A GUIDE TO SOLAR PANEL RATINGS

There are essentially two classes of solar panel ratings. There are ratings based on tests performed in a laboratory under tightly controlled settings and there are ratings that more closely reflect real world conditions.

STANDARD TEST CONDITIONS

A solar panel is initially tested in a factory under controlled settings. As the solar panel comes off the production line, the panel is exposed to artificial sunlight. There are electronic devices connected to the terminals of the panel that record a number of performance values including the solar panel's voltage (volts), current (amperes) and power (watts). These testing conditions are called "Standard Test Conditions" or STC. Because changes in temperature and light exposure can significantly impact a solar panel's voltage and current production, all solar panels are tested at the same standard test conditions. This includes the panel's temperature of 25°C (77°F), light intensity of 1,000 watts per square meter (1,000 Wm^2), which is basically the sun's position at noon, and the atmospheric density of 1.5 AM, or the sun's angle directly perpendicular to the solar panel at 500 feet above sea level.

Pmax is the maximum rated power output of a solar panel. This is sometimes referred to as nameplate capacity.

Vpmax is the maximum voltage the solar panel can produce at the maximum power point.

Ipmax is the maximum current the solar panel can produce at the maximum power point.

The open circuit voltage (**Voc**) is how many volts the solar panel outputs with no load on it. If you measured across the plus and minus leads with a voltmeter, under standard testing conditions, it would read 36.9V.

The short-circuit current (**Isc**) is the amount of amperes that are being produced when the panel is not connected to a load but when the plus and minus terminals are connected to each other.

PHOTOVOLTATIC MODULE

MODEL	KZ235GX-LPB	MAXIMUM SYSTEM VOLTAGE
IRRADIANCE AND CELL TEMPERATURE	$1000Wm^2$ AM 1.5 25° C	600V
Pmax	235W	MASS
Vpmax	29.8V	
Ipmax	7.89A	21.0 Kg
Voc	36.9V	
Isc	8.55A	
Serial No.	9999999	

WARNING
- Photovoltaic modules generate electricity when exposed to light. Hazardous Electricity can shock, burn, or cause death.
- Do not touch terminals when exposed to light.
- When connected or disconnected to the output cable, upper surface should be shaded from light.
- Must comply with local safety standards prior to installation.

Fire Rating	Field Wiring	Series Fuse
Class C	10~14 AWG	15A

PLEASE READ THE INSTRUCTION MANUAL FOR MORE INFORMATION PRIOR TO INSTALLATION.

Unfortunately, STC ratings seldom reflect real world conditions. For example, let's assume a solar panel typically operates at temperatures 20° hotter than the surrounding air temperature, which is common for most rooftop applications. For a solar panel to produce its max power STC rating, it would actually need to operate at a temperature of 77°F when the surrounding air temperature registers somewhere around 57°F. To put that in perspective, the average temperature in Arkansas often exceeds 57°F and that includes overnight temperatures when the sun is not even shining. In other words, solar panels in Arkansas will typically operate at hotter temperatures than the temperatures specified under standard testing conditions. And when solar panels heat up, the electricity produced by the panels will actually go down.

NOMINAL OPERATING CELL TEMPERATURE

To calculate a more realistic maximum power output rating for any given solar panel, first locate the Nominal Operating Cell Temperature (NOCT) and the Temperature Coefficient of Pmax on the solar panel specification sheet.

Temperature Characteristics

Nominal Operating Cell Temperature (**NOCT**)	45±2°C
Temperature Coefficient of Pmax	-0.45 %/°C
Temperature Coefficient of Voc	-0.34 %/°C
Temperature Coefficient of Isc	0.050 %/°C

The NOCT is the temperature that the solar panel reached in the laboratory when subjected to 800 Wm^2 of light intensity at an ambient temperature of 20°C (68°F), which is closer to a real-world setting. The Temperature Coefficient of Pmax details how much power the panel loses for every °C that the panel is hotter than 25°C. In other words, the above panel will lose .45% of its maximum power rating for every degree registered above 25°C (i.e., the panel's temperature under standard testing conditions). The NOCT informs us the solar panel will typically operate at 45°C (113°F), so it's rather simple to work out the power loss at this temperature.

Power Loss % = Temperature Coefficient of Pmax x (NOCT – 25°C)

Power Loss % = -.45%/°C x (45°C – 25°C)

Power Loss % = -9.0%

So, we can realistically expect the maximum power of the solar panel to be 9% lower than the panel's Pmax STC rating. For a panel with a Pmax STC rating of 235W, an estimated real world maximum power would fall close to 214W.

HOW DOES THESE RATINGS IMPACT SOLAR PANEL PRODUCTION ESTIMATES?

In both Arkansas and Missouri, the average peak sun hour exposure is 4 hours per day. Peak sun hours refer to how much sun exposure is useable for efficient solar energy production in an area. Although your solar panels may receive an average of 7 hours of sunlight per day, the average peak sun hours are far less. From this figure we can estimate the annual sun peak hours our solar panels will be exposed to. And then from each rating, we can predict the number of kilowatt-hours (DC) the solar panel can produce under each environment (i.e., laboratory setting versus a real-world setting). As you can see, the NOTC rating yields a difference of 31 kilowatt-hours (or 9% less) than what we estimate under the STC rating).

Days in Year	365
Average Peak Sun Hours	4
Total Annual Sun Peak Hours	**1,460**

STC Rating (Watts)	235
Annual Watt-hours DC	343,100
Annual Kilowatt-hours DC	**343**

NOTC Rating (Watts)	214
Annual Watt-hours DC	312,440
Annual Kilowatt-hours DC	**312**

Just remember, the STC and NOTC ratings are listed in direct current (DC) and do not account for all real-world power losses. Actual solar systems will produce lower outputs due to soiling, shading, wire losses, inverter and transformer losses, shortfalls in actual nameplate ratings, panel degradation over time, and high-temperature losses for arrays mounted close to or integrated within a roofline.

The online PVWatts calculator (https://pvwatts.nrel.gov/index.php) can be used to project a solar system's annual AC kilowatt-hour production using the DC power rating in kilowatts (kw) of the solar panel array at standard test conditions (STC). This free online resource allows those interested in purchasing solar systems to verify whether a quoted future solar production schedule is accurate.