The Temperature Dependence of Solar Cells

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Question: Does temperature affect the amount of energy a solar panel receives?

Answer: The short answer is: yes, temperature does affect how much energy a solar panel can produce. When a solar cell is heated, it becomes less efficient.
The amount of energy a solar panel can produce depends on its efficiency. The efficiency is determined by comparing how much power the solar cell produces to the amount of light that shines on it. This is measured by illuminating the solar cell with a calibrated light and measuring the current produced at different voltages. This measurement gives us current as a function of voltage which we can plot on a graph. For a solar cell, this function looks like the one shown in red in the figure on the next page. The power produced by a solar cell is calculated from the current and voltage with the following equation.

$$P = JV \tag{1}$$

where

P is the power produced
J is the current and
V is the voltage.

The power is plotted in blue in the figure. Somewhere along the current-voltage curve the power, P, will have a maximum value. This point is called the maximum power point and it is where we calculate the efficiency. The efficiency is given by

$$\eta = \frac{J_{max}V_{max}}{P_{in}} \tag{2}$$

where

η is the efficiency
J_{max} is the current at the maximum power point
V_{max} is the voltage at the maximum power point and
P_{in} is the power incident on the solar cell (the power from the light shining on it).

This can also be written as

$$\eta = \frac{J_{sc}V_{oc}FF}{P_{in}} \tag{3}$$

where

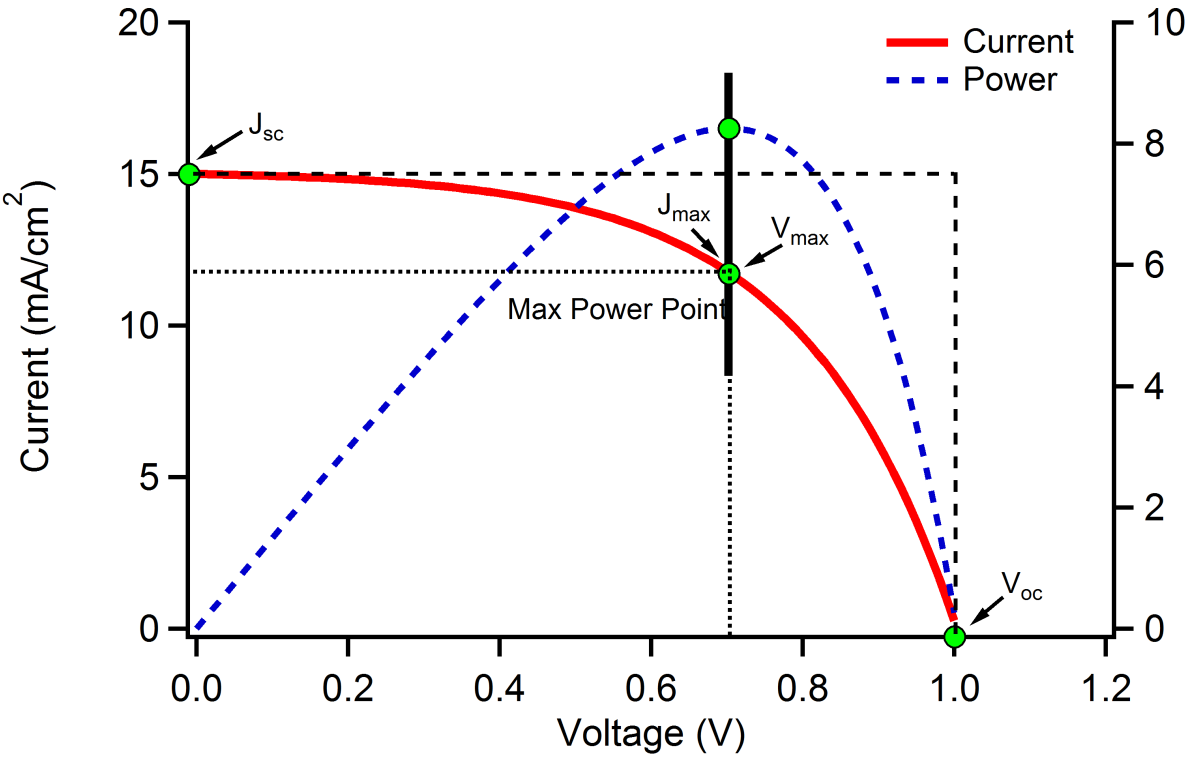
J_{sc} is the current at short circuit (when V = 0)
V_{oc} is the voltage at open circuit (when J = 0) and
FF is the fill factor which describes how "square" the current-voltage curve is. It is the ratio between the two rectangles drawn in the figure.

When the solar cell is heated, the current, J_{sc} will increase, but the voltage, V_{oc}, will decrease. Since the voltage decreases faster than the current increases, the result is that the overall efficiency goes down.

$$\eta\downarrow = \frac{J_{sc}\uparrow V_{oc}\Downarrow FF}{P_{in}} \tag{4}$$

Although the performance of solar panels does depend on temperature, the effect is not very strong so solar panels can still function properly even in the summer when it is hot outside.

References: Nelson, Jenny. *The Physics of Solar Cells.* London: Imperial College, 2003. Print.


Current
Power
J_{sc}
J_{max}
V_{max}
Max Power Point
V_{oc}
Current (mA/cm^2)
Voltage (V)
20
15
10
5
0
10
8
6
4
2
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2