow Diagram



* The streamlined permit for solar PV is a combination permit for both building and electrical. A licensed Electrician must apply for the permit.

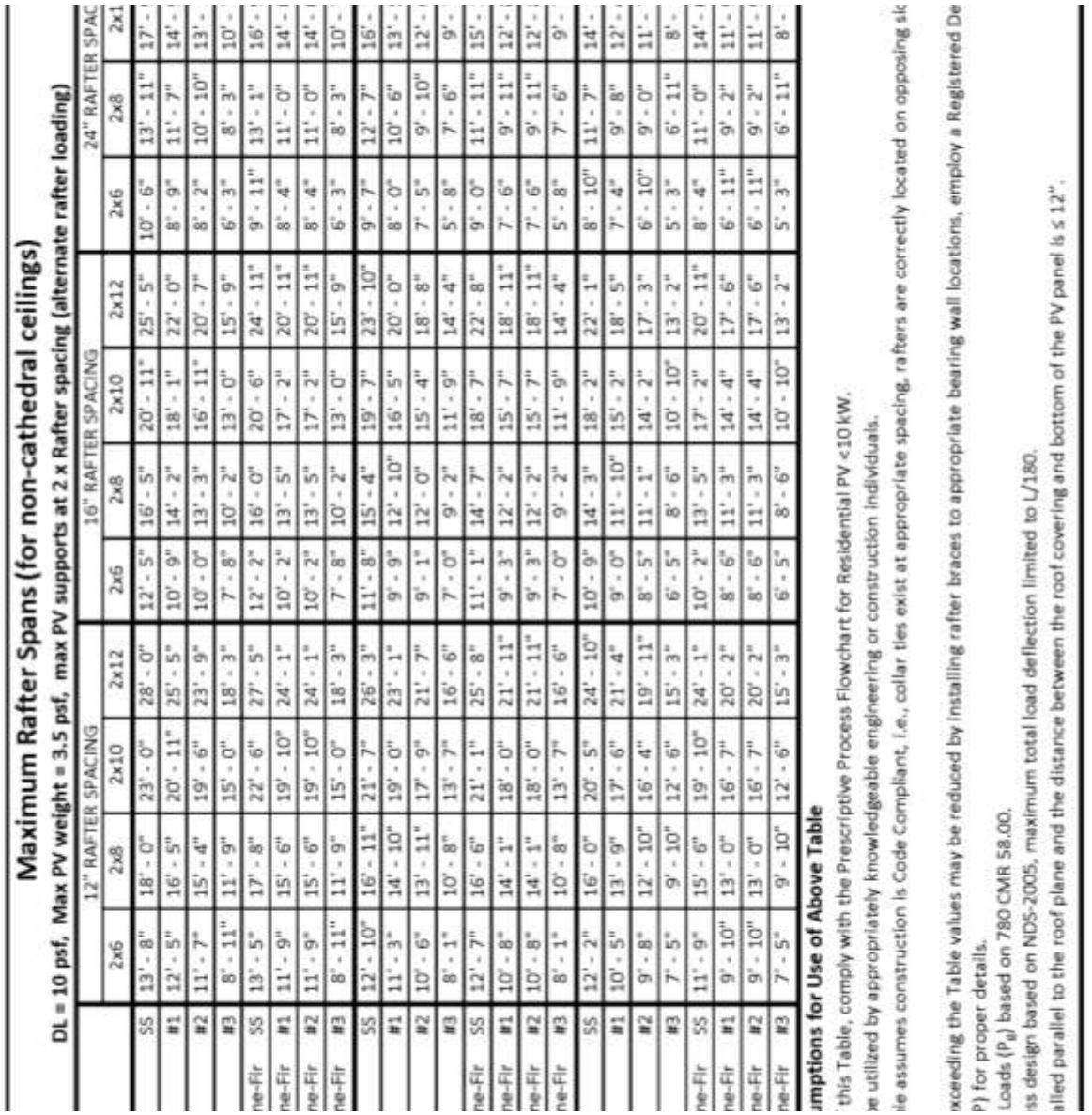
Appendix B. Prescriptive Process for Structural Approval of Small PV Systems

Prescriptive Process Flowchart for Residential PV <10 kW



If none of the answers to the above questions caused you to employ a Registered Design Professional to evaluate the structure, you may proceed to utilize the Maximum Rafter Span table for the evaluation of the roof framing to support the proposed PV system.

Appendix C. Maximum Rafter Span Table



Maximum Rafter Spans (for non-cathedral ceilings)

DL = 10 psf, Max PV weight = 3.5 psf, max PV supports at 2 x Rafter spacing (alternate rafter loading)

		12" RAFTER SPACING				16" RAFTER SPACING				24" RAFTER SPAC	
		2x6	2x8	2x10	2x12	2x6	2x8	2x10	2x12	2x6	2x8	2x1
	SS	13' - 8"	18' - 0"	23' - 0"	28' - 0"	12' - 5"	16' - 5"	20' - 11"	25' - 5"	10' - 6"	13' - 11"	17' -
	#1	12' - 5"	16' - 5"	20' - 11"	25' - 5"	10' - 9"	14' - 2"	18' - 1"	22' - 0"	8' - 9"	11' - 7"	14' -
	#2	11' - 7"	15' - 4"	19' - 6"	23' - 9"	10' - 0"	13' - 3"	16' - 11"	20' - 7"	8' - 2"	10' - 10"	13' -
	#3	8' - 11"	11' - 9"	15' - 0"	18' - 3"	7' - 8"	10' - 2"	13' - 0"	15' - 9"	6' - 3"	8' - 3"	10' -
ne-Fir	SS	13' - 5"	17' - 8"	22' - 6"	27' - 5"	12' - 2"	16' - 0"	20' - 6"	24' - 11"	9' - 11"	13' - 1"	16' -
ne-Fir	#1	11' - 9"	15' - 6"	19' - 10"	24' - 1"	10' - 2"	13' - 5"	17' - 2"	20' - 11"	8' - 4"	11' - 0"	14' -
ne-Fir	#2	11' - 9"	15' - 6"	19' - 10"	24' - 1"	10' - 2"	13' - 5"	17' - 2"	20' - 11"	8' - 4"	11' - 0"	14' -
ne-Fir	#3	8' - 11"	11' - 9"	15' - 0"	18' - 3"	7' - 8"	10' - 2"	13' - 0"	15' - 9"	6' - 3"	8' - 3"	10' -
	SS	12' - 10"	16' - 11"	21' - 7"	26' - 3"	11' - 8"	15' - 4"	19' - 7"	23' - 10"	9' - 7"	12' - 7"	16' -
	#1	11' - 3"	14' - 10"	19' - 0"	23' - 1"	9' - 9"	12' - 10"	16' - 5"	20' - 0"	8' - 0"	10' - 6"	13' -
	#2	10' - 6"	13' - 11"	17' - 9"	21' - 7"	9' - 1"	12' - 0"	15' - 4"	18' - 8"	7' - 5"	9' - 10"	12' -
	#3	8' - 1"	10' - 8"	13' - 7"	16' - 6"	7' - 0"	9' - 2"	11' - 9"	14' - 4"	5' - 8"	7' - 6"	9' -
ne-Fir	SS	12' - 7"	16' - 6"	21' - 1"	25' - 8"	11' - 1"	14' - 7"	18' - 7"	22' - 8"	9' - 0"	11' - 11"	15' -
ne-Fir	#1	10' - 8"	14' - 1"	18' - 0"	21' - 11"	9' - 3"	12' - 2"	15' - 7"	18' - 11"	7' - 6"	9' - 11"	12' -
ne-Fir	#2	10' - 8"	14' - 1"	18' - 0"	21' - 11"	9' - 3"	12' - 2"	15' - 7"	18' - 11"	7' - 6"	9' - 11"	12' -
ne-Fir	#3	8' - 1"	10' - 8"	13' - 7"	16' - 6"	7' - 0"	9' - 2"	11' - 9"	14' - 4"	5' - 8"	7' - 6"	9' -
	SS	12' - 2"	16' - 0"	20' - 5"	24' - 10"	10' - 9"	14' - 3"	18' - 2"	22' - 1"	8' - 10"	11' - 7"	14' -
	#1	10' - 5"	13' - 9"	17' - 6"	21' - 4"	9' - 0"	11' - 10"	15' - 2"	18' - 5"	7' - 4"	9' - 8"	12' -
	#2	9' - 8"	12' - 10"	16' - 4"	19' - 11"	8' - 5"	11' - 1"	14' - 2"	17' - 3"	6' - 10"	9' - 0"	11' -
	#3	7' - 5"	9' - 10"	12' - 6"	15' - 3"	6' - 5"	8' - 6"	10' - 10"	13' - 2"	5' - 3"	6' - 11"	8' -
ne-Fir	SS	11' - 9"	15' - 6"	19' - 10"	24' - 1"	10' - 2"	13' - 5"	17' - 2"	20' - 11"	8' - 4"	11' - 0"	14' -
ne-Fir	#1	9' - 10"	13' - 0"	16' - 7"	20' - 2"	8' - 6"	11' - 3"	14' - 4"	17' - 6"	6' - 11"	9' - 2"	11' -
ne-Fir	#2	9' - 10"	13' - 0"	16' - 7"	20' - 2"	8' - 6"	11' - 3"	14' - 4"	17' - 6"	6' - 11"	9' - 2"	11' -
ne-Fir	#3	7' - 5"	9' - 10"	12' - 6"	15' - 3"	6' - 5"	8' - 6"	10' - 10"	13' - 2"	5' - 3"	6' - 11"	8' -

umptions for Use of Above Table

' this Table, comply with the Prescriptive Process Flowchart for Residential PV <10 kW.

ye utilized by appropriately knowledgeable engineering or construction individuals.

ie assumes construction is Code Compliant, i.e., collar ties exist at appropriate spacing, rafters are correctly located on opposing sic

xceeding the Table values may be reduced by installing rafter braces to appropriate bearing wall locations, employ a Registered De

P) for proper details.

Loads (P_g) based on 780 CMR 58.00.

ss design based on NDS-2005, maximum total load deflection limited to L/180.

alled parallel to the roof plane and the distance between the roof covering and bottom of the PV panel is ≤ 12".

Appendix D. Contributors to this Report

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Step 1: Structural Review of PV Array Mounting System

A. *Roof Information:*

YES ☐ NO☐ Does the roof have a single roof covering?

YES ☐ NO☐ Is the roofing type lightweight (composition, lightweight masonry, metal, etc.)?
Roofing Material Description_____

Explanation: Roof structures supporting heavier roofing materials (e.g. slate, heavy masonry, tile) may not have the assumed dead loading and live loading capacities that are found with lighter weight roofing materials and may justify a further review to clarify whether the roof structure is either in compliance or needs enhancement.

YES ☐ NO☐ Weatherproofing sealant is compatible with the roofing material. Describe method *and* type of weatherproofing roof penetrations (e.g. flashing, caulk) _____

YES ☐ NO☐ The roof was visually inspected for pre-existing damage. (*If damage is noted, provide details for any work necessary to repair the existing roof structure.)*

B. *Mounting System Information:*

YES ☐ NO☐ Is the mounting structure an engineered product designed to mount PV modules with no more than an 18" gap beneath the module frames?

If YES, complete information on the mounting system below:

a. Mounting System Manufacturer _____
   Product Name and Model# _____
b. Total Weight of PV Modules and Rails _____lbs
c. Total Number of Attachment Points _____
d. Weight per Attachment Point (Total Weight of Modules and Rails (from line b.) ÷ Total Number of Attachment Points (from line c.) = _____lbs.

YES ☐ NO☐ Is the point load weight in line (d.) above, less than or equal to 45 lbs? If YES, complete the following:

e. Maximum Spacing Between Attachments Points on a Rail =_____inches (see product manual for maximum spacing allowed based on maximum design wind speed)
f. Total Surface Area of PV Modules (square feet) _____ ft^2.
g. Distributed Weight of PV Module on Roof (Total Weight of PV Modules and Rails (from line b.) ÷ Total Surface Area of PV Modules (from line f.) = _____lbs/ft^2.

YES ☐ NO☐ Is the distributed weight in line (g) above, less than or equal to 5 lbs/ft^2?

8. Pole Mount or Ground Mount Information (if applicable):*

- Racking system
- Mounting specification sheets and details from manufacturer (PDFs)
- Manufacturer's Pre-Engineered Document or PE Stamp
- Code Compliance Manual (If Requested by Municipality)
- One-way distance from the Solar PV system to the interconnection point
- Electrical grounding details
- Height of solar PV system at maximum design tilt
- Applicable zoning information if not shown on site plan (e.g. setback from property line)

Notes:

- Ground mounted systems are trickier because there is likely more variation in their design (e.g. landfill versus airport, versus farmland, versus parking canopy) which makes standardization difficult. The Massachusetts expedited process for ground mounted systems only requires a 12-month decision and for projects 250kW or smaller.