Solar 101 - Applying Solar Photovoltaic Technology to the Roof

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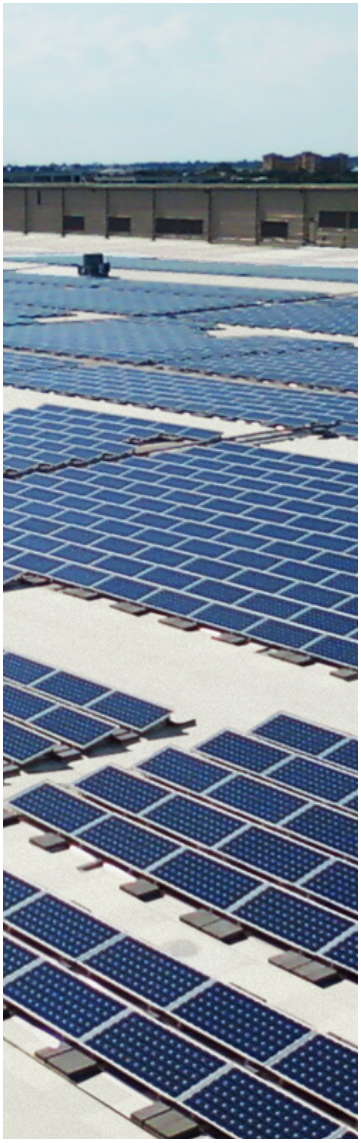
WHITE PAPER



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INTELLIGENT ROOFING SOLUTIONS

Objective of this paper

The objective of this paper is to provide a basic understanding of solar photovoltaic (PV) as an integrated component of roofing systems. Questions of focus include the following:

1. How is solar photovoltaic energy generated?
2. How is solar energy purchased and what is the approximate cost?
3. What is the best solar panel product to purchase?
4. What is the distribution channel; who can I talk to regarding the possibility of purchasing solar for my roof?

How is solar energy generated?

Solar Photovoltaic (PV) - A solar cell converts light to electricity. This solar cell can be made from a number of different substrates. The most common is silicon. (Computer chips and semiconductors are made of this same material, which is an abundant chemical element.) Basically, when light strikes the surface of a solar cell, some of it is absorbed into the silicon. This light energy bumps the electrons loose and causes energy to flow.

Conversion Efficiency - The percent of the sunlight absorbed into the solar cell that is converted to usable energy is referred to as its efficiency. For example, if a solar cell is rated at 10% efficiency, that means that 10% of the captured energy from the sun is being converted into electricity. If solar PV module 'A' is rated at 10% and module 'B' is 20%; then you would need to purchase twice as many 'A' modules to equal the capacity of module 'B'.

Solar Irradiation - Solar Irradiation is the total amount of solar energy accumulated on an area over time, (i.e. one day) and is often expressed as "peak sun hours per day". As example, in Los Angeles the sun may shine 15 hours per day in the summertime. That sun energy equates to 5.63 hours of full sun, or sun shining at the "optimal angle", which is considered to be the angle of the sun around high noon. The government has calculated what the full sun hours by region are within each state. (http://rredc.nrel.gov/solar/codes_algs/PVWATTS/version1/). Here are a couple of other examples: Akron, Ohio 4.18 hours; Minneapolis, Minnesota 4.74 hours. This metric is a key factor in determining the economics of solar power in any given area. It is also an essential metric for solar installers who must adequately measure and verify that the output of an installed PV system is consistent with expectations.

How is solar energy purchased and what is the approximate cost?

Solar energy is purchased based on the watt capacity (or peak production) of the system, also known as the "nameplate" or "system capacity".

It should be quoted to buyers as the cost per watt capacity. Cost per panel or cost per square foot is, basically, irrelevant.

Costs can vary widely, but, as an example, a 30,000 square foot manufacturing facility typically has usable solar space of 15,000-20,000 square feet. For space to be considered usable, it must be free of shading from other buildings, mechanical apparatus on the rooftop, or other obstructions. Generally, if 15,000 square feet are available for solar panels, a system with a capacity of 150kW (kilowatts) or greater can be installed.

Based on hypothesized energy use of a 30,000 square foot manufacturing facility, the 150kW system may generate as much as 50% of the energy needs of that building and would typically have a gross installed cost of $4 to $6 per watt or $600,000-$900,000. The net cost, less government and utility incentives, could lower that projected cost by a minimum of 30%, to upwards of 50%. Variables affecting this result include the building's location, the affiliated utility company and the solar rebates and incentives in the area. These incentives, in concert with the "avoided electricity cost" that no longer has to be paid because the solar system is generating the electricity, form the basic economics of the financial return of a PV system.

For a general idea of the incentives available in your area, refer to the U.S. Department of Energy's Database of State Incentives for Renewables & Efficiency found at www.dsireusa.org. Examples include the following:

- Federal Tax Credit of 30%
- State Tax Credits and / or Deductions in 25 States
- State Local Property Tax Exemptions for Renewable Energy in 35 States
- State Sales Tax Exceptions for Renewables in 25 States
- State and / or Utility Rebate Programs in 40 States
- State or Utility Grants for Renewable Energy Technologies in 23 States
- State or Utility Loan Programs in 38 States
- Net Metering – Utilities in 44 States provide a credit for the amount of renewable energy that is created. The program works as follows: If a solar PV array generates more electricity than what one requires to run their facility, at a given point in time, you will earn a credit that can be used when your Solar array is generating less electricity than you require. This credit must be used within 12 months.

What is the best solar panel product to purchase?

The objective of this paper is to give a broad overview of the different types of solar PV technology, rather than to provide a detailed comparison of each. Nevertheless, a brief description of the different technologies is included at the conclusion of this paper.

Solar panels come in at least three popular forms: rigid panels, flexible "thin" films, and tubular "fluorescent tube" forms. There are basically four different types of technology: Crystalline Silicon (c-Si), Amorphous Silicon (a-Si), Copper Indium Gallium Diselenide (CIGS) and Cadmium Telluride (CdTe). They all have advantages and disadvantages, but interestingly, most have a similar installed cost range per watt capacity. To determine which system best suits your needs, examine your past 12 months of utility bills and ask yourself the following important questions:

1. What is my installed cost per capacity watt? (As previously mentioned, cost per panel or cost per square foot is insignificant.)
2. How much real estate do I want to commit to solar?
3. What is the track record of the given technology? Most solar investments are based on securing a 20 year life. **(Note: Be sure your roofing system has a 20 year life; otherwise, you could incur significant costs in re-installing your solar panels on a new roof.)**
4. Will my structure be able to handle the added weight?
5. What is my payback, through a cash purchase or if financing?
    a. Become familiar with the forecasted cost of your electricity from current sources.
    b. Research the available government and utility incentive programs in your area.

Finally, consider all the alternatives before settling on one type of solar panel for your facility.

Distribution

Members of the distribution system include:

- Solar panel manufacturers
- Accessory parts manufacturers
- Integrators
- Solar panel installers
- Power Purchase Agreement Providers

The Integrators are the people who can access your current situation and make a recommendation to you regarding the type of solar panel to purchase, how much watt capacity can be installed, and how much energy can be generated, based on the solar irradiation of that system. The Integrator, typically, will purchase the solar panels and accessories, and resell them to you.

Most Integrators specialize only in “Solar Integration.” Other companies, including roofing contractors and roofing system manufacturers, are starting to offer integration services.

How can I finance solar?

In addition to financing solar or leasing it, one may be able to purchase solar through a third party, a Power Purchase Agreement (PPA) Provider. This method would require little or no up front capital.

There is a very strong trend towards PPA Providers financing the solar PV purchase, and selling the electricity under contract back to the end user. According to some reports, up to 90% of commercial jobs are financed this way.

The following is an example of a relationship formed between the building owner and the PPA Provider. The PPA Provider will try to offer a first year electricity cost that is equal to the building owner’s current grid cost. The Provider will typically add an escalator clause of something like 3% per annum for 20 years. This 3% is below the often quoted CAGR forecast for non-renewable energy of 6%. The owner makes money with the projected 3% saved per year, compounded. In addition, if the owner’s system generates more electricity than the building requires, the owner earns energy credits toward their utility bill; a concept referred to as Net Metering, discussed above.

Behind the scenes, the PPA Provider does the following. The Provider sets up a holding company. Investors provide capital that is used to pay the Provider a development fee, and pay for the site assessment and installation for each solar job. Other revenues that will feed this holding company include: the renewable energy credits, tax credits, rebates and other incentives associated with installing a solar system, and the per kHw contract payments from the building owner.

Solar Product Overview – In Brief

Crystalline Silicon (c-Si) – Typically referred to a "rigid panels" because that is the predominant manufactured form.

Product Form

- Rigid panels encased in glass are by far the most common. These panels are typically placed at an angle towards the sun to optimize efficiency.
- Thinner panels and "building integrated" forms that would affix directly to the roof are now just starting to be introduced at increased cost.

Efficiency

- Efficiency can vary greatly among manufacturers. Typical rates are between 10% and 20%. Again, efficiency is defined as the amount of sunlight that is converted into energy. Some (< 5%) of its efficiency output is typically lost during its life, with most manufacturers providing efficiency and power output warranties over the life of the panel.

Advantage

- This is the most proven solar PV technology, having been introduced over thirty years ago. It has the highest efficiency vs. the other commonly used products, which basically translates into less real estate required to generate the same capacity of watt power.

Disadvantage

- A disadvantage of c-Si vs. the thin film products (discussed later), can be their weight. A Structural Engineer should inspect your building to ensure that the structure can handle an additional 4-5 lbs per sq ft. of roof space.
- Shading used to be a major disadvantage of c-Si, whereby if you had 8 panels strung together in a solar array, and; e.g., panel #2 became shaded, the entire string would have a major decline in solar output. However, that has changed and c-Si and other products are affected by shade in a minor way.

Amorphous Silicon Thin Film (a-Si)

Product Form

- a-Si is available in rigid panels, encased in glass, and in a flexible form with either stainless steel or a plastic as the base layer. In the rigid panel form, they can be placed at an angle just like c-Si. Most thin film, however, lays flat on the roof.

Efficiency

- Efficiency tends to be in the 6-9% range. Twenty percent of its efficiency is typically lost after the first few years, and then it levels off.

Advantage

- a-Si is the oldest thin film technology, introduced approximately 10 years ago, with many long-term, real world tests and installation data, but less than c-Si.

Disadvantage

- Lower efficiency vs. c-Si
- a-Si doesn't have the track record of c-Si

Copper Indium Gallium Diselenide (CIGS)

Product Form

- As with a-Si Thin Film, CIGS can be supplied in a rigid panel, encased in glass and in a flexible form with either stainless steel or a plastic as the base layer. In addition, CIGS is also supplied in a glass "fluorescent looking" tube.

Efficiency

- The thin film form's efficiency is similar to a-Si, in the 6-9% range. In the tube form, the efficiency is slightly higher, due to the cylindrical surface having more "optimal angle" with the sun during the day, and from the reflectivity generated if using a white membrane. Ten percent of its efficiency is lost after the first 10 years.

Advantage (tubes)

- Given that a reflective roofing membrane may be considered an integral part of the PV system due to its reflectivity benefit, you may be able to depreciate the roofing membrane, which is normally depreciated over 39 years, to that of 5 years like the solar PV is.

Disadvantage

- CIGS has not been proven yet, as it is just being introduced to the market.

Cadmium Telluride (CdTe)

Product Form

- CdTe is only supplied in rigid panels, encased in glass.

Efficiency

- Efficiency range is 11-14%

Advantage

- CdTe is more proven than CIGS
- The cost is very low

Disadvantage

- Safety concerns of cadmium have slowed the product's growth. Truth be told, however, one "D" size flashlight battery has more cadmium than an entire solar panel.

Contact Us:

For more information about FiberTite Roof Systems or to see if solar makes sense for company your please call Seaman Corporation at 800-927-8578, or click here.

Useful Resources:

National Renewable Energy Laboratory
http://www.nrel.gov/learning/re_photovoltaics.html

NC Solar Center and the DSIRE Solar Database
http://www.ncsc.ncsu.edu/gosolarnc/solar101.php
http://www.dsireusa.org/solar/index.cfm?ee=1&RE=1&spf=1&st=1

US Department of Energy Solar Energy Technologies Program
http://apps1.eere.energy.gov/solar/cfm/faqs/second_level.cfm/name=Photovoltaics