How Does Cloud Coverage Affect Solar Panels

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Abstract

While testing how solar irradiance affects clouds, a pyranometer and the GLOBE app were used to configure our data. After doing online research and experimental tests, it's come to the conclusion that clouds affect solar output quite some, although some other factors, such as the angle of the sun off the horizon must be taken into account as well.

Center Bold Statement

Solar panels are producing slightly less electricity when cloud coverage is high, although other variables like sun angle must be taken into account as well.

Introduction

Although it's obvious cloud cover has an effect on solar output, this research project was based solely on testing *how much* of an effect clouds and sun angles have on a solar panel's output. The GLOBE app–on an iPad–and a pyranometer were used to collect our daily data. The GLOBE app helped with recognizing the type of clouds, cloud cover, and if they are opaque or translucent, etc. A pyranometer is a type of actinometer used for measuring solar irradiance. Stated in, *The Monthly Weather Review*, “clouds absorb…solar energy,” and this statement helped to conclude and solidify all the research and data collected. In *Energies,* Ioannis-Panagiotis Raptis et al., authors of “Selecting Surface Inclination for Maximum Solar Power,” describe the “Maximum efficiency of surfaces that exploit solar energy, including Photovoltaic Panels and Thermal

collectors, is achieved by installing them in a certain inclination (tilt).” The more research is done, the better chance there will be to figure out how to get the best solar irradiance results. The more power generated from the solar panels, the more energy has to be used. It is hoped the information on this topic that has been researched can have the findings be used to help people throughout time.

Hypothesis

Cloud coverage and sun angle have a noticeable effect on the amount of solar irradiance a solar panel can receive and turn into energy output.

Objective

The objective is to collect a series of data to determine how cloud coverage and sun angle correlate to solar panels and how much energy they output, but also determine if there's any other variables with a noticeable effect.

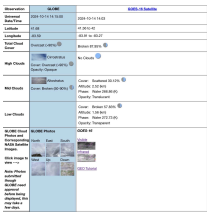
Methods

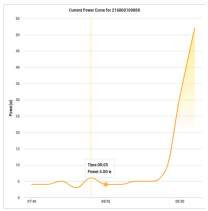
Cloud Data - The GLOBE Observer app has helped to collect data about clouds. Questions get answered about the clouds seen, pictures taken of the sky, and comparing the observations with images from NASA satellites–specifically, GOES-16. *Solar Irradiance Data* - To collect solar irradiance data, a pyranometer is used on the roof, and the apsystensema website for knowing power produced is linked to our roof solar panels. *Sun Angle* - We used the data on our Globe App entries and entered it into a website called Omni Calculator to calculate the angle of the sun. *Graphs* - The graphs were made by inputting the data collected into the Stats Blue website.

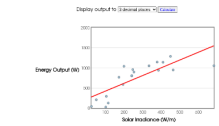
Results

After doing research and collecting around 20 complete data analyses, It has been figured out how much clouds impact the solar panels and the amount of power produced. The more opaque clouds in the sky will make the power produced much lower. On a bright and sunny day, solar output would typically be about 1000w; however, on a gloomy day, the lowest recorded output was 25w. After every data collection, notes were written down about all the information gathered that day–the time stamps, extra information, etc–onto a Google document, and we were able to take all of that data and turn it into the graphs you see on our poster here. Overall, we were able to conclude that cloud cover has a correlation of about 0.4, but sun angle has a correlation of about 0.7.

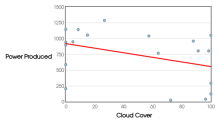
Graphs, Photos, Maps



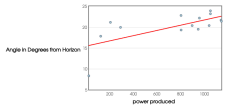




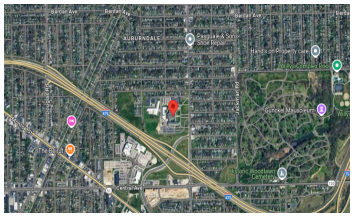
Regression Line: ENERGY OUTPUT (W) = 1.925 · SOLAR IRRADIANCE (W/M) + 230.039
Correlation: r = 0.794
R-squared: r^2 = 0.631



Regression Line: POWER PRODUCED = −3.6216 · CLOUD COVER + 917.7188
Correlation: r = −0.3881
R-squared: r^2 = 0.1506



Regression Line: ANGLE IN DEGREES FROM HORIZON = 0.01 · POWER PRODUCED + 15.44
Correlation: r = 0.67
R-squared: r^2 = 0.45



Conclusions

After spending weeks collecting data from solar panels, the data can determine whether the clouds are the primary variable affecting the way the solar panels produce power. Our Globe app collected data from clouds, got our solar irradiance from a pyranometer, and got power produced from our website. All of our data was taken, analyzed, and transferred into graphs to compare their qualities. After an initial observation of the data, we realized that clouds do affect how much power a solar panel produces, and it proves our hypothesis to be correct. However, after further consideration, we found out there must be another variable affecting it as well–the angle of the sun. After further consideration, it proved to be affecting the solar panels *more* than cloud cover was. So to determine *only* cloud cover's true effect on the energy produced, you have to either isolate the variables or keep sun angle consistent. Doing this research can help anyone with solar panels predict when less power will be produced due to the sky being covered in clouds, but can also help determine how much of an angle their solar panels need to be set at to reap the benefits for their full potential.

Badges

With our project, we are able to get the “I am a data scientist,” “I am a problem solver,” and the “I work with a stem professional” badges. We were able to acquire these badges through-out the way our research was cultivated and how it was presented at the end.

More specifically, we were able to earn the “I am a data scientist” badge because we collected raw solar panel and cloud data, and were able to analyze it to come to the conclusions we reached in our project. This data analysis lead to a variety of charts and graphs about cloud cover, sun angle, and energy produced. These graphs are clearly displayed on our final poster and

make up a large portion of our project.

The “I am a problem solver badge” was also acquired from our project due to the fact that our research can directly correlate to real-world problems that anyone with solar panels could potentially have. Our project can be used to help determine how much of an angle the solar panels should be set at for maximum efficiency and also when to expect lower energy levels due to cloud cover due to the data we collected and the conclusions we were able to make.

Finally, the last badge our project earns that we’re choosing to highlight is the “I work with a STEM professional badge.” We were able to gain this badge due to how closely we worked with local STEM professionals in the Toledo area, more specifically, Grant Wilson from The University of Toledo and NASA Scientist Geoff Bland. Consistently working with these professionals throughout the development of our project allowed us to create a college-level scientific research project we may not have been able to make without them.

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