Does a decreasing solar zenith angle cause higher solar irradiance

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Introduction

This project investigates how solar irradiance changes in relation to the solar zenith angle over time. Solar irradiance, is a key factor influencing climate and energy systems. Our Hypothesis was that Solar irradiance will increase from Early February to mid-March as the solar zenith angle decreases. Understanding this relationship is important for identifying seasonal trends in solar energy availability so we can make decisions on how much and when we can rely on energy systems that use solar energy when switching over to renewable energy sources.

Methods

We used a pyranometer and multimeter to measure daily solar irradiance for 6 weeks from February 3 to March 17th. We took these measurements around the same time each day (afternoon) to ensure consistency among measurements. Additional instruments (i.e. barometer, thermometer, and handheld anemometer) were used to record meteorological parameters such as atmospheric pressure, temperature and wind speed and direction. We also made visual observations of the sky color, sky clarity and sky obscuration at the time of measurement for solar irradiance. We separately recorded the solar zenith angle and the time of day to also ensure precise analysis. Since identifying cloud types through visual observation can be subjective, we also obtained cloud cover data from reliable meteorological databases, such as the Cloud Observation Report from Environment Canada, and analyzed irradiance variations for each cloud type separately. Our pyranometer measurements (in volts) were also calibrated using solar radiation data from the University of Toronto Atmospheric Observatory to convert them into solar irradiance (W/m^2).

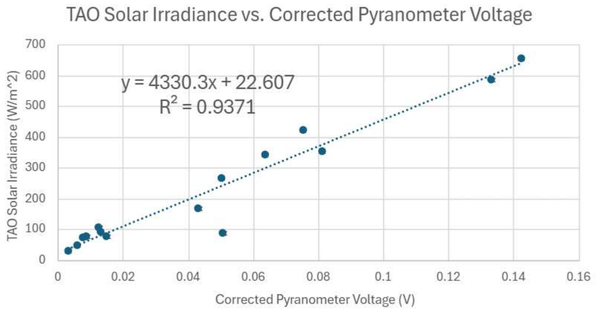

Figure 4: This is the TAO solar irradiance vs. corrected pyranometer voltage

Results

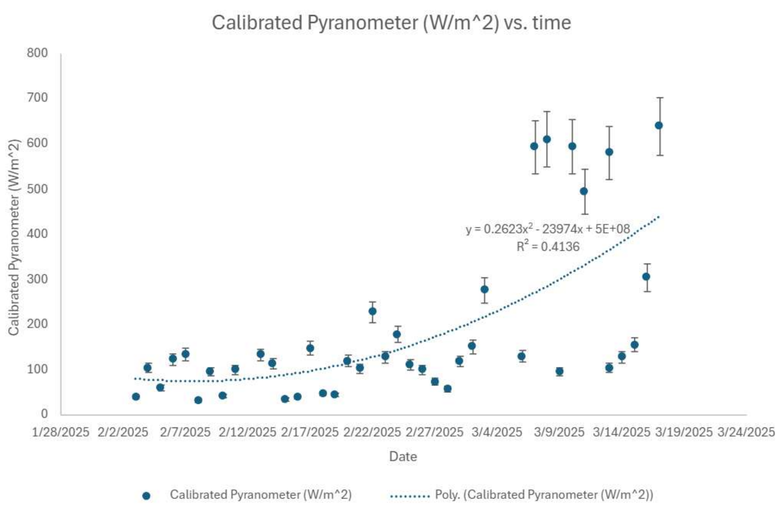

Figure 1: This is the Calibrated Pyranometer Values (measurements taken and fixed for accuracy from calibration data) over our measurement period

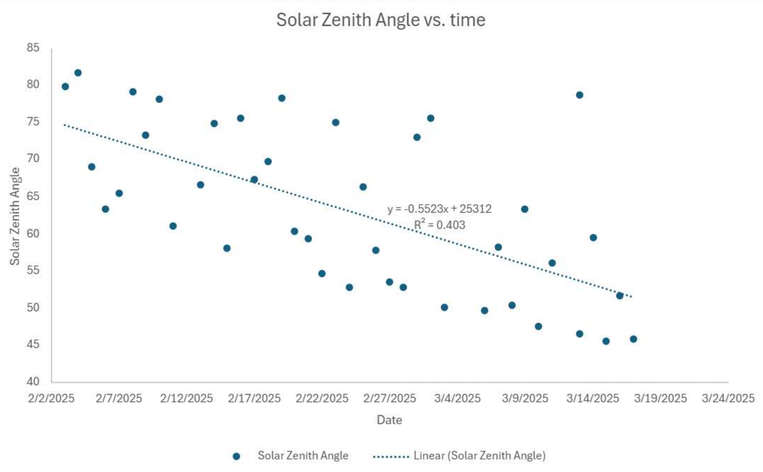

Figure 2: This is the Solar Zenith Angle (Angle that the sun is in the sky) over our measurement period

Results

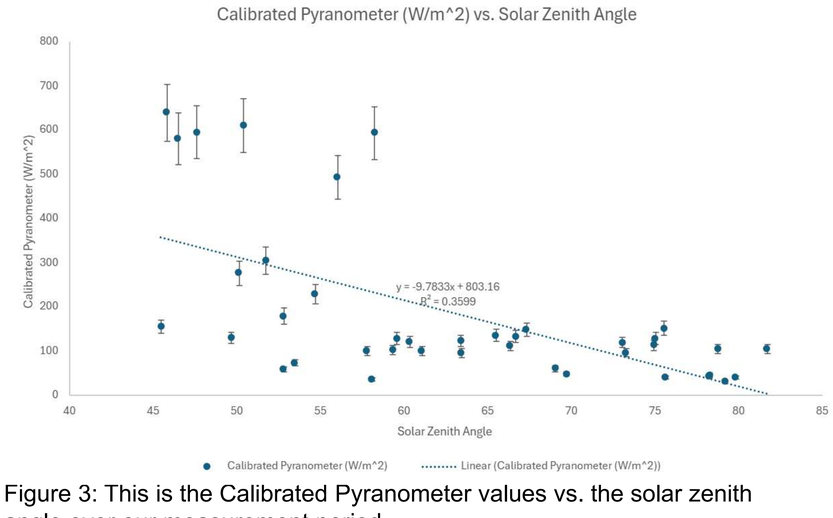

Figure 3: This is the Calibrated Pyranometer values vs. the solar zenith angle over our measurement period

Based on the results all of the plots have an R value between 0.29 and 0.50 suggesting a moderate correlation between Solar Irradiance and seasonality. It also Suggests a moderate correlation between solar zenith angle and Solar irradiance and Solar zenith angle and time of year. If you look at these plots you can also very clearly see this correlation helping us even more. This essentially proves our hypothesis correct in that as the solar zenith angle decreases solar irradiance increases and since solar zenith angle decreased as we got closer to summer, solar irradiance essentially increases as we get closer to summer and this is most likely due to seasonal changes.

Conclusions

In conclusion, This study showed a moderate negative correlation between solar zenith angle and solar irradiance over a six-week period. As the solar zenith angle decreased as we approached spring, irradiance values generally increased, supporting the hypothesis. These results show us the seasonal effect on solar energy input and suggest that zenith angle can be a useful predictor for irradiance under relatively consistent weather conditions.

References

Masters GM. *Renewable and Efficient Electric Power Systems*. 2nd ed. Hoboken, NJ: Wiley; 2013

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Acknowledgements

Thank you to my groupmates, TA's and professor for helping me with this project.