Measuring PV Efficiency

Efficiency in photovoltaic solar panels is measured by the ability of a panel to convert sunlight into usable energy for human consumption. Knowing the efficiency of a panel is important in order to choose the correct panels for your photovoltaic system. For smaller roofs, more efficient panels are necessary, due to space constraints. How do manufacturers determine the maximum efficiency of a solar photovoltaic panel though? Read below to find out.

Let us first start out by saying that the maximum power, also known as P_{max}, of a 200W panel is 200W regardless of the panel efficiency. It is the area the solar panels use up to get those 200W that determines how efficient the panel is. The panel efficiency determines the power output of a panel per unit of area. The maximum efficiency of a solar photovoltaic cell is given by the following equation:

$$\eta_{max}\,(\text{maximum efficiency}) = \frac{P_{max}(\text{maximum power output})}{(E_{S,\gamma}^{SW}\,(\text{incident radiation flux}) * A_c(\text{area of collector}))}$$

The incident radiation flux could better be described as the amount of sunlight that hits the earth's surface in W/m^2. The assumed incident radiation flux under standard test conditions (STC) that manufacturers use is 1000 W/m^2. Keep in mind though, that STC includes several assumptions and depends on your geographic location.

Now, we'll make a sample calculation to determine how manufacturers calculate the maximum solar panel efficiency under STC.

Assume you have a 400W system with an area of 30 ft^2 and you want to determine the maximum efficiency of your solar panels under STC. Your first step would be to convert the area of your panels' to units of square meters which is:

$$A_{m^2} = \frac{A_{ft^2}}{10.76}$$

$$30\ ft^2 * \frac{1\ m^2}{10.76\ ft^2} = 2.79\ m^2$$

(In determining the efficiency, I would personally include the dimensions of the frames in your calculations. Although they are there for structural purposes, they are necessary components that do take up area)

Now that you have your P_{max} (400W), $E_{S,\gamma}^{sw}$ (1000W/m^2), and A_c (2.79 m^2), you can plug your numbers into the efficiency equation where all units will cancel out and then multiply the value by 100% to give you your efficiency percentage:

$$\eta_{max} = \frac{400\ W}{(1000\frac{W}{m^2} * 2.79m^2)} = 0.143 \text{ x } 100\ \% = 14.3\ \%$$

This would be the *maximum* efficiency of your solar panel, not to be confused with the *minimum* that may be found on the specification sheet.

So when you are determining what solar panels are right for you, think about how important the efficiency of panels are in paying a premium price. Perhaps you have a roof with a large area that would be ideal for the placement of solar panels, and therefore, lower cost and less efficient panels would work for you. If your rooftop area is limited though, you may want to determine the efficiency you will need for your panels to achieve the desired power output over a limited area.