Elevation Equals Energy

Category: Energy and Environmental Engineering

Introduction

Purpose

The purpose of this experiment is to see if a solar panel can be made more efficient using elevation. I became interested in this topic when I learned how solar panels work and how expensive electricity can be. So, I decided that I wanted to do something to help. Electric bills can be very expensive and some people cannot afford to pay for electricity. For example, the average electricity cost in the US is 13.31 cents per kilowatt-hour (kWh,) (Electricchoice.com) and "the average household electricity consumption kWh per day is 28.9 kWh," (elecricityplans.com) which means you would be paying 384.65 cents each day for electricity, or $115.39 a month. So, I want to try to help those people by finding out whether or not elevation affects how much energy a solar panel produces. This will help people because if solar panels could be made more efficient through elevation, you could help lower electric bills with a simple change in elevation.

Research

- Solar panels produce light when "the particles of sunlight (photons) knock electrons free from atoms, setting in motion a flow of electrons." -news.energysage.com/solar-panels-work
- Solar panels are made of a layer of silicon cells, a glass casing, wiring to allow current to flow from silicon cells, and a metal framing. The silicon cells are able to conserve and convert sunlight into energy. This is called the photovoltaic effect. -news.energysage.com/solar-panels-work
- "Research indicates that for every 1,000 feet of elevation gain, the sun's UV rays intensify by 8-10 percent because of the thinning atmosphere." -rockymountainurgentcare.com

Question/Hypothesis

My question is “Does elevation affect how much energy is produced by a solar panel?” ***If you change the elevation of a solar panel, then the solar panel will produce more energy at a higher elevation.This*** is because a solar panel produces energy when photons knock electrons free from atoms, setting in motion a flow of electrons. This flow of electrons is electricity, and solar panels are designed to capture this flow, making it a usable electric current. The silicon in a solar panel has conductive properties, making it able to conserve and convert sunlight into energy. This is called the photovoltaic effect. (-news.energysage.com) According to rockymountainurgentcare.com, the sun’s UV rays intensifies after about every 304.8 meters (or about 1,000 feet) of elevation gain. Because of this, when the sunlight becomes more intense at higher elevations, there should be more electrons, causing the solar panel to produce more energy at a higher elevation than a lower one.

Procedure

1. Take the Solar Science Station to your backyard.
2. Tilt the solar panel at a 30 degree angle.
3. Turn the Solar Science Station so it faces the sun and wait for ten minutes.
4. Check the voltmeter on the Solar Science Station and write down the voltage.
5. Repeat steps 3-4 five more times.
6. Calculate the average of the six voltages.
7. Multiply the average by the amps of the solar panel (0.2 amps) to find the Watts.
8. Take the Solar Science Station to a location with a elevation about 610 meters greater than your backyard.
9. Tilt the solar panel at a 30 degree angle.
10. Repeat steps 3-4 six times.
11. Repeat steps 6-7.
12. Wait for the next day until about the same time you started the experiment.
13. Take the Solar Science Station to your backyard.
14. Tilt the solar panel a a 30 degree angle.
15. Repeat steps 3-4 six times.
16. Repeat steps 6-7.
17. Take the Solar Science Station to a location with a elevation about 610 meters less than your backyard.
18. Tilt the solar panel at a 30 degree angle.
19. Repeat steps 3-4 six times.
20. Repeat steps 6-7.
21. Compare the watts of the higher location to the first watts of your backyard.
22. Compare the watts of the lower location to the second watts of your backyard.

Experimental Design

Controlled variables:

- Angle of the solar panel
- Time of day (as close to each other as possible)
- Amount of time exposed to sunlight.
- The amount of time between checking the voltage.

The independent variable is: the elevation of the solar panel.

The dependent variable is: the amount of energy the solar panel produces in Watts (W).

The control group is: the solar panel in our backyard since there isn't a recommended elevation for the solar panel of the box, and this is where you would install a solar panel if you purchased one. **We could only record two different elevations in one day, so a second control group was created to be compared to the lower elevation. Both the second control group and the lower elevation were recorded on the second day.**

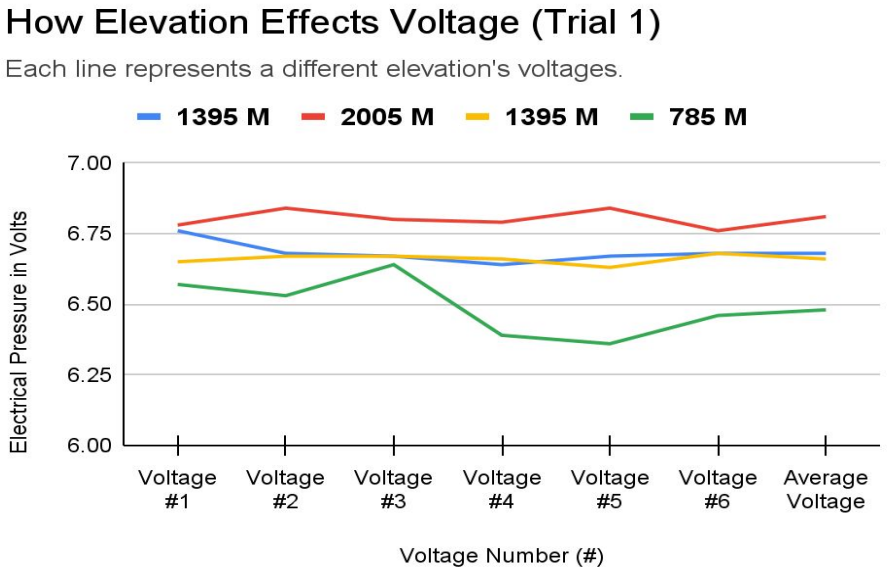
We will measure the DV (dependent variable) by checking the voltmeter on the Solar Science Station every ten minutes, and after an hour we will average the six voltages and multiply the voltage by the amps of the solar panel to get the amount of Watts the solar panel produced.

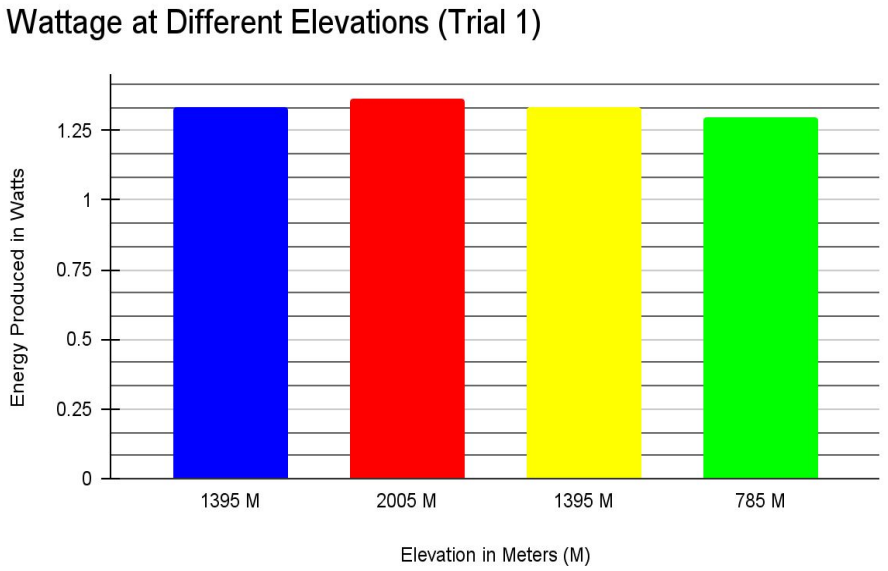
Data Table (Trial 1)

Elevation in Meters (M)	Voltage (V)			
Sierra Vista	6.76V	6.68V	6.67V	6.64V
1395 M	6.67V	6.68V	Average:	6.68V
Mount Lemmon	6.78V	6.84V	6.8V	6.79V
2005 M	6.84V	6.76V	Average:	6.81V
Sierra Vista	6.65V	6.67V	6.67V	6.66V
1395 M	6.63V	6.68V	Average:	6.66V
Tucson	6.57V	6.53V	6.64V	6.39V
785 M	6.36V	6.46V	Average:	6.48V

Wattage at different Elevations	
Elevation in Meters (M)	Wattage (W)
1395 M	1.336 W
2005 M	1.362 W
1395 M	1.332 W
785 M	1.298 W

Data Analysis (Trial 1)





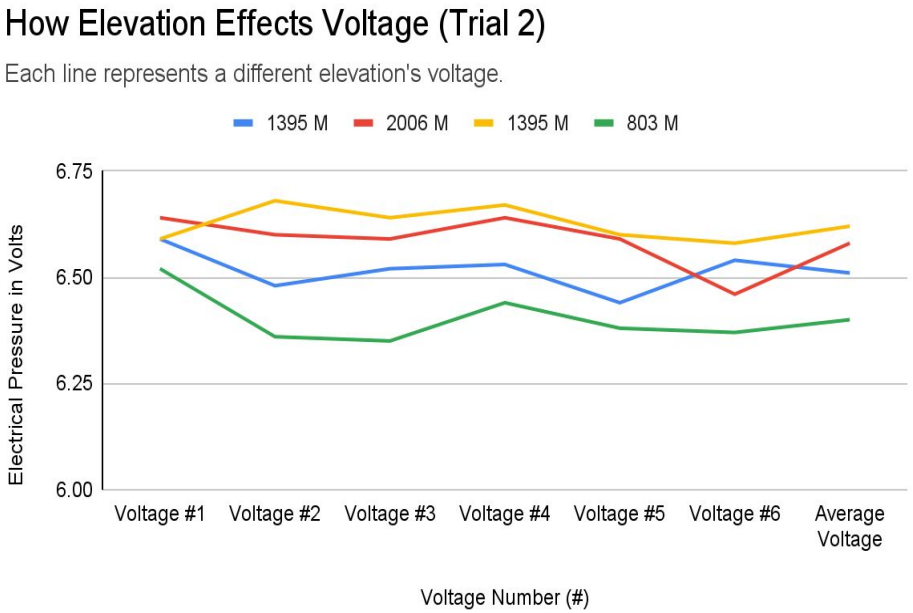
The line graph represents the electrical pressure in voltage of the solar panel at each elevation during Trial 1. The first control group had an average of 0.118 volts less than the higher elevation. The second control group had an average of volts more than the lower control group. This shows that elevation had a positive effect on the voltage of the solar panel. The bar graph represents the amount of energy produced in watts by the solar panel at each elevation during Trial 1. The first control group had produced 0.026 watts less than the higher elevation. The second control group had produced 0.034 watts more than the lower control group. This shows that elevation had a positive effect on the watts produced by the solar panel.

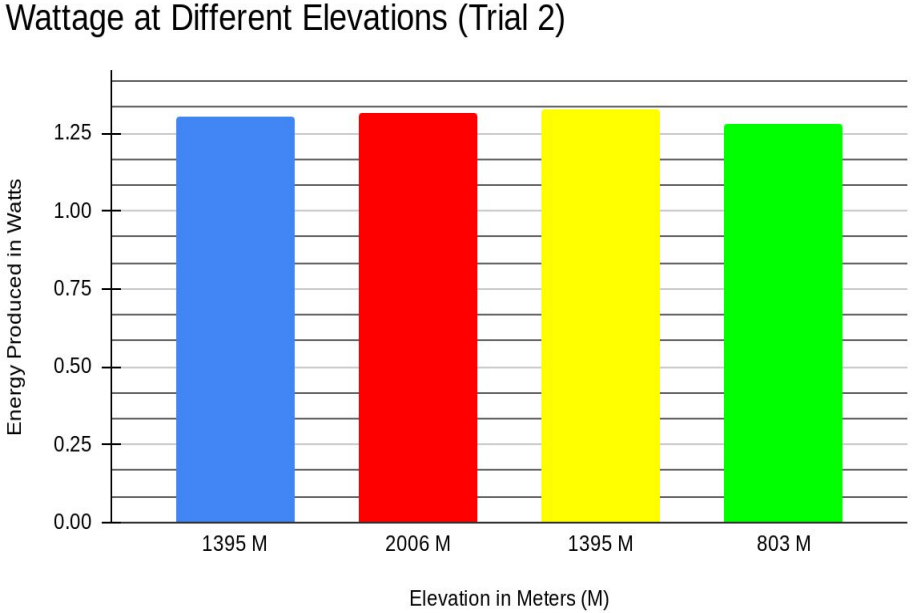
Data Table (Trial 2)

Elevation in Meters (M)	Voltage (V)			
Sierra Vista	6.59V	6.48V	6.52V	6.53V
1395 M	6.44V	6.54V	Average:	6.51V
Mount Lemmon	6.64V	6.6V	6.59V	6.64V
2005 M	6.59V	6.46V	Average:	6.58V
Sierra Vista	6.59V	6.68V	6.64V	6.67V
1395 M	6.6V	6.58V	Average:	6.62V
Tucson	6.52V	6.36V	6.35V	6.44V
785 M	6.38V	6.37V	Average:	6.4V

Wattage at different Elevations	
Elevation in Meters (M)	Wattage (W)
1395 M	1.304 W
2006 M	1.316 W
1395 M	1.324 W
803 M	1.28 W

Data Analysis (Trial 2)





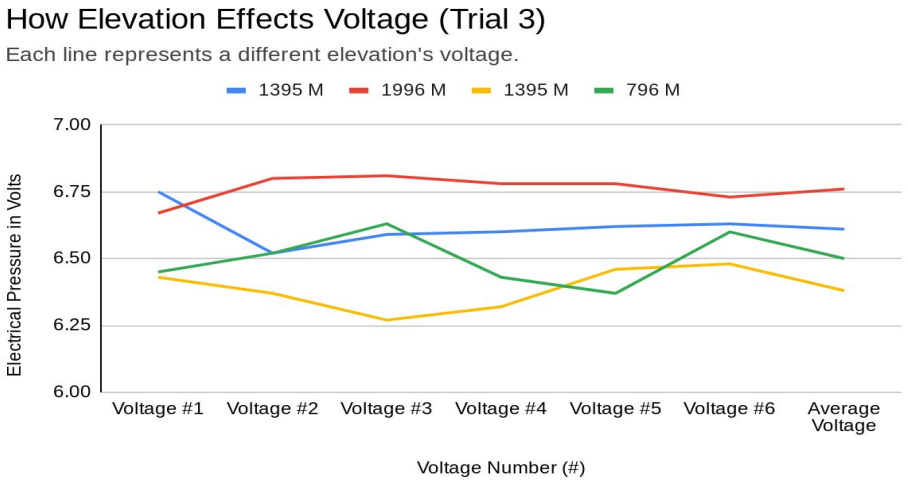
The line graph represents the electrical pressure in voltage of the solar panel at each elevation during Trial 2. The first control group had an average of 0.07 volts less than the higher elevation. The second control group had an average of 0.22 volts more than the lower control group. This shows that elevation had a positive effect on the voltage of the solar panel. The bar graph represents the amount of energy produced in watts by the solar panel at each elevation during Trial 2. The first control group had produced 0.012 watts less than the higher elevation. The second control group had produced 0.044 watts more than the lower control group. This shows that elevation had a positive effect on the watts produced by the solar panel.

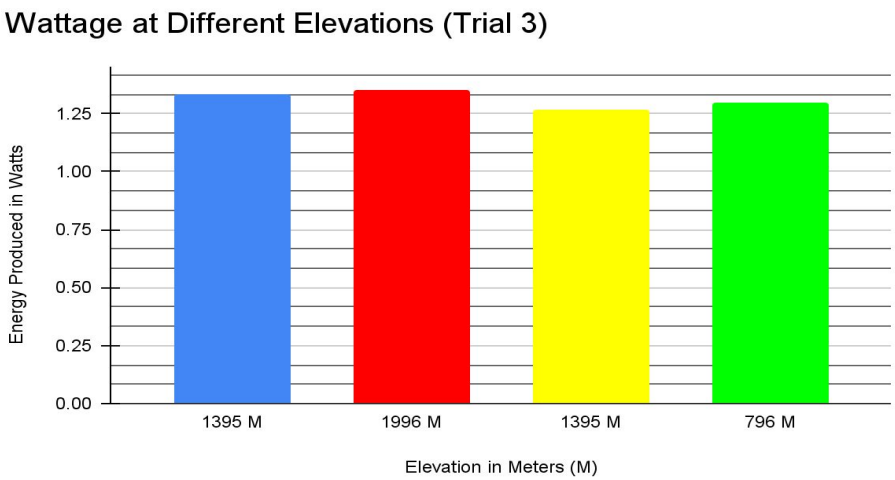
Data Table (Trial 3)

Elevation in Meters (M)	Voltage (V)			
Sierra Vista	6.75V	6.52V	6.59V	6.6V
1395 M	6.62V	6.63V	Average:	6.61V
Mount Lemmon	6.67V	6.8V	6.81V	6.78V
1996 M	6.78V	6.73V	Average:	6.76V
Sierra Vista	6.43V	6.37V	6.27V	6.32V
1395 M	6.46V	6.48V	Average:	6.38V
Tucson	6.45V	6.52V	6.63V	6.43V
796 M	6.37V	6.6V	Average:	6.5V

Wattage at different Elevations	
Elevation in Meters (M)	Wattage (W)
1395 M	1.332 W
1996 M	1.352 W
1395 M	1.27 W
796 M	1.3 W

Data Analysis (Trial 3)





The line graph represents the electrical pressure in voltage of the solar panel at each elevation during Trial 3. The first control group had an average of 0.18 volts less than the higher elevation. The second control group had an average of 0.11 volts less than the lower elevation. This is because there was a greater cloud coverage at the second control group compared to the lower elevation, causing the solar panel to not have as much access to sunlight as in the lower elevation, leading to the solar panel to produce a lower voltage. This shows that elevation had a positive effect on the voltage of the solar panel.The bar graph represents the amount of energy produced in watts by the solar panel at each elevation during Trial 3. The first control group had produced 0.02 watts less than the higher elevation. The second control group had produced 0.03 watts less than the lower control group. Again, this is suspected to be due to difference in could coverage as mentioned previously. Other than the interference with weather, this shows that elevation had a positive effect on the watts produced by the solar panel.

Results

The purpose of this experiment was to test whether or not elevation affected the amount of energy a solar panel produces. The results were that the solar panel produced more energy at a higher elevation compared to the first control group, and less at lower elevation compared to the second control group. The difference between the first control group and the second control group is the first one was recorded on the same day as the higher elevation- the one it's being compared to- and the second control group was recorded on the same day as the lower elevation- the one it's being compared to. The control groups are only being compared to the elevation that was recorded on the same day In all three trials. The solar panel always produced from 0.012 to 0.026 more watts at a higher elevation than the first control group. The solar panel also produced from 0.034 to 0.044 less watts at a lower elevation than the second control group, except for when weather interfered with the solar panel in the third trial.

Conclusion

My hypothesis was that the solar panel would produce more energy at a higher elevation than a lower one. The results indicate that this hypothesis should be supported. Because of the results of this experiment, I wonder if temperature affects the amount of energy a solar panel produces, since each location didn't have exactly the same temperature. If I were to conduct this experiment again, I would try to take the solar panel to all three locations on the same day to save time, and I wouldn't need multiple control groups. Another thing I would do differently in the future would be not having the control group as my backyard, but instead having the control group be halfway up Mount Lemmon, have the higher elevation be at the top of the mountain, and have the lower elevation be at the bottom of the mountain. This would be to minimize the amount of time in between each part of the experiment, and hopefully eliminate the chance of having different cloud coverage or weather so it wouldn't interfere with the solar panel.

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