How does Cloud Coverage Affect Solar Panels

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Introduction

Although it's obvious cloud cover has an effect on solar output, this research project was based solely on testng *how much* of an effect clouds and sun angles affect a solar panels 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 gotten from the solar panels, the more energy has to be use. 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 had 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.

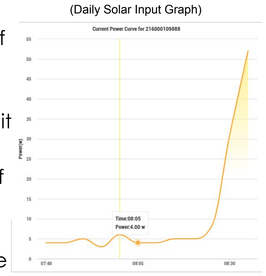
Solar Irradiance Data - To collect solar irradiance data, a pyranometer is used on the roof and the apsystensema website for knowing power produced is linked to our roof solar panels.

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.

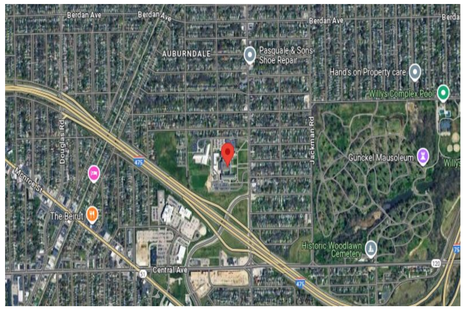
(Satellite Match)

(Daily Solar Input Graph)

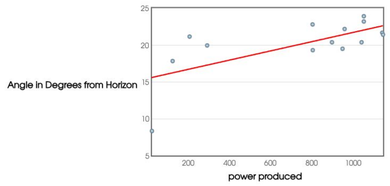


Solar panels are producing slightly less electricity when cloud coverage is high, although other variables like sun angle, must be taken into account as well.

(Collecting Solar Irradiance from our buildings roof with pyranometer)



(Where data was collected, the TTA yard and roof)

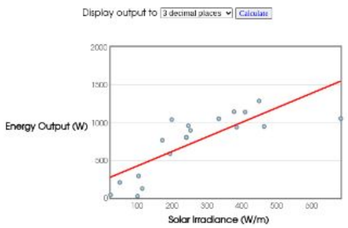


Regression Line: $\text{ANGLE IN DEGREES FROM HORIZON} = 0.01 \cdot \text{POWER PRODUCED} + 15.44$
Correlation: $r = 0.67$
R-squared: $r^2 = 0.45$

(Sun Angle in Degrees from Horizon compared to solar output)

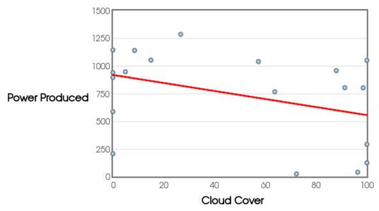
(Collecting cloud data from our courtyard with Ipad)

Energy Output Compared to Solar Irradiance



Regression Line: $\text{ENERGY OUTPUT (W)} = 1.925 \cdot \text{SOLAR IRRADIANCE (W/M)} + 230.039$
Correlation: $r = 0.794$
R-squared: $r^2 = 0.631$

Power Produced Compared to Cloud Cover



Regression Line: $\text{POWER PRODUCED} = -3.6216 \cdot \text{CLOUD COVER} + 917.7188$
Correlation: $r = -0.3881$
R-squared: $r^2 = 0.1506$

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.

Results

After doing research and collecting around 20 complete data analyses, It has been figured out how much clouds impact the solar panels and 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 was an output of 25w. After every data collection, notes were wrote 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 cloud cover has a correlation of about 0.4, but sun angle has a correlation of about 0.7.

Conclusion

After spending weeks of collecting data from solar panels, the data can determine whether the clouds are the primary variable affecting the way the solar panels produced 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. Although, after further consideration we found out there must be another variable affecting it as well–the angle of the sun. Which after further consideration, proved to be affecting the solar panels *more* than cloud cover was. So to determine *only* cloud covers true effect on the energy produced you have to either isolate of 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 also can help determine how much of an angle their solar panels need to be set at to reap the benefits for their full potential.

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References

Ali, R. (2023). Importance of Solar Energy. *Enterprise (Pakistan)*, *17*(94), 6.

Wood, R. (2012). Stratocumulus Clouds. *Monthly Weather Review*, *140*(8), 2373–2423.

JAZAYERI, M.; JAZAYERI, K.; UYSAL, S. Generation of spatially dispersed irradiance time-series based on real cloud patterns. Solar Energy, *[s. l.]*, v. 158, p. 977–994, 2017. DOI 10.1016/j.solener.2017.10.026. Disponível em:

Neuhauser, A. (2018). Is Buying Renewables Anti-American? U.S. News - The Report, 11–13.