To find out if increasing the number of concave mirrors increases the efficiency of the solar panel

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Abstract

We use fossil fuels for energy, which is depletable and unsustainable. Burning fossil fuels contributes greatly to global warming. A substitute for using fossil fuels is solar energy. Singapore has abundant sunlight and we can harness it using solar panels. However, solar panels have high costs and many improvements are needed to increase its efficiency and make it widely used in Singapore. We found out that concave mirrors are able to reflect light into one focal point. It increases the intensity of the light reflected onto the solar panel which can improve the efficiency of the solar panels as more energy from the photons.

Introduction

In this investigation, we researched on how the number of concave mirrors increases the efficiency of solar panels. We depend largely on fossil fuels as our main source of energy. However, the burning of fossil fuels is highly damaging to our environment as it produces carbon dioxide that trap heat in the earth's atmosphere which results in global warming. If we want to reduce the amount of carbon-gas emissions and global warming, the energy sources used have to change. A good alternative would be using solar energy as it has a lesser negative impact on the environment. Solar energy is a renewable energy source that will prevent the environment from being polluted and lower the impacts of climate change. Currently, high-efficiency solar cells that convert more energy are very expensive as they have to be carefully manufactured in a complex environment and are only cost-effective for spacial or defensive applications. Since Singapore receives more sunlight than temperate countries, solar cells used in Singapore can convert more energy for usage. Hence, using solar energy as a source of electricity is viable in Singapore.

Theoretical Background

A solar panel is made of many photovoltaic cells, which consists of 2 slices of semiconducting material, usually silicon. The panels often have a sheet of glass on the front side (the one facing the sun) to protect the semiconductor wafers from abrasion and impact due to rain or hail. Photovoltaic cells need to establish an electric field to work. An electric field occurs when opposite charges are separated. Thus, manufacturers put phosphorus into the top layer of silicon, which adds extra electrons to that layer. However, boron is added to the bottom layer, which results in fewer electrons, and a positive charge. This adds to an electric field at the junction of the 2 layers. When a photon of sunlight knocks an electron free, the electric field will push the photon out of the silicon junction. There are also metal conductive plates at the sides of the cell, which collect electrons and transfer them to wires. At this point, the electrons can flow like electricity. A research paper done by Julajaturasirarath and his team showed that the reflectivity of a mirror can convert more energy than without using any mirrors. (Julajaturasirarath, 2011 [2]). When parallel rays of light hit a concave mirror, the rays reflect inwards towards a focal point.(See fig. 1) Hence, the intensity of the light increases.

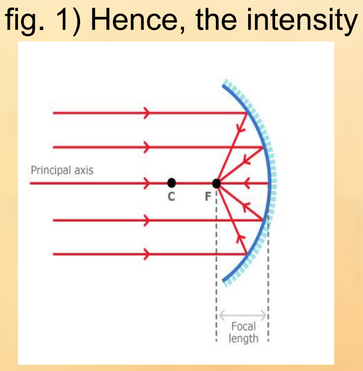

Fig. 1: Focal Point of Concave Mirrors

Materials and Procedure

The independent variable is the number of concave mirrors and the dependent variable is the amount of energy converted in volts. The control is the amount of energy converted without using any mirrors.

Materials:

- 1 multimeter
- 6 concave mirrors
- 1 solar panel
- 1 lamp (60 W)
- wires

Procedure (to find out which angle of concave mirror reflects the most light):

1. Connect the solar panel to the multimeter using wires and set the setting of the multimeter to 20V
2. Mount the solar panel onto a board parallel to a lit lamp and mount 6 concave mirrors along the solar panel at 45°.
3. Record the results.
4. Repeat steps 2 and 3 at least 2 more times and find the average.
5. Repeat steps 2 to 4 for 65°, 75°, 85°, and 90°.

Procedure (to find out the no. of concave mirrors that increases the efficiency of the solar panel the most):

1. Connect the solar panel to the multimeter using wires and set the setting of the multimeter to 20V and mount the solar panel onto a board parallel to a lit lamp.
2. Mount the solar panel onto the board parallel to a lit lamp
3. Record the result of the amount of energy converted without any concave mirrors.
4. Mount 2 concave mirrors around the solar panel at 85°.
5. Record the results.
6. Repeat steps 2 to 4 at least 2 more times and find the average.
7. Repeat steps 2 to 6 with 4 and 6 concave mirrors mounted along the solar panel.

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Fig. 2: Experimental Set-up

Results

Table 1: Angle of concave mirror (to find out which angle is most suited)

Angle of concave mirrors (°)	1st result (20V)	2nd result (20V)	3rd result (20V)	Average (3s.f.)
45	6.17	6.26	6.22	6.22
65	6.30	6.32	6.18	6.26
75	6.20	6.35	6.26	6.27
85	6.27	6.33	6.24	**6.28**
90	6.22	6.32	6.25	6.26

From **Table 1**, it can be observed that 85° is the angle that reflects the most light into the solar panel and causes the solar panel to convert the most amount of energy. Thus, we used 85° to position the concave mirror for the next experiment. In the second experiment, we changed the number of concave mirrors to see how the amount of energy converted would change.

Table 2: Number of concave mirrors (to find out what number of concave mirrors is the best)

Number of Concave Mirrors	1st result (20V)	2nd result (20V)	3rd result (20V)	Average (3s.f.)
0	6.25	6.14	6.16	6.18
2	6.27	6.16	6.19	6.21
4	6.29	6.20	6.23	6.24
6	6.32	6.22	6.25	6.26

Discussion

We analysed the data collected by organising it in a table and deciding which number of concave mirrors or which angle increased the most amount of energy converted. From our experiment, we concluded that increasing the amount of concave mirrors around a solar panel would increase the amount of energy it converted. In our experiment, 6 concave mirrors was the number of concave mirrors that had the most amount of energy converted and 0 was the number of concave mirrors that had the least amount of energy recorded. We also concluded that 85° is the best angle to carry out the experiment as the amount of energy converted by the solar panel is the highest. From **Table 1**, mounting the mirrors at 45° around the solar panel had the least voltage recorded.

Conclusion

From our results, we also realise using concave mirrors to increase the efficiency of solar panels also might not have been suitable as the energy increase when we add more concave mirrors is insignificant as there were factors like the concave mirrors only being able to focus the light onto a small area on the solar panel and that using concave mirrors to reflect light onto the solar panels may not be very cost-efficient. In the final stages of the project, we realised that we could have used a convex lens to focus more light onto the solar panel instead. As convex lenses are thicker in the middle, rays of light that pass through the lens converge at a point called the focal point. Thus, using convex lenses might be better than using concave mirrors.

If we had more time and means, we would also try using more concave mirrors and using a bigger solar panel. Our team would like to also conduct an experiment about how using different types of mirrors (e.g. plane mirrors, convex mirrors, and concave mirrors) would change the amount of energy converted by the solar panel.

Solar panels can possibly replace our use of fossil fuels one day if we increase the amount of solar cells used, along with maximising it by increasing the amount of energy converted by adding concave mirrors. Thus, on a larger scale, the amount of energy converted can sustain our daily usage and be considered as a main source of electricity in Singapore. Singapore, being a country that is abundant in sunlight, can harness the amount of solar energy that we have and reduce the use of fossil fuels.

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