

Article

Factors that Affect the Amount of Electricity Produced by Solar Panels

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Article history:

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Abstract: This research was carried out to study the factors that affect the amount of electricity produced by solar panels. The effect of the surface area, distance and the brightness of the light bulb on the amount of electricity produced were studied. A self-made solar box was built to run the experiment on the solar panel to get unaltered result. Our research reveals that a larger surface area of a solar panel is able to produce more electricity. Variation on the distance of the solar panel from the light bulb and the brightness of the light bulb caused changes in producing the electricity. This research findings provide some useful indicators which can be applied in our daily lives.

Keywords: Brightness of the light; Distance; Solar panel; Surface area

1. Introduction

The sun produces enough energy that can be used to generate electricity without producing any negative side effect of pollution or dangerous wastes. The energy from the sun can be harnessed using solar panels, which converts solar light energy directly into electricity (Tan Kim Low, 2009). A solar panel provides direct current (DC) electricity that can be used to power the motors (The World Book Encyclopedia, 1994). Solar panels can also be used to charge rechargeable batteries so that electricity can be stored for later use. A solar panel is a sandwich of n-type silicon and p-type silicon. It generates electricity by using sunlight to make electrons hop across the junction between the different layers of silicon (Wikipedia, 2011). Sunlight contains packets of energy called photons that can be converted directly into electrical energy. As photons enter the solar panel, they surrender their energy to the atoms in the silicon. The incoming energy knocks electrons out of the lower, p-type layer so they jump across the barrier to the n-type layer above and flow out around the

circuit (Explains that stuff, 2016). The amount of photons hitting the solar panel is related to the amount of light hitting the solar panel. A greater amount of light available means a greater amount of photons are hitting the solar panel and hence, the more current flows.

Solar energy is undoubtedly the future trend of energy. Nowadays, many households have converted their home to be powered solely by solar power, reaping all the advantages offered by the sun. Many people use solar power because it reduces electricity bills. Furthermore, as it is a renewable energy source, it is environmentally friendly. However, it has become evident that many factors can make a solar panel less efficient. A shade could be produced by any obstruction around the solar panel, such as tall buildings, trees and power poles (Energysage, 2017). As the position of the sun changes during the day, so does the shading effect of these obstructions. So, we need to take into consideration the factors related to the location and the sun's position when installing a solar panel. To overcome such issues, we have designed three experiments to investigate whether the shade formed on the surface of a solar panel affects the amount of electricity produced. We attempt to demonstrate the effects of surface area, distance and the brightness of the light on the amount of electricity produced with the help of a multi-purpose solar box.

2. Methodology

2.1 Materials

We have used a self-made multi-purpose solar box, multimeter, connecting wires, calculator, measuring tape, ruler, solar panel (12V), light bulb (40W), cardboard and cutter knife.

2.2 Method

There are three experiments conducted. In Experiment 1, we test the effect of exposed surface area on the amount of electricity produced. First, a self-made solar box is designed and prepared. Different sizes of cardboard pieces are prepared to

cover the surface area of the solar panel to replicate the effect of shade. A solar panel that is completely covered is used as control group. The size and type of solar panel, the brightness of the light bulb, the distance of the solar panel from the light bulb, the colour of the light bulb and the angle of the solar panel are kept constant in this experiment. The amount of electricity produced is determined by measuring the voltage, current and power generated by the solar panel. Higher voltage and current generated indicates a greater amount of electricity produced. To measure the effect of shade, the solar panel is covered with a piece of cardboard and its exposed surface area is measured and recorded. Then the multimeter is connected to the solar panel and the electric bulb is switched on to heat up the solar panel. The door of the solar box is closed to ensure no background light enters the solar box. The voltage and current generated by the solar panel are measured and recorded. The reading of voltage and current is taken for five times. The same procedure is carried out by increasing the exposed surface area of the solar panel by using various cardboard pieces. The average power generated by the solar panel on different surface is calculated by using the formula:

$$\text{Average Power (P)} = \text{Average voltage (V)} \times \text{Average Current (I)} \quad (\text{Eq 1})$$

In our second experiment, we observe the effect of distance on the amount of electricity produced.

Experiment 1 is repeated to verify the second objective, where the surface area of the solar panel is kept the same and the distance of the solar panel from the light bulb changes. The reading of voltage and current is recorded five times to ensure robustness of the results. The experiment is repeated 2 more times by increasing the distance between the solar panel and the light bulb each 4 time. The average power generated by the solar panel on different distance is calculated and recorded.

In our third experiment, we analyze the effect of brightness of the light bulb on the amount of electricity produced. In this experiment, the distance

of the solar panel from the light bulb and the surface area of the solar panel are kept constant, while the brightness of the light bulb changes in increasing levels for two different level of brightness. The average power generated by the solar panel on different brightness of the bulb is calculated and recorded.

In order to control for background light, a multi-purpose solar box is made to overcome the negative effects of background light. It is specially designed with fitting bulbs and has a controller to adjust the brightness of the bulb. A tray is used to place the solar panel at a certain distance. Furthermore, a 5V solar panel was showing a low and weak reading. Hence, we decided to use a bigger solar panel of 12V so that the reading of voltage and current could be more accurate. . Moreover, as the multimeter readings are not constant and take time to stabilize, we need to allocate more time to determine the results. Hence, the experiment was repeated 5 times systematically.

3. Results and Discussions

3.1 Result

The results show that the solar panel with the largest surface area generates the most voltage, current and power. The amount of electricity produced increases as the exposed surface area of the solar panel increases. The results from Experiment 1 are recorded below in Table 1 and presented graphically in Figure 1. The result indicates that the amount of

voltage, current and power generated by the solar panel decreases as the distance of the solar panel from the light bulb increases. The results from Experiment 2 are recorded in Table 2 and presented graphically in Figure 2.

The results show that the brightness of the bulb affects the voltage and current generated by the solar panel. When the brightness of the bulb increases, the voltage, current and power generated increases as well. Hence, the amount of electricity produced also increases. The results from Experiment 3 are recorded in Table 3 and presented graphically in Figure 3.

3.2 Discussion

When the solar panel is heated by the light bulb, it converts light energy into electrical energy. The photons of light hit the solar panel and produce free electrons that move through the wires and cause an electric current. The amount of electricity produced is related to the amount of light hitting the solar panel.

The amount of light energy reflected on the solar panel depends on its surface area. The bigger surface area of the solar panel generates more voltage, current and power. Our experiment also shows that the voltage, current and power generated depends on the distance between the solar panel and the light bulb. The shorter the distance, the greater the intensity of the light and the amount of electricity produced increases. The brightness of the light bulb

Table 1: Results of the relationship between the exposed surface area of the solar panel and the amount of electricity produced.

The exposed surface area of the solar panel (cm ²)	The amount of the electricity generated												
	Voltage (V)						Current (mA)						Average Power
	Rdg1	Rdg2	Rdg3	Rdg4	Rdg5	Avg	Rdg1	Rdg2	Rdg3	Rdg4	Rdg5	Avg	
0 (completely covered) Control group	0.16	0.15	0.16	0.15	0.16	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0
66	2.79	2.83	2.84	2.82	2.83	2.82	0.01	0.02	0.02	0.01	0.01	0.01	0.000028
132	5.43	5.42	5.40	5.43	5.42	5.42	0.03	0.03	0.04	0.04	0.03	0.03	0.000163
198	8.77	8.75	8.74	8.75	8.76	8.75	0.25	0.23	0.21	0.23	0.25	0.23	0.002013
264	10.86	10.87	10.85	10.87	10.86	10.86	2.84	2.85	2.86	2.86	2.84	2.85	0.030951

Table 2: Results of the relationship between the distance of the solar panel from the Light bulb and the amount of electricity produced.

The distance of the solar panel from the light bulb (cm)	The amount of electricity generated												Average Power
	Voltage (V)						Current (mA)						
	Rdg1	Rdg2	Rdg3	Rdg4	Rdg5	Avg	Rdg1	Rdg2	Rdg3	Rdg4	Rdg5	Avg	
11	11.78	11.76	11.75	11.77	11.76	11.76	5.50	5.56	5.60	5.59	5.57	5.56	0.0654
21	10.97	10.95	10.94	10.96	10.95	10.95	2.87	2.86	2.89	2.87	2.86	2.87	0.0314
31	10.28	10.25	10.26	10.27	10.27	10.27	1.74	1.76	1.75	1.74	1.75	1.75	0.0180

Table 3: The relationship between the brightness of the bulb (level) and the amount of electricity generated.

The brightness of the bulb (level)	The amount of electricity generated										Average Power
	Voltage (V)					Current (mA)					
	Rdg1	Rdg2	Rdg3	Rdg4	Avg	Rdg1	Rdg2	Rdg3	Rdg4	Avg	
1	9.69	9.68	9.67	9.68	9.68	0.94	0.94	0.95	0.93	0.94	0.0091
2	11.33	11.32	11.30	11.29	11.31	3.40	3.42	3.39	3.43	3.41	0.0386
3	11.69	11.70	11.69	11.68	11.69	5.27	5.27	5.28	5.26	5.27	0.0616

also affects the amount of voltage, current and power generated. If the bulb lights up brighter, more light energy is transferred to the solar panel and more electricity is produced. Based on our experiment results, we found that the bigger surface area of a solar panel has the ability to produce more electricity. The results also show that shade affects

the performance of the solar panel. Shade cast by trees and buildings will decrease the exposed surface area of a solar panel and reduce its power output. We need to consider the location when installing a solar panel in order to get maximum power output.

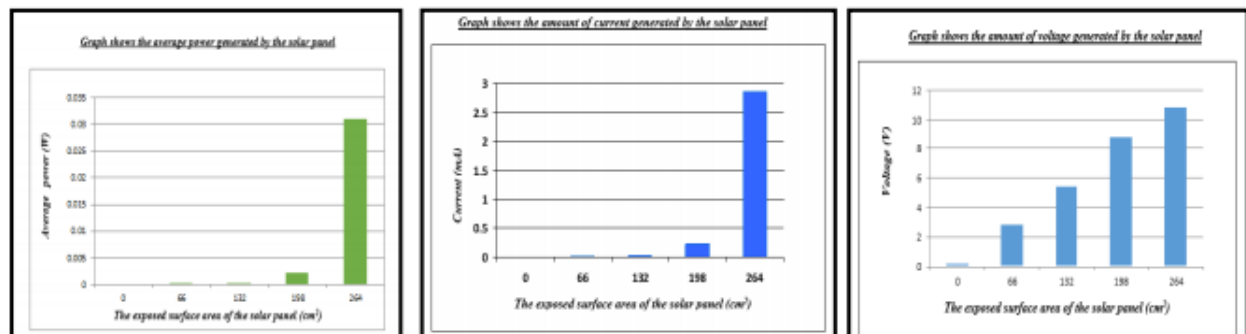


Figure 1: (a) Average power, (b) Amount of current, and (c) Amount of voltage generated vs Exposed surface area of the Solar Panel.

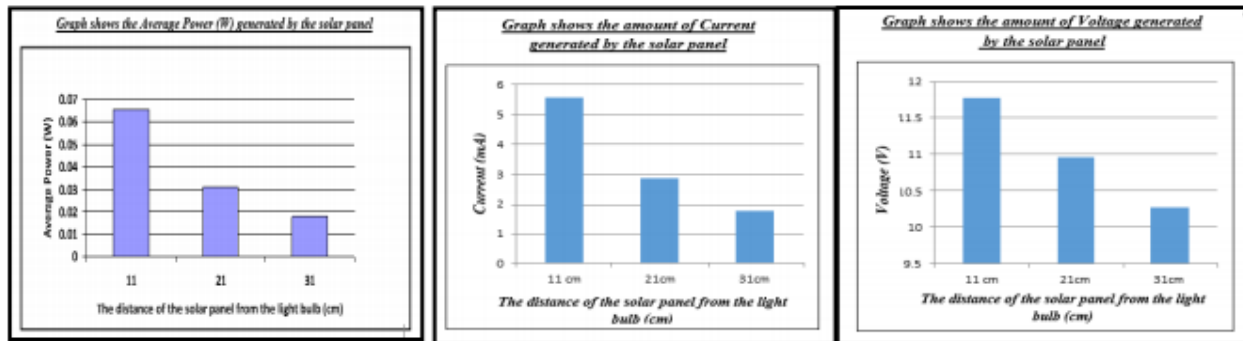


Figure 2: (a) Average power, (b) Amount of current, and (c) Amount of voltage generated Vs Distance of the solar panel from the light bulb.

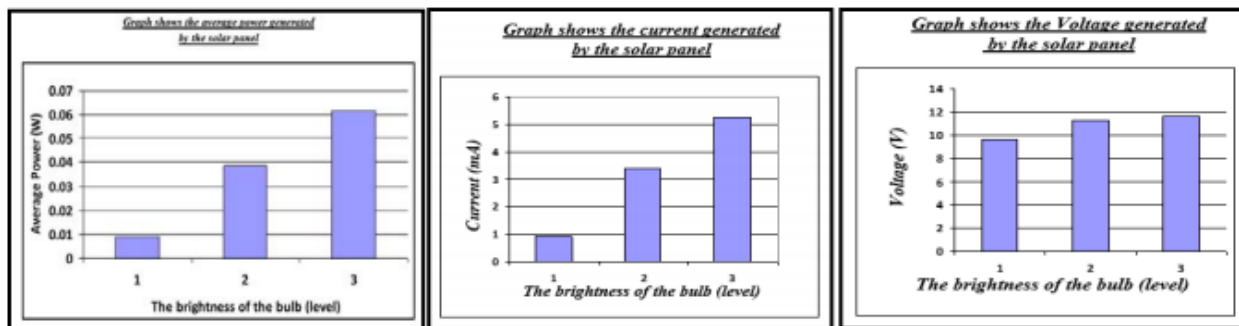


Figure 3: (a) Average power, (b) Amount of current, and (c) Amount of voltage generated Vs Brightness level of the bulb.

4. Conclusion

In this study we conduct three experiments to measure the effect of shade on the amount of electricity produced. With the increasing popularity of solar panels, it is interesting to note the different effects on the amount of electricity produced by solar panels. Our experiments indicated three main results. First, the larger the surface area of a solar panel, the greater the amount of electricity produced. Second, the farther the solar panel from the light bulb, the amount of static electricity produced decreases. Lastly, the amount of electricity produced increases as the brightness of the bulb increases.

Acknowledgement

We wish to express our sincere appreciation and gratitude to our science teachers, as well as our head

-mistress, parents, friends and the organizers for giving us the opportunity, guidance, ideas, support and encouragement to complete this science project and research paper.

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