# Real World Expectations for Your Solar System

As our last bulletin mentioned, there are a lot of factors that influence solar production. That can make it hard to tell if your panels are living up to their solar ratings. However, a few handy formulas can make it easy to compare real world power production and rated production. Let's start off with two essential benchmarks for your comparisons: energy production and peak power production.

## Understanding System Performance Terms

**Energy Production**

These terms should be looking more familiar at this point if you weren't already aware of them. In our first bulletin, we talked about energy and power. Expressed in kilowatt-hours (kWh), energy production is the first and most important benchmark of system performance.

The predicted energy production of a system is based on local, historical weather patterns. Because energy is measured over a period of time, energy production does not require many adjustments for an accurate comparison between forecast production and actual production. The differences between the two are usually because of variations in sunlight, i.e. there was more or less sunlight than the forecast assumed.

Whenever possible, we highly encourage you to use energy production as your main benchmark for comparison because it is actually what your system has produced.

**Peak Power Production**

Power production at a specific moment in time (instantaneous power production) is the second performance benchmark. It is commonly discussed as kilowatts (kW), and this is where the fun begins. This measure is not as reliable as the energy benchmark. However, it can be evaluated quickly by normalizing performance data. If normalization is a new term for you, just think of it as a way to level the playing field.

Essentially, normalization is a way to adjust values measured under actual conditions to compare them directly to power rating values under standard test conditions (STC) or other ratings. For example, how a solar system is performing relative to its AC rating at specific irradiance and temperature conditions can be estimated with very good accuracy.In both situations, the production difference is largely because of differing amounts of sunlight. But other external factors like temperature, shading, weather, and soiling also affect the total energy a system can produce.

**Normalizing Performance Data**

1. Normalize the irradiance.

Example: A system is producing 80 kWac at 900 W/m², but the AC rating conditions require 1000 W/m². Power normalized to irradiance is: **80 kWac * (1000/900) = 88.9 kWac**.

Short and sweet for that one, right?

2. Normalize the temperature.

All right, we admit it. This one is a little more complex, but it's the last of the math for now. For crystalline solar panels, the temperature factor varies from -0.35%/ °C to -0.55%/ °C. A typical value is -0.45%/ °C.

Example: The ambient temperature measured at the system site referenced above is 35 °C. Rating conditions (PTC) require 20 °C. Power normalized to temperature (and irradiance) is: **88.9kW * (100% + (20 °C – 35 °C)*(-0.45%/ °C)) = 94.9 kWac**.

An additional step can be taken for wind speed and air mass, but you get the idea. There are different equations that will allow you to determine if a solar system is performing up to its rated performance or not.

## Setting Performance Expectations for Solar System Performance

**Energy**

As we've discussed before, a solar system will produce different amounts of energy each year depending on the available sunlight. Some years, a solar system will produce more than predictions, and some years it will produce less. Energy production from year to year can vary by as much as 20%.

But don't worry. Generally, it will remain fairly consistent. When you're working with a quality solar provider, you can expect that the average annual energy production will be within one or two percent of the performance simulation.

**Power**

Since most of the industry talks about watts and kilowatts, we're spending quite a bit of time explaining power. These terms are important, but you are probably realizing that energy production (kilowatt-hours) is much easier to understand. Power can range widely because solar system power output is highly dependent on the local conditions, time of day, season of the year, geographic location, and so forth.

For example, many people expect that if their solar system capacity is rated at 100 kWac, then the system will produce 100 kW on any sunny day. But it won't. A 100 kWac system is not expected to produce 100 kW on average during any month of the year in any geographic location. It is perfectly normal for a 100 kWac rated system to produce an average of 70 kW at noon in June. As we mentioned in the solar ratings bulletin, standardized conditions usually occur for a few minutes of just a few days in any year.

And geography plays a big role because of the different solar resources available around the globe. For example, consider a 100 kW system located in New York and California. Power production on an average day in California is greater than that of an average day in New York in every month of the year. So clearly geography plays in major role in solar production.