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THE IMPORTANCE OF SITE SURVEYS IN FLORIDA'S PV BUILDINGS PROGRAM

by

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ABSTRACT

One of the goals of the Florida PV Buildings Program is to ensure that only quality utility-interactive PV systems are installed in the state. One important component of the Program is the site survey. The purpose of the site survey is to inspect the potential location for PV system *before* beginning construction, ensuring it is a sensible place to install it. The purpose of this paper is to introduce the method used by this Program and to present some examples that will demonstrate why it is important.

INTRODUCTION

In January of 1999, the Florida Solar Energy Center (FSEC), in collaboration with the Florida Energy Office (FEO) and Sandia National Labs, initiated the Florida PV Buildings Program [1]. One of the goals of this program is to install 20,000 utility-interactive PV systems by 2010 and to create a sustainable market for PV in the process. This Program was Florida's response to the Million Solar Roofs Initiative proposed by President Clinton to install one million solar systems on rooftops by the year 2010. To help push this initiative forward, buy-down money in the amount of \$2/Wp was offered to help defray the cost of the system. In order to insure all these new systems worked correctly, a major focus of this Program is quality control. The diagram below gives a brief overview of some of the features of the quality control program.

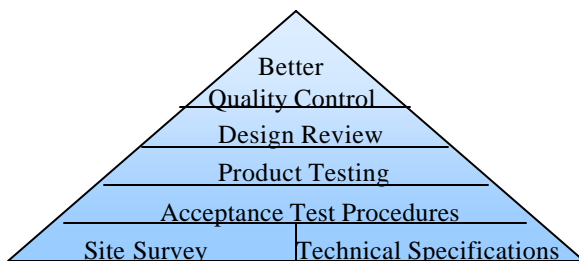


Figure 1. Factors involved in quality control in Florida's PV Buildings Program

So far, around 50 utility-interactive PV systems have been installed and included in the program. As a result, researchers in the PV Division at FSEC now have some experience using and further

developing some of the original materials. One very important part of the program has been the site survey. The purpose of the site survey is to ensure that the system can be installed safely and that it will be able to produce a reasonable amount of energy. While site surveys were performed before the majority of the systems in this program were installed, a few did not. Because some projects began before the Program was up and running, design changes could not be made. The following sections will outline the procedures used by FSEC for performing reliable site surveys and will demonstrate the results using some examples. One of the systems that did not have a site survey performed had some serious shading problems. Using a Solar Pathfinder, an attempt will be made to estimate the resulting energy losses.

PROCEDURE

Below is a list of tools that can be helpful when performing a site survey:

- Camera
- Video Camera (optional)
- Tape Measure
- Ladder
- Solar Pathfinder or Equivalent
- FSEC Site Survey Form
- Clipboard
- Pencils and Rulers for drawing
- Inclinometer

A Solar Pathfinder [2] is an effective device for determining the potential of array shading at any time of day or month of the year. This is very important since even small amounts of shading can have a very severe effect on array performance.

The FSEC Site Survey Form is a one-page document to be used as a checklist when performing a site survey. It contains the following sections:

- General Information
- Roof or other Array Mounting Surface
- Inverter, Utility-Access, Batteries and Engine Generator Recommendation

Survey Reviewer Information

Area for Sketch of PV array and BOS Locations

When beginning a site survey, sometimes a particular site can be ruled out almost immediately. If a home is under canopy of trees or has little south-facing roof space, the proposed system would get little or no direct sunlight. If the home is very old and the roof has obvious sags, it's probably not a safe place to install a system. If the building passes these initial tests, one can begin filling out the information on the form.

After getting the site address and contact information, an analysis of the roof of the building can begin. The following need to be considered when looking at a roof:

1. The type of roof material or mounting surface
2. The roof or mounting surface condition
3. The age of the roof
4. The roof supporting structure (e.g. roof trusses)
5. The roof or mounting surface slope
6. The available roof area for mounting the array
 - Azimuth Direction (degrees E or W of true South)
 - Eave Height
 - Ridge Height
7. The accessibility to the proposed array location
8. The potential for shading

In most residential applications, shingles are used to protect the roof because of their low initial cost. Other common roofing materials include concrete tile, metal seam, and built-up roofs. Installation of PV systems on a shingle or metal roofs is generally easier than those installed on concrete tile or built-up roofs. Concrete tile usually requires a carbide or diamond coated hole saw to penetrate the tile. Built-up roofs usually require a roofing expert to make sure any penetrations are properly sealed. This will add cost to the overall system cost and should be taken into account when making a recommendation to a potential customer.

The surface condition and age of the roof is important as well. If the roof is old and needs to be replaced in a few years, it may be in the best interests of the customer to replace the roof before the system is installed. This will lower the overall system cost since it will not be necessary to remove and reassemble the array when the new roof is installed. Signs that a shingle roof needs to be replaced include curling at the corners, brittleness, cracking, or a worn away mineral granule coating. Metal roofs generally only need replacement if excessive corrosion is evident. Concrete tile roofs may have excessive chalky deposits or may be cracked.

Since most of the homes in Florida are relatively new, most roofs will have supporting structures capable of enduring the load of a PV array. However, checking the trusses for signs of wear is a good idea. It is also important to check for roof leaks before the installation begins so there are no misunderstandings regarding who is responsible for making repairs.

The next step is to determine the amount of roof space for the PV array. The more closely the array faces true South, the more energy the system will produce. Some utilities that are installing PV systems

may choose to face the system West so that the most power will be produced in the afternoon, matching their peak demand. Since most crystalline silicon module have efficiencies around 10 percent, a good rule of thumb is that a 1 kWp DC array will need to cover around 10 m² (~ 110 ft²) of roof area. The roof slope can be measured with an inclinometer. The slope of the roof and the direction it faces can be used to better predict the output of the system.

Array shading is one of the more insidious problems that can have a devastating effect on array performance. Unless the array is installed in an area that has no obstructions, it is sometimes difficult to be sure if an array will be shaded at some point during the year. In order to be certain the array will not be shaded, it is necessary to use a tool like the Solar Pathfinder or some equivalent. The Pathfinder can show if any shading will occur at a particular location on a roof at

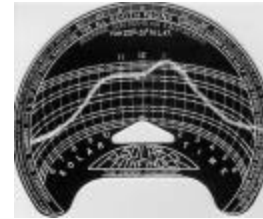


Figure 3. Example of shading diagram produced by the Solar Pathfinder

any point in time during the year. It accomplishes this by using a plastic lens to cast a reflection of potential impediments onto a map indicating sun positions at any time of day during the entire year. An example of such a map is shown below.

The vertical lines indicate the time of day and the horizontal lines indicate the time of year. The white chalk line drawn on the map indicates when this particular location on a roof would be shaded. The area above the line represents times when the array would be shaded by obstructions while the area below represents times the array would receive direct sunlight. As you can see, this would not be a good location for an array since there are several months where the array would be shaded all morning and some in the afternoon. In general, FSEC recommends that the entire array area should be free of any shading from 9 am to 3 pm all year long. Otherwise the customer should be notified that their system would produce less energy during certain times of year.

The next section on the Site Survey Form, Inverter, Utility Access, Batteries, and Engine Generator, notifies the surveyor to be sure there is room for the inverter, batteries, and engine generator if they are part of the system. It is preferable to have the inverter relatively close to both the array and the utility service panel so wire runs are not too long. Batteries are required to be enclosed so they are only accessible to qualified personnel. They also must be ventilated so high concentrations of hydrogen gas do not build up in the enclosure. Since many generators are noisy, it is preferable to keep them as far away as possible. Generator emissions must be ventilated as well.

A final step would be to make a sketch of the building and showing where the PV array and the balance of system (BOS) equipment would be located. The sketch should indicate any areas on the roof where shading occurs between 9 am and 3 pm. This information is crucial when getting ready to design a system.

RESULTS

Of course there are some installation sites where site surveys can be completed in just a few minutes. In Lakeland, FL, seventeen 2 kWp systems were installed on portable classrooms. All seventeen had the same basic design with 2/12 pitch asphalt shingle roofs. All of the arrays are facing either west or south. It was clear from the beginning that shading was not an issue at any of the sites since there were never many trees on school grounds and most of the buildings were only single story. The only real consideration was the age of the classroom. There is the potential for problems in the future if the classrooms are moved to a location in which the array is not facing the sun. However, the utility in Lakeland has now gained enough experience with photovoltaics to prevent that from occurring. Below is a picture of one of the systems.



Figure 4. Picture of a utility-interactive PV system on a portable classroom in Lakeland, FL

Many times the survey is not so easy. In New Smyrna Beach, a site survey [3] was performed on the home of a resident that was very interested in having a PV system on his roof. He was an active member of a local environmental group and had decided to do what it took to have a system installed. The concrete-block home had an asphalt shingle roof that was in reasonably good condition. The front of the house faced 20° W of due south and had a 3/12 pitch. The home was also surrounded by trees making it difficult to find a good location for the array. As a reminder, any location on the roof in which the Solar Pathfinder showed that would be shaded between 9 am and 3 pm during any month of the year was considered shaded. The diagram in Figure 5 shows the roof of the house from above.

The trees directly in front of the house included a large Cabbage Palm that had been damaged in a storm. Because that tree may have damaged the home, it had been previously decided that it would be removed. Other smaller trees surrounded the palm had the potential of growing higher and causing shading later, so it was decided that the modules should be close to the roof ridge as possible. The Red Bay tree on the east corner of the house caused a considerable amount of shading in the morning to the east side of the south-facing roof. Because the local utility was partially subsidizing the system, the west-facing roof was also considered a potential location for the

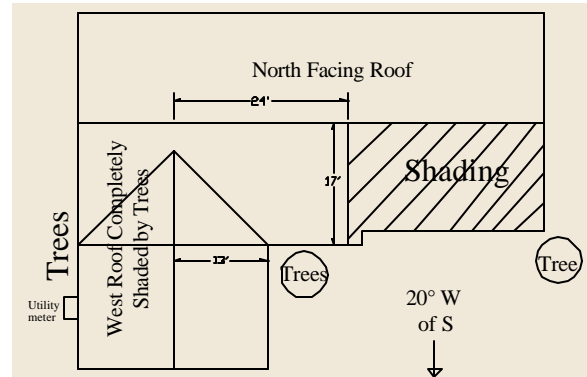


Figure 5. Schematic of home in New Smyrna Beach indicating areas of shading

array since power would be generated during the utility's summer peak. However, it was shaded by a number of trees and was not considered as a result. Since the homeowner wanted to purchase a two kW PV system, there was not enough viable area on the south-facing roof for the PV system. To create more viable space on the roof, both the Cabbage Palm and the Red Bay tree were removed. This allowed room for all the modules to fit on the roof with full access to the sun. Figure 6 shows in the roof with the array layout.

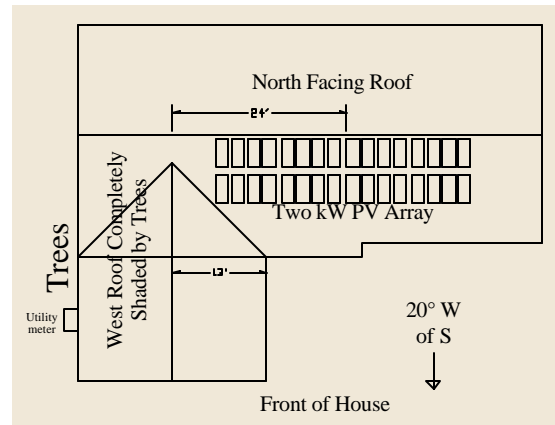


Figure 6. Schematic of home in New Smyrna Beach with PV array layout

As was mentioned in the introduction, some projects were underway before our Program was completely in place. As a result, some systems were installed without going through our entire process. An example [4] of such a system was installed for one of Florida's municipal utilities with the intention of selling the energy through a green pricing program. The array was installed on a metal structure in front of a public building as an awning. Since both the building and the array support structure were designed and built at the same time, it was impossible to perform a standard site survey before the array was installed. This PV system has a 10.2 kWp array connected to two bipolar, utility-interactive inverters. It is in very conspicuous location and has aesthetically pleasing design.

Unfortunately, array shading was not adequately considered before deciding on the array location. As a result, a good portion of the array is shaded in the morning by the building behind it. The diagram in Figure 7 shows a layout of the array.

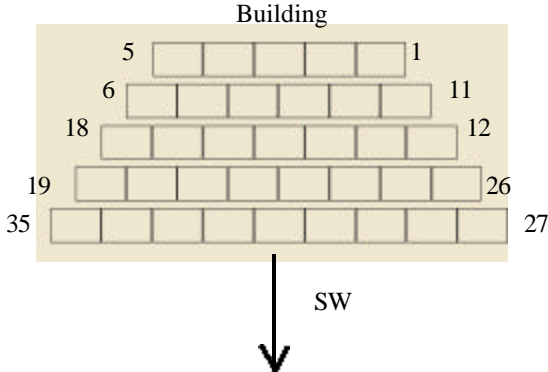


Figure 7. PV system module layout.

Upon first noticing the location of the array with respect to the building, it became obvious that the building would prevent some direct sunlight from reaching the array, however it was difficult to know how great the effect would be. When placing the Solar Pathfinder in the location of module three, it was apparent that there would be significant morning shading depending on the season. The shading diagram is shown below in Figure 8.

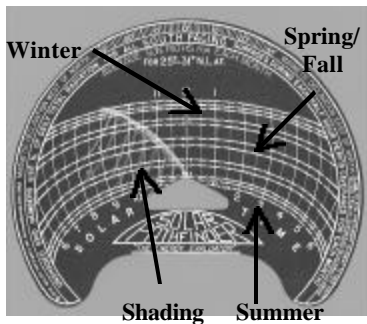


Figure 8. Shading diagram produced at module three

Shading occurred to the left of the chalk line. The winter months are represented in the diagram by the top three horizontal lines, spring and fall months are the six months by the middle lines, and the bottom three horizontal lines represent the summer months. The diagram shows that in the summertime, the modules close to the building will be shaded until around noon. In the wintertime, the module should receive direct sunlight by 9 am. However most of the year, the output of this string will be compromised by morning shading. Less severe shading also occurs due to an outdoor lighting pole and fixture west of the array. Because the Solar Pathfinder so accurately determines the amount of shading a particular location receives during the year, an attempt can be made to quantify the energy lost due to this shading. However, this would require one to have diagram for *every location* on the array where shading would occur. Modules (or even individual cells) would receive less and less

shading the farther away they were from the building. A rough estimate of energy losses could range anywhere from 20 – 40%. A more accurate estimate of energy losses can be made when system monitoring equipment is installed later this year.

CONCLUSIONS

With the onset of restructuring, many states now have money set aside to develop renewable energy programs using technologies like PV. In order to have a successful program, it is important to develop a comprehensive plan to ensure quality systems are installed. This is a substantial part of the Florida PV Buildings Program. As demonstrated above, site surveys play a vital role in this process. If systems are installed in locations that do not receive direct sunlight between 9 am and 3 pm all year long, energy production can be severely compromised. If systems are installed on roofs that are old and unsound, safety becomes an issue. Site surveys also provide a way for installers to obtain all the necessary preliminary information to size the system. This information includes not only the maximum size of the system but the inevitable location for the array, inverter(s), and other balance-of-system equipment.

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