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FLORIDA PHOTOVOLTAIC BUILDINGS PROGRAM

Mounting Methods for Rooftop Photovoltaic Arrays Shingle, Tile, and Metal Roofing Systems

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Florida Solar Energy Center
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Introduction

The decision to install a PV array on a rooftop should be followed by the questions where, what, and how. Site selection determines where the array will be installed. The system design provides details on what hardware will be used; and the selected mounting method determines how the array will be attached to the roof.

Site Selection

A survey of the proposed project location is required to determine the acceptability of the building as a utility-interactive PV site. A site selection survey should be conducted to verify that a building meets a series of selection criteria that will ensure satisfactory system performance for the application.

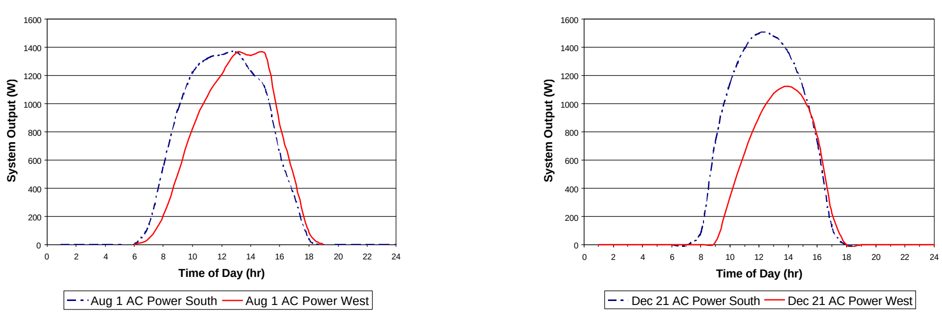
Roof Type

The roofing system, including the roof surface material and structural components, play an important part in determining the feasibility and method of installing a rooftop PV system. Composite shingles, tile, and metal roofing with a wood support structure are several types of roofing systems for residential and light commercial construction. The type of roof determines the mounting method required for supporting the PV array. Also, the type of roof can significantly affect both the initial cost of an installation and the lifecycle costs.

Orientation

A south-facing array tilted at an angle slightly less than the site latitude will typically produce the maximum power on an annual basis in the southern regions of the Northern Hemisphere. Other orientations may be selected depending on the application and the desired result. Tilt angles lower than the site latitude will tend to have a greater output in the summer season than in the winter. Conversely, arrays with greater tilt angles tend to have higher production during the winter months when the sun is lower in the sky. The tilt angle should be selected to meet the needs of the given application.

South-facing arrays have been shown to be the most productive on an annual basis for general applications. However, other factors such as the time of day value of the electricity produced or local weather conditions may also influence the appropriate orientation of the array.



Figures 1a and 1b) Simulation model predictions for systems with 2kW roof mounted arrays facing south and west for single days in summer and winter.

Available Roof Area

The available roof area is a limiting factor in determining of the size of a PV array that can be installed at a particular site. The physical dimensions of the PV modules that will be used must be arranged to fit within the available area and there must be ample room for installation and maintenance work. Sometimes the total roof area cannot be used because of roof penetrations such as vent stacks or other rooftop structures.

Solar Accessibility

Solar access, or the unobstructed path of sunlight to the PV array, is a critical part of the selection criteria for a PV site. Even a slight amount of periodic shading can significantly reduce the total output of the system and the value of the system as an energy producer.

Roof Accessibility

PV arrays are installed on many types of structures and each type of installation has an associated level of difficulty that affects the cost of installing the system. For example, two people using a ladder can lift modules to the roof of a single story home, but a crane or special lift would be required for the installation of an array on a multi-story structure.

Roof Life Expectancy and Re-roofing

PV modules can be expected to last 20 years or more. The condition of the roof that the array is being mounted on should be carefully assessed. The time period until the roof needs to be replaced should ideally be greater than the life expectancy of the PV array. If the roof is in need of replacement, the removal and reinstallation of the array during re-roofing activities is an added cost that affects the overall life cycle cost for the PV system.

Figure 2. A small standoff mounted PV array installed on a standing seam metal roof.

System Design and PV Array Hardware

Specific information is required for the PV system design once all of the preliminary information has been evaluated and a site has been selected. The details of the structure aid in the selection of the appropriate hardware for arranging the modules and for attaching the array to the roof.

Type of Roof

The type of roof is very important to the selection of the array mounting method and to the structural connections required. Mounting hardware can be directly attached to the surface of shingle and metal roofs. Tile roofs require special attachment hardware and methods because the tiles themselves cannot support the array safely.

Attic Access

Some mounting methods require access to the attic space for the proper installation of the hardware or supports. If access is not possible (i.e., an existing home with cathedral ceilings), alternative mounting systems or design changes may be required.

Physical Dimensions and Aesthetics

The visibility of the PV array and the importance of appearance to the building owner are significant factors in assessing the aesthetic requirements for the array. The available roof area dictates the maximum size of the array but the maximum number of modules may not coincide with the electrical design or may not be aesthetically pleasing. Modules must be grouped into panels of a specific number of modules connected in series to obtain the proper operating voltage. The available roof area may not be fully utilized due to the inability to fit full panels or the appearance of the hardware, if the array is highly visible.

Figure 3. A 2kW utility-interactive system installed on a shingle roof.

Attachment Methods

There are many different methods for attaching PV modules to roofs and each method has positive and negative aspects. A good design is the best attempt to maximize the benefits and eliminate the drawbacks. Design criteria that influence the selection of a mounting system include the following: roof type, wind loading, code compliance, ease of installation, and cost. Properly installed, these mounting techniques are no more likely to cause leaks in the roof than the fasteners used to hold the actual roofing materials in place.

The methods for attaching PV modules to rooftops discussed in this section deal with three common roofing systems: composite shingle, standing seam metal, and concrete tile. A specific method of attachment is described for each roof type. Some of the attachment techniques can be interchanged and used with roofing systems other than the specifically described system.

Sample Method: Shingle Roof

Wood Screws into Sheathing

A simple method for attaching mounts to a shingle roof is the use of screws directly into the plywood deck. This method would be used in cases where access to the attic is not possible. Typically, shingle roofs use relatively thin (1/2 in) plywood or OSB sheets for decking. Because of this practice the number of mounts and the number of fasteners per mount must be engineered to ensure a secure attachment. A long-life, high temperature sealant should be used to prevent leaks at the penetrations.

Figures 4a and 4b. A standoff roof mount showing the attachment screw locations and aligning and fastening a roof mount to a shingle roof.

Sample Method: Metal Roof

Lag Screws into Blocking

Blocking (or 2x members that span between two trusses) is installed when there is adequate access to the attic space below the roof area where the PV array is to be installed. The installation of the blocking increases the pull out strength of the fasteners and the individual mounts can better resist wind uplift forces. A rubber or neoprene pad should be installed between the roofing and the mount to help seal the penetrations, to prevent rubbing or punctures, and to minimize corrosion with dissimilar metals.

Figures 5a and 5b. Installing blocking between two trusses on the roof deck underside and applying sealant at the penetrations.

Sample Method: Concrete Tile Roof

Through-bolts and Blocking

Most methods for installing PV arrays on tile roofs are very labor intensive and involve the removal of tiles or cutting through tiles. The use of through bolts requires cutting holes in the tiles and installing blocking. Wood screws could be used successfully to fasten mounting brackets to the decking because thicker (3/4 in) plywood is typical. However, the use of blocking and through bolts requires smaller holes and allows the mounts to be placed further apart because of the stronger connection and thereby minimizing the number of penetrations.

Waterproofing the penetrations through the underlayment layer of a tile roof system is critical. This layer is the actual waterproofing membrane in a tile system. Sealing around the tile penetration is also important and must be flexible enough to allow some movement of the hardware without cracking the brittle tiles.

Figures 6a and 6b. A carbide grit hole saw is used to cut through the tile in place and a cross section of the complete assembly.

Case Study: Rooftop Array Installation Procedure

Step 1: Assess Roof

Identify the available roof area and the footprint of the array. Locate the array on the roof to avoid shading and roof penetrations. Also consider functionality and the aesthetics of the installed array.

Step 2: Identify Array Support Locations

Using a convenient reference such as the roof edge or ridge to align the array support locations, locate all of the support locations.

Step 3: Install Roof Mounts

The roof mounts are installed using the appropriate method for the system.

Step 4: Install Junction Boxes and Conduit

Junction boxes and conduit are installed under the array when possible to conceal the hardware. However, consideration should be give to the requirements for future access for repairs and maintenance.

Step 5: Install Panels

Modules that have been pre-assembled into panels are placed in the appropriate locations so that the source circuit wiring can be completed.

Completed System

The inverter and all BOS have been installed and the system is ready for inspections and commissioning.