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Effect of Temperature on Solar Cell Efficiency

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Abstract: *The main limit of solar cell is low conversion efficiency of photovoltaic panels. Efficiency of photovoltaic panels is strongly affected by temperature of photovoltaic cell. The light intensity loading on the panel will cause its own temperature change. And change in temperature will affect the power output from the solar cell. In this research paper we established a relation between efficiency and temperature of photovoltaic cell. In order to calculate efficiency of photovoltaic cell we have gone through output voltage, output current and power input of photovoltaic cell.*

Keywords: *Efficiency; Temperature; Photovoltaic cell; Output voltage; Output current; Input power.*

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Introduction:

A solar cell (also known as a photovoltaic cell or PV cell) is defined as an electrical device that converts light energy into electrical energy through the photovoltaic effect. A solar cell is basically a p-n junction diode (Fig.1). Solar cells are a form of photoelectric cell, defined as a device whose electrical characteristics such as current, voltage, or resistance vary when exposed to light. Individual solar cells can be combined to form modules commonly known as solar panels. The common single junction silicon solar cell (Javed, 2014) can produce a maximum open-circuit voltage of approximately 0.5 to 0.6 volts. By itself this isn't much – but remember these solar cells are tiny. When combined into a large solar panel, considerable amounts of renewable energy can be generated.

Photovoltaic solar panels convert sunlight into electricity, so we think that the more sunlight, the solar panels will be more efficient (Bezzahe, 2019). That's not always true, because sunlight consists not only the light that we see, but also invisible infrared radiation, which carries heat. The solar panel will perform great if it gets a lot of light, but as it gets hotter, its performance may decrease.

According to the manufacture standards a 25 or 77 temperature shows the peak of the optimum temperature range of solar panel (Dubey et. al., 2013). Means at 25 solar panel will absorb sunlight with maximum efficiency which is called maximum power temperature coefficient (P_{max}).

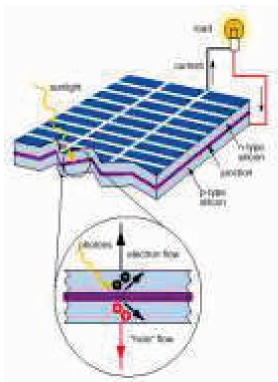

Fig. 1. Solar Cell

Efficiency: Efficiency of a photovoltaic cell is defined by ratio of power output and power input multiplied by area of solar panel. Amount of energy produced by solar panel calculated by products of output current and the voltage.

$$\text{Efficiency} = \frac{\text{output current x output voltage}}{\text{power input x area}}$$

In this article, we have studied the change in output current, output voltage and efficiency of solar cell at different temperatures (Tobnaghi et.al, 2013). In order to calculate efficiency of solar cell or photovoltaic cell, we have used output voltage, output current and power input of photovoltaic cell (Bezzahe, 2019).

Methodology:

Apparatus Used: Photovoltaic cell (6V), light source (bulb 100W), regulator, connecting wire, thermometer, a small LED light 100 mA (for load), multimeter.

The light intensity loading on the panel will cause its own temperature change (Tobnaghi et. al., 2013). Therefore, the light intensity on the surface of the photovoltaic module and the corresponding output voltage and current data are analyzed under different temperatures of the photovoltaic cell. Due to the packaging of photovoltaic modules. The temperature data of the photovoltaic module are measured, respectively. The most important parameter of silicon solar cell efficiency is output voltage.

Result and Discussion:

The data analyzed for output current corresponding to temperature of photovoltaic cell is given in Table 1. Here we can see that output current slightly increases with increase in temperature.

Table 1. Output voltages at different temperatures

Temperature T (°C)	Output voltages V (mV)
20	5620
22	5580
24	5510
26	5460
28	5400
30	5360
32	5320
34	5280
36	5250
38	5215

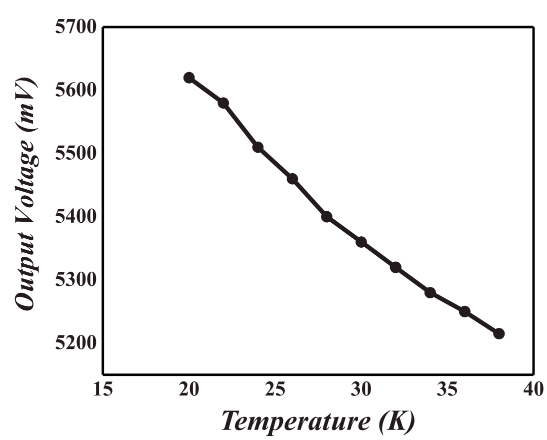

Fig. 1. Graphical representation of output voltage corresponding to temperature of solar cell

Table 2. Output current at different temperatures

Temperature *T* (°C)	Output current *I* (mA)
20	38.78
22	38.79
24	38.81
26	38.83
28	38.84
30	38.85
32	38.87
34	38.89
36	38.90
38	38.92

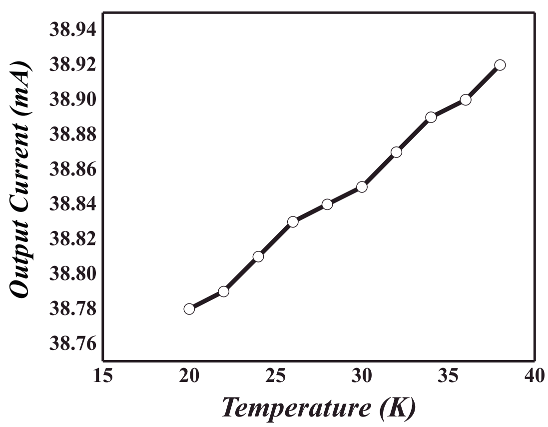

Fig. 2. Graphical representation of output current corresponding to temperature of solar cell

Power output is given by $P = V \times I$ as shown in Table 2.

Table 3. Output power from output currents and output voltages at different temperatures

Output voltage *V* (*mV*)	Output current *I* (*mA*)	Output Power *P* (*μW*)
5620	38.78	217943.6
5580	38.79	216448.2
5510	38.81	213843.1
5460	38.83	212011.8
5400	38.84	209736.0
5360	38.85	208236.0
5320	38.87	206788.4
5280	38.89	205339.2
5250	38.90	204225.0
5215	38.92	202967.8

Now, we have the measurement of power output (given in Table 3).

Power input = 100 W

Area of solar cell = 7 x 7 = 49 cm^2

$$Efficiency = \frac{output\ current\ x\ output\ voltage}{power\ input\ x\ area}$$

Using above formula, we get efficiency corresponding to different temperatures (see Table 4).

Table 3. Efficiency of Solar Cell at different temperatures

Temperature *T* (°C)	Efficiency (%)
20	44.7
22	44.17
24	43.64
26	43.26
28	42.80
30	42.49
32	42.20
34	41.90
36	41.67
38	41.42

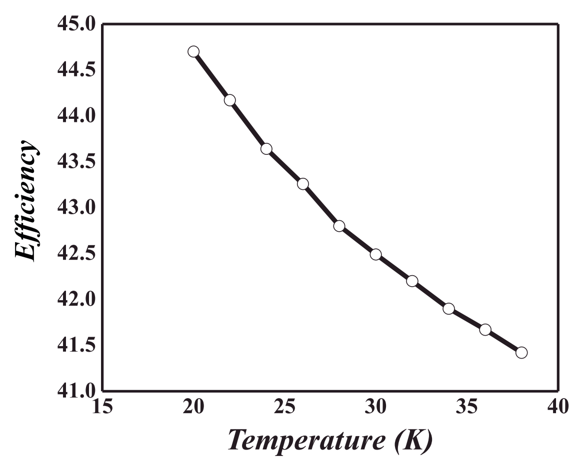

Fig. 3. Graphical representation of efficiency and temperature of solar cell

From above result it is concluded that efficiency of a solar cell decreases with increase intemperature of photovoltaic cell or solar cell.

Conclusion:

In this article, efficiency of photovoltaic cell is calculated at different temperatures. The efficiency of solar cell decreases with rise in temperature. Thus, it is concluded that the efficiency is strongly affected by temperature of photovoltaic cell.

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