Tempe

Permitting Process for Residential PV Systems

with Explanations to Help you through the Process

Prepared by:

City of Tempe Development Services Department

Building Safety Division

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INTRODUCTION:

This document is a guide to help you through permit process, and explain what steps and information are needed so your new PV system may be permitted as quickly as possible. As most systems have unique characteristics, they may be handled with small additions to this process or may require much more information, depending on the uniqueness of the installation.

The diagrams show a typical installation along with what information is needed for a complete review of the PV system. Additional drawings may be needed depending on the uniqueness or complexity of the installation.

This process provides flexibility in the structural review. PV systems with battery backup may be able to use a portion of this information to assist the permitting process, but array configurations and the battery system require a more detailed electrical drawing than this process provides.

The appendix to this explanatory document has an example submittal in Appendix A also has a variety of special electrical topics in Appendix C. It also includes temperature tables in Appendix D that are used in applying the National Electrical Code's temperature-dependent criteria.

Permit Process for Small Scale PV Systems

The information in this guideline is intended to help contractors identify when PV system installations are simple, and when an installation is more complex. It is likely that more than 50% of all residential systems will comply with these simple criteria. For projects that fail to meet the simple criteria, additional plans and system information will be needed.

Required Information for Permit:

1. 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).
2. Electrical diagram showing PV array configuration, wiring system, overcurrent protection, inverter, disconnects, required signs, and ac connection to building (see example of standard electrical diagram).
3. Specification sheets 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. Specification sheets must include third party listing information.

Section 2. **Step 1: Structural Review of PV Array Mounting System**

Is the array to be mounted on a defined, permitted roof structure? **[ ] Yes [ ] No**

If No due to non-compliant roof or a ground mount, submit complete roof details and calculations certified by a design professional.

Roof Information:

1. Is the roofing type lightweight (Yes = composition, lightweight masonry, metal, etc…)
   [ ]Yes [ ]No Specify type _____
   If No, submit complete calculations certified by a design professional for roof structure. (No = heavy clay, concrete, slate, etc…).
2. Does the roof have a single roof covering? **[ ]Yes [ ]No**
   If No, submit complete calculations certified by a design professional for roof structure.
3. Provide method and type of weatherproofing roof penetrations (e.g. flashing, caulk).
   _____

Mounting System Information:

1. The mounting structure is an engineered product designed to mount PV modules?
   [ ] Yes [ ] No
   If No, provide details of structural attachment certified by a design professional.
2. For manufactured mounting systems, fill out 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 (b÷c)_____lbs (*if > 40 lbs, submit calculations certified by a design professional*)
   e. Maximum Spacing Between Attachment 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)_____ ft2
      Distributed Weight of PV Module on Roof (b÷f) _____ lbs/ft2
      If distributed weight of the PV system is >5 lbs/ft2, submit calculations certified by a design professional).
3. Attachment of the panel mounting system to the roof structure may be with two 5/16" lag bolts per attachment point with a minimum 2 1/2" thread embedment into the roof structural members provide all of the following conditions are answered with a "Yes". *Submit uplift calculations certified by a design professional if any conditions are not met.*
   a. Are the PV panels mounted flush to the roofs surface? **[ ] Yes [ ] No**
      Flush is defined as panel parallel to the surface (or with no more than 3" difference between ends of assembly) with no more than 10" space between the roof surface and the bottom of the panel. If No, provide wind load and uplift structural calculations.
   b. The building height is ≤ 35'. **[ ] Yes [ ] No**

c. The building has a flat or gable roof with a pitch less than 45^0 or a hip roof with a pitch less than 27^0. **[ ] Yes [ ] No**
d. The building is enclosed, not open or partially enclosed structure, for example a carport. **[ ] Yes [ ] No**
e. The distance between supports is 4' or less. **[ ] Yes [ ] No**
f. Individual panels are no larger than 16 square feet in size. **[ ] Yes [ ] No**

Section 3. **Step 2: Electrical Review of PV System (Calculations for Electrical Diagram)**

In order for a PV system to be considered a small scale system and able to be reviewed using this process, the following must apply:

1. PV modules, utility-interactive inverters, and combiner boxes are identified for use in PV systems.
2. The PV array is composed of 4 series strings or less per inverter, and 15 kWSTC or less.
3. The total inverter capacity has a continuous power output 13,440 Watts or less
4. The ac interconnection point is on the load side of service disconnecting means (690.64(B)).
5. The electrical diagram (E1.1) can be used to accurately represent the PV system.

Provide an electrical diagram. An example of the electrical diagram is provided (see example in Appendix A) to help the applicant understand what information is needed. If the electrical system is more complex than what the standard electrical diagram can effectively communicate, provide an alternative diagram with appropriate detail.

Section 4. **Inverter Information**

A copy of the manufacturer's specification sheet(s) is required with permit submittal. It must contain the following information:

a) INVERTER MAKE: This is the manufacturer's name: (e.g. PV Powered, SMA, etc…)
b) INVERTER MODEL #: This is the model number on the listing label: (e.g. PVP 5200, SB7000US, etc…)
c) MAX DC VOLTAGE RATING: Provided either on listing label or specification sheet.
d) MAX POWER @ 40ºC: The maximum continuous output power at 40ºC is required information for the listing label.
e) NOMINAL AC VOLTAGE: This is the ac output voltage of the inverter as configured for this project. Some inverters can operate at multiple ac voltages.
f) MAX OCPD RATING: This is the maximum overcurrent protective device (OCPD) rating allowed for the inverter. This is either stated on the listing label or in the installation manual. Sometimes this is also listed on the specification sheet—but not always. It is important to check that the inverter OCPD rating in the panel is less than or equal to this maximum rating to preserve the listing of the inverter.

Section 5. **Module Information**

A copy of the manufacturer's specification sheet is required for a permit submittal.

a) MODULE MANUFACTURER: This is the manufacturer's name: (e.g. Evergreen, SunPower, etc…)
b) MODULE MODEL #: This is the model number on the listing label: (e.g. EGS185, SP225, etc…)
c) MAXIMUM POWER-POINT CURRENT (IMP)
Explanation: The rated IMP is needed to calculate system operating current. This is the current of the module when operating at STC and maximum power.

d) MAXIMUM POWER-POINT VOLTAGE (VMP)
Explanation: The rated VMP is needed to calculate system operating voltage. This is the voltage of the module when operating at STC and maximum power.
e) OPEN-CIRCUIT VOLTAGE (VOC)
Explanation: The rated VOC is needed to calculated maximum system voltage specified in NEC 690.7.
f) SHORT-CIRCUIT CURRENT (ISC)
Explanation: The rated ISC is needed to calculate maximum current specified in NEC 690.8(A).
g) MAXIMUM SERIES FUSE (OCPD)
Explanation: Maximum series fuse (OCPD) rating is needed to ensure that the proper overcurrent protection is provided for the modules and array wiring.
h) MAXIMUM POWER (PMAX) at Standard Test Conditions (STC is 1000W/m2, 25°C cell temp & Air Mass 1.5)
Explanation: Maximum power at STC specifies the rated power of the PV module under simulated conditions.
i) MAXIMUM SYSTEM VOLTAGE
Explanation: Maximum system voltage (often 600 Vdc) is needed to show that the NEC 690.7 voltage does not exceed this value.

Section 6. **Array information**

a) NUMBER OF MODULES IN SERIES
Explanation: For simplicity, the diagram only addresses the most common configuration of PV modules—multiple modules in series. Although single module PV power sources exist, it is more common to see PV arrays configured with as many as 12 or 16 modules in series.
b) NUMBER OF PARALLEL CIRCUITS
Explanation: Since single phase inverters can be as large as 12 kW or more, and the largest PV source circuits are only 2 or 3 kW, it is common for PV arrays to have two or more source circuits in parallel. From Example in Appendix One:

Number of modules in series = 12
Number of parallel source circuits = 4
Total number of modules = 12 x 4 = 48

c) LOWEST EXPECTED AMBIENT TEMP
Explanation: The mean extreme low temperature is the coldest expected temperature for a location. Half of the years on record have not exceeded this number, and the rest have exceeded this number. These data are supplied in the appendix for reference.
d) HIGHEST CONTINUOUS TEMP (ambient)
Explanation: Continuous is defined in the NEC as a 3-hour period (Article 100). ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers) has performed statistical analysis on weather data from the National Weather Service. These data include design values of 0.4%, 1%, and 2% for each month signifying that the temperature only exceeds the recorded value up to 2% of the time for a given location with temperature data. The 2% value has been chosen by the Copper Development Institute as the value that best represents a condition that would create the 3-hour continuous condition referred to in Article 100. Two percent of one month is about 14 hours.
Since high temperatures usually last for several days in most locations, the assumption is that at least one or two 3-hour high temperature events will happen during a given month. These data are supplied in the appendix for reference.

Section 7. Labels/Signs

a) PV POWER SOURCE [NEC690.53]
   i) RATED MPP (MAXIMUM POWER-POINT) CURRENT (sum of parallel source circuit operating currents)
   ii) RATED MPP (MAXIMUM POWER-POINT) VOLTAGE (sum of series modules operating voltage in source circuit)
   iii) MAXIMUM SYSTEM VOLTAGE [*NEC* 690.7]
   iv) MAXIMUM SHORT CIRCUIT CURRENT [*NEC* 690.8]
b) WARNING SIGN REQUIRED BY *NEC* 690.17 & 690.35.
c) Point of Connection Sign [*NEC* 690.54]
(To be placed on the Solar AC Disconnect and AC Point of Connection locations)
   i) AC OUTPUT CURRENT
   ii) NOMIMAL AC VOLTAGE

Section 8. Wiring and Overcurrent Protection

a) DC Wiring Systems:
   I. In Exposed Locations:
   PV module interconnections are generally 90°C wet-rated conductors (*NEC* 690.31(A)
   FPN). The same conductor type is typically used for all home run conductors needed for source circuit conductors in exposed locations.
   Allowable wire types are as follows:
   - USE-2 single conductor cable for exposed locations. [*NEC* 690.31(B)]
   - PV Wire or PV Cable as a single conductor for exposed locations (required for all ungrounded systems). [*NEC* 690.31(B)]

II. In Conduit on Rooftops:

TWO OPTIONS FOR SOURCE CIRCUIT CONDUCTOR TYPE ARE THWN-2 and XHHW-2

(Identify which one will be used)

Explanation: Conductors in conduit, when exposed to direct sunlight, must account for the higher temperatures caused by intense sunlight and the proximity of the roof. The 2008 NEC classifying the temperatures based on the height above the roof surface. On residential roofs, where conduit typically is spaced between ½" and 3 ½" above the roof surface, the temperature adder is stated as 22°C above the ambient temperature according to NEC Table 310.15(B) (2) (c).

b) AC Wiring Systems

Inverter Output Circuit overcurrent protection should be sized and protected according the manufacturer's directions. The circuit and corresponding overcurrent protection should be sized at a 125% of the maximum continuous output of the inverter [*NEC* 215.3 Overcurrent for Feeder Circuits, and *NEC* 690.8(A) (3) and 690.8(B)]. The inverter may also have a maximum allowable overcurrent requirement.

Section 9. AC Point of Connection

NEC 690.64 (B) covers the requirements for Point of Connection of the PV inverter to the building electrical system. The most common method of connection is through a dedicated circuit breaker to a panelboard busbar. The sum of the supply breakers feeding the busbar of a panel can be up to 120% of the busbar rating. Appendix B treats this subject in detail.

NEC 690.64(B) (6) Fastening. Listed plug in type circuit breakers back fed from utility interactive inverters complying with 690.60 shall be permitted to omit the additional fastener normally required by 408.36(D) for such applications.

NEC 690.64(B) (6) Fastening. Listed plug-in-type circuit breakers back fed from utility-interactive inverters complying with 690.60 shall be permitted to omit the additional fastener normally required by 408.36(D) for such applications.

Section 10. Grounding

a) System Grounding

The NEC requires [690.41] that all systems operating above 50 volts have one conductor referenced to ground unless the system complies with the requirements of *NEC* 690.35 for ungrounded PV arrays.

b) Equipment Grounding

The code also requires that all exposed non-current-carrying metal parts of module frames, equipment, and conductor enclosures be grounded regardless of system voltage [*NEC* 690.43]. A discussion on module frame grounding is found in the Appendix.

c) Sizing of Grounding Conductors

i) Equipment grounding conductor (EGC) sizing [NEC 690.45]

The size of the EGC is dependent on whether the system has ground fault protection (GFP) equipment or not. The provisions for GFP equipment are stated in NEC 690.5. Almost all inverters have GFP equipment integral to the inverter and require that the PV array be grounded at the inverter only.

(1) Systems with ground fault protection equipment. - Size equipment grounding conductor according to *NEC* Table 250.122.

(2) Systems without ground fault protection equipment
The *NEC* requires that equipment grounding conductors for systems without GFP equipment be sized for twice the circuit short circuit current [*NEC* 690.45].

ii) System grounding conductor sizing

(1) AC System - Size grounding electrode conductor (GEC) according to *NEC* Table 250.66. Normally the site already has the conductor and electrode installed for the ac building wiring.

(2) DC System - Size grounding electrode conductor (GEC) according to *NEC* 250.166. This results in a minimum size of 8 AWG. The maximum size of the GEC is dependent upon the type of grounding electrode or the maximum size conductor in the system, whichever is smaller.

APPENDIX

APPENDIX A: EXAMPLE SUBMITTAL

Step 1: Structural Review of PV Array Mounting System

Is the array to be mounted on a defined, permitted roof structure? **[x] Yes [ ] No**
(structure meets modern codes)
If No due to non-compliant roof or ground mount, submit complete details and calculations certified by a design professional for roof structure.

Roof Information:

1. Is the roofing type lightweight (Yes = composition, lightweight masonry, metal, etc…) _Yes—composition.
   If No, submit complete calculations certified by a design professional for roof structure (No = heavy masonry, slate, etc…).

2. Does the roof have a single roof covering? **[x] Yes [ ] No**
   If No, submit complete calculations certified by a design professional for roof structure.
3. Provide method and type of weatherproofing roof penetrations (e.g. flashing, caulk).__flashing_____

Mounting System Information:

1. The mounting structure is an engineered product designed to mount PV modules?
   [x] Yes [ ] No
   If No, provide details of structural attachment certified by a design professional.
2. For manufactured mounting systems, fill out information on the mounting system below:
   a. Mounting System Manufacturer _UniRac_.
      Product Name and Model#__SolarMount___.
   b. Total Weight of PV Modules and Rails ___1780_____lbs
   c. Total Number of Attachment Points____48___
   d. Weight per Attachment Point (b÷c) ____37_____lbs (if >40 lbs, see WKS1)
   e. Maximum Spacing Between Attachment Points on a Rail _____48_____inches (see product manual for maximum spacing allowed based on maximum design wind speed)
   f. Total Surface Area of PV Modules (square feet) _____674_____ ft2
   g. Distributed Weight of PV Module on Roof (b÷f) _____2.64_____ lbs/ft2
   If distributed weight of the PV system is >5 lbs/ft2, submit complete calculations certified by a design professional.
4. Attachment of the panel mounting system to the roof structure may be with two 5/16" lag bolts per attachment point with a minimum 2 1/2" thread embedment into the roof structural members provide all of the following conditions are answered with a "Yes". *Submit uplift calculations certified by a design professional if any conditions are not met.*
   a. Are the PV panels mounted flush to the roofs surface? **[x] Yes [ ] No**
      Flush is defined as panel parallel to the surface (or with no more than 3" difference between ends of assembly) with no more than 10" space between the roof surface and the bottom of the panel
   b. The building height is ≤ 35'. **[x] Yes [ ] No**
   c. The building has a flat or gable roof with a pitch less than 45^0 or a hip roof with a pitch less than 27^0. **[x] Yes [ ] No**
   d. The building is enclosed, not open or partially enclosed structure, for example a carport. **[x] Yes [ ] No**
   e. The distance between supports is 4' on less. **[x] Yes [ ] No**

f. Individual panels are no larger than 16 square feet in size. **[x] Yes [ ] No**

Step 2: Electrical Review of PV System (Calculations for Electrical Diagram)

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