

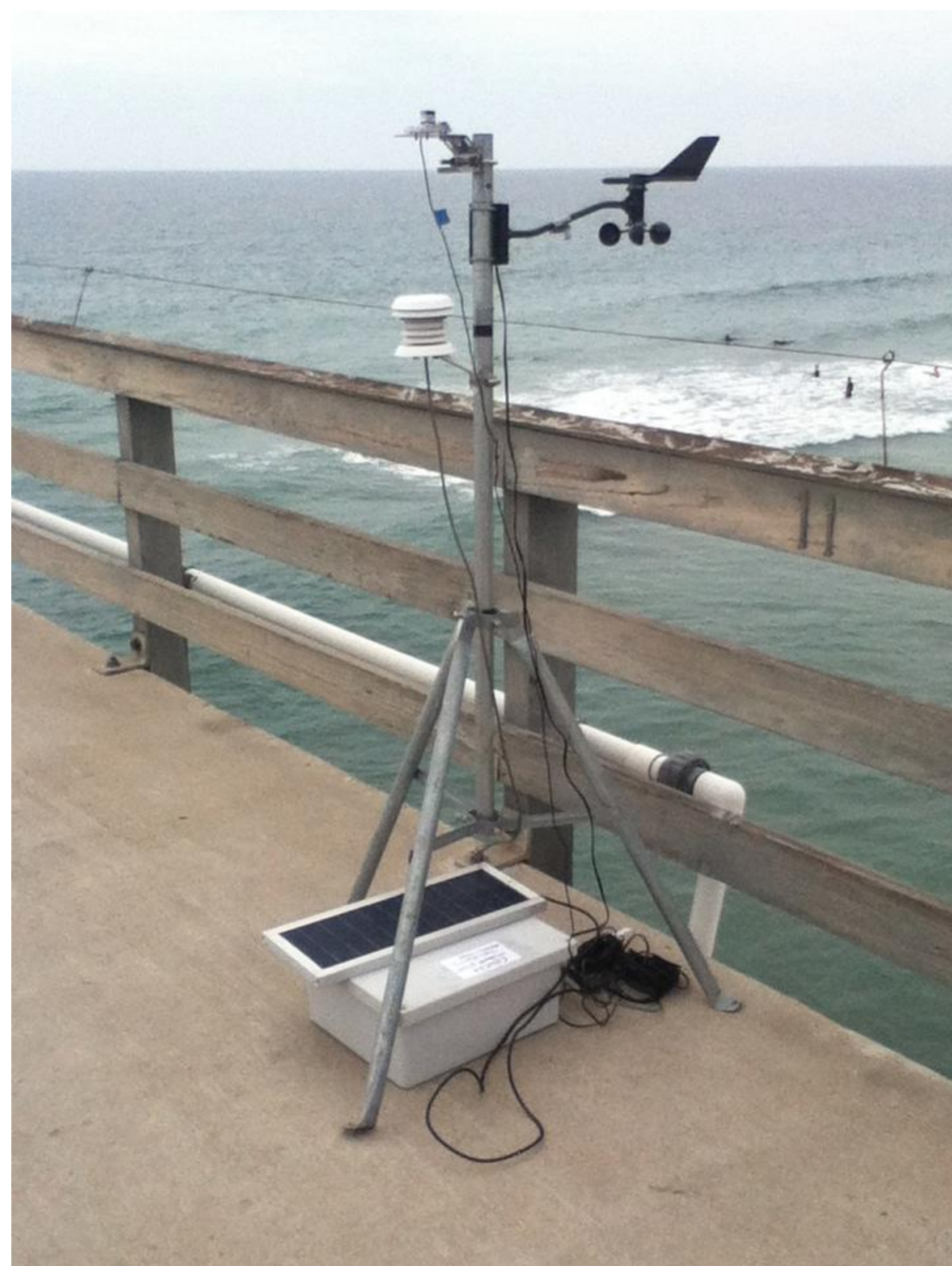
# The Key to a Sustainable Future: Wind and Solar Energy

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### Abstract

The purpose of our experiment was to determine if there is enough solar radiation and wind power available in La Jolla, CA to meet electrical demand during peak hours. To test our hypothesis, we set up a tripod on Scripps Pier that collected data every five minutes for twelve days using a thermometer, hygrometer, pyranometer, and an anemometer. We found several correlations between the different variables. For example, as temperature rises, both solar radiation and wind speed follow as they all increase throughout the day. As humidity increases, there is also an increase in solar power. We have concluded that solar radiation and wind speed are abundant near the ocean in La Jolla, CA during times of peak temperature and humidity (this is when the need for power for air conditioning is at its highest). Solar cells and wind turbines would be able to meet a significant amount of the energy demand in La Jolla during peak energy times, and therefore should be considered as a reliable and practical source of energy.

### Measurements



Wind speed and direction anemometers

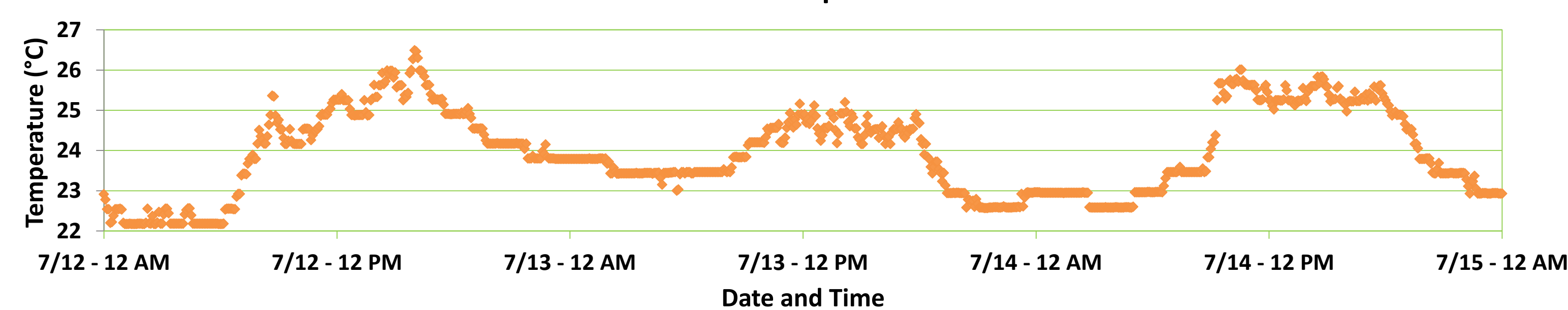


Pyranometer

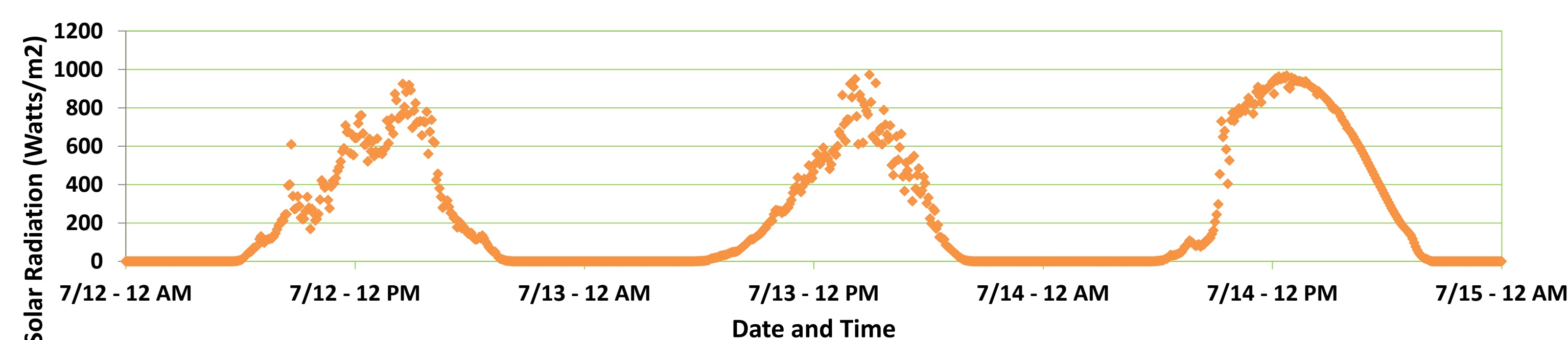


Hygrometer and thermometer

Time vs. Temperature



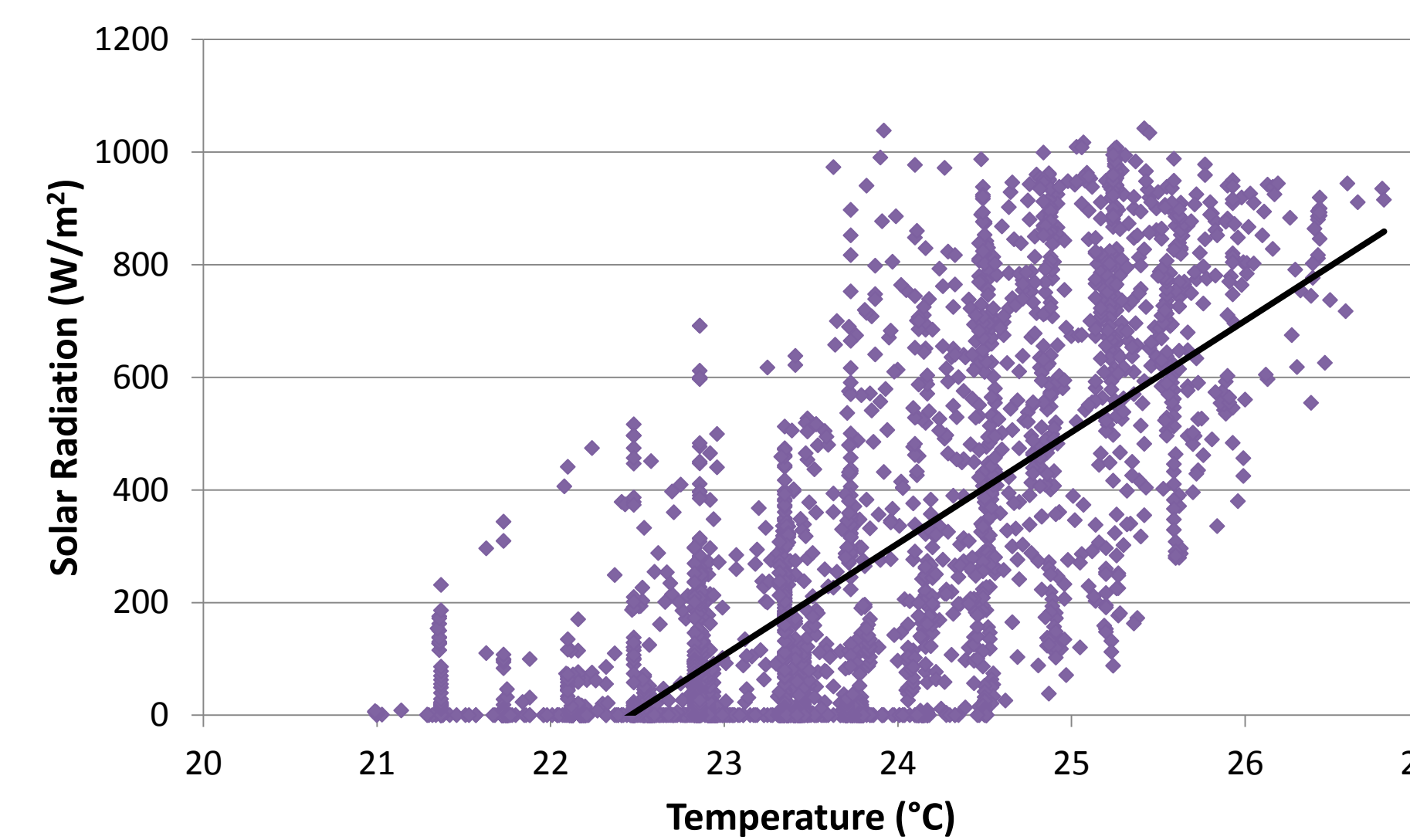
Time vs. Solar Radiation



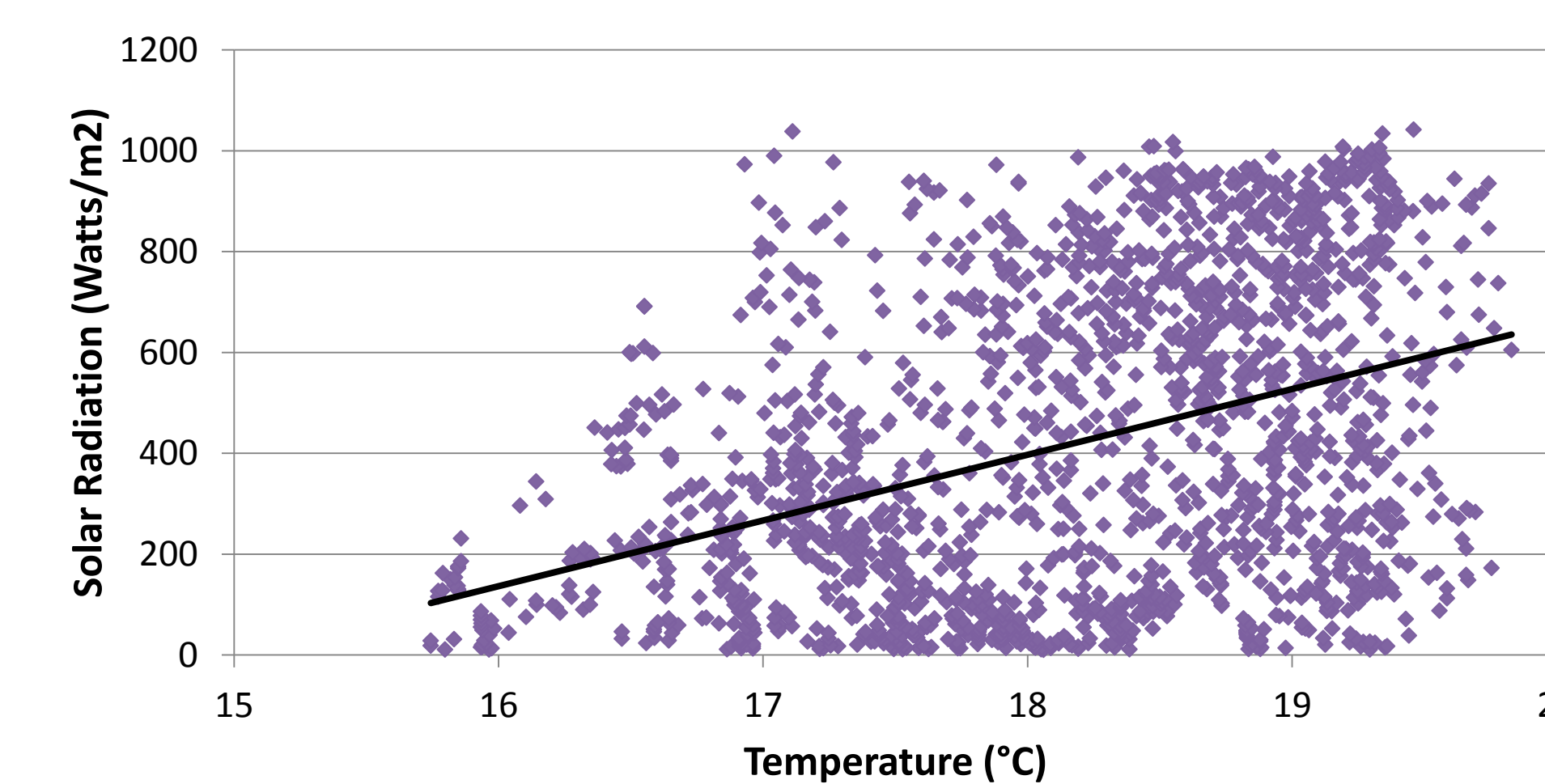
### Background

Renewable energy is energy harvested from either an inexhaustible resource or a source that can replenish itself faster than it is utilized. Out of all electricity used in the world, only 11.86% is derived from renewable energy. Further, only 1.7% of this renewable energy comes from solar energy; 12.6% is made from wind power. Why is this source not utilized more? The main problem is the lack of storage options: while some newer, more expensive technologies can store energy, traditional photovoltaic cells and windmills cannot. Thus, energy must be present when it is most desired. Our goal is to determine whether wind and solar power are abundant in La Jolla, CA when demand for energy (due to usage of air conditioning on warm days) is at its highest.

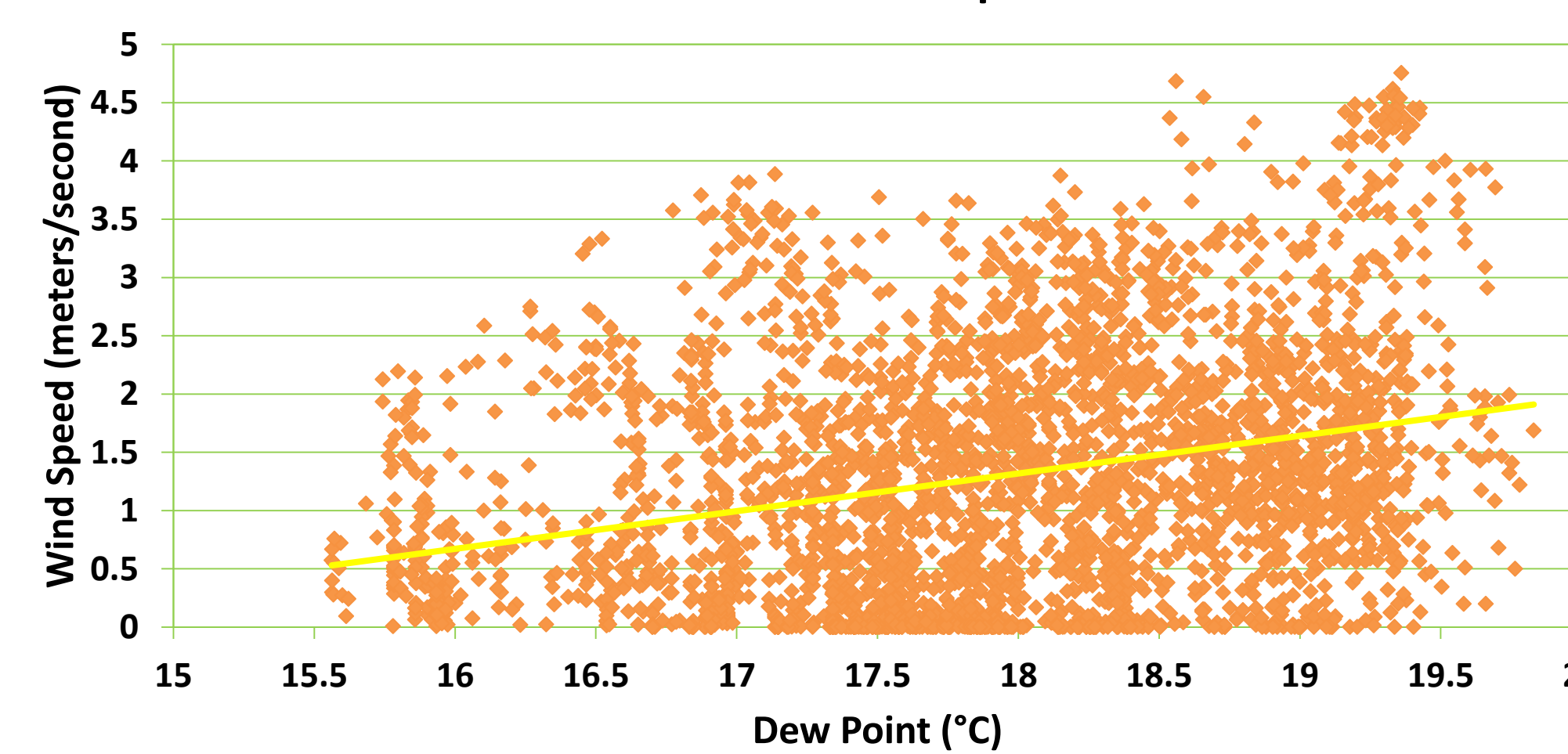
Temperature vs. Solar Radiation



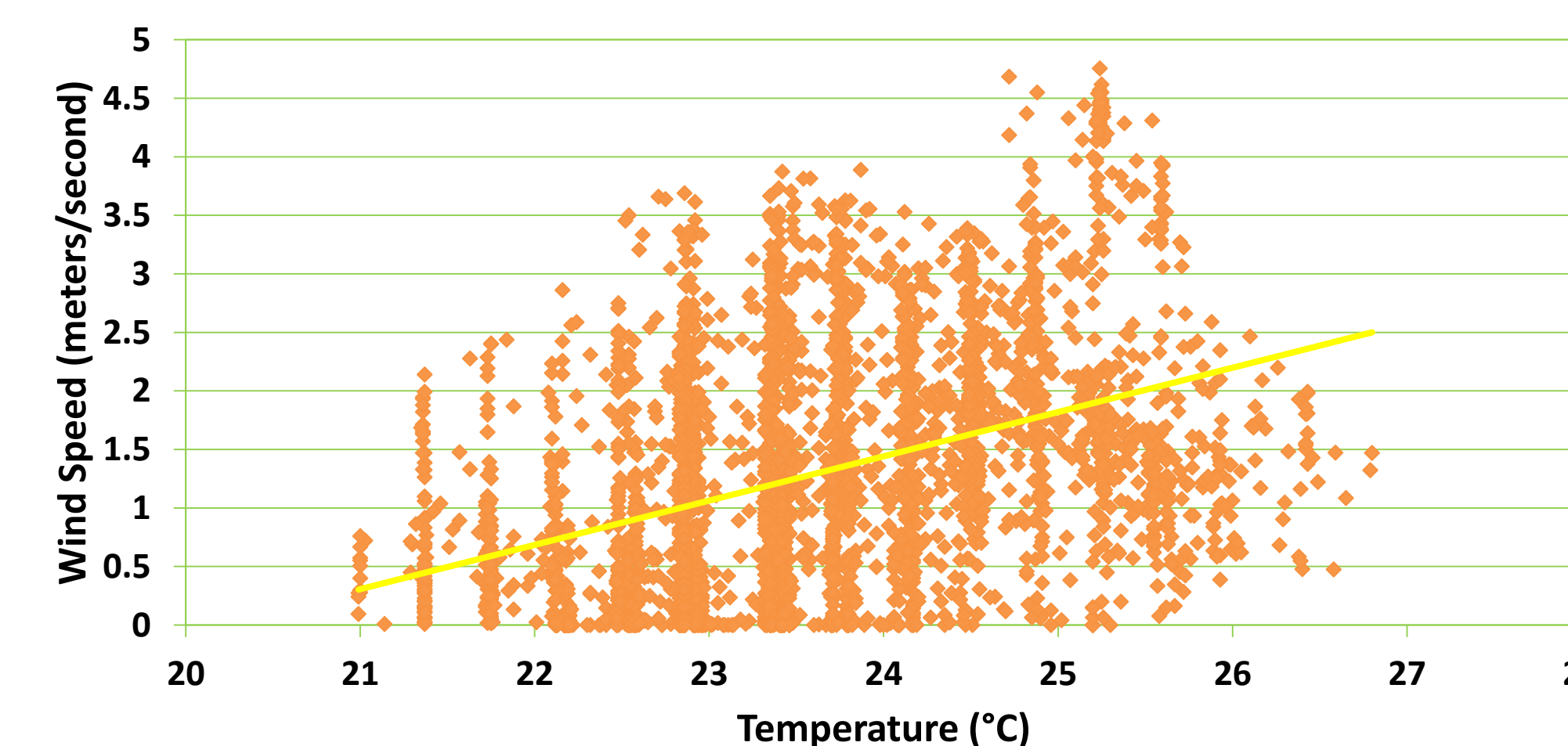
Dew Point vs Solar Radiation



Dew Point vs Wind Speed



Temperature vs Wind Speed



### Methods

1. Create graphs in MS Excel and insert a least squares linear regression line
2. Calculate the chi-square test for the trendline and calculate sigma b for the data of this graph
3. Calculate Student's t-test:  $N_{\text{effective}} = N/100$  and use 95% uncertainty
4. Calculate the following:  $(\text{slope}) - (\text{two tail t-value}) \times (\text{sigma b}) \times 10$
5. Dew point formula:  $(\text{temperature}) - \frac{(100 - \text{relative humidity})}{5}$

### Conclusion

Temperature vs. Solar: Based on the data collected in our experiment, the sun is a viable source of solar energy during peak energy usage hours (usually mid-morning to late afternoon, when temperatures are at daily peaks and demand for air conditioning is at its highest). As determined by the results, with every 1 degree Celsius increase in temperature, the increase in the solar radiation is 198 Watts/m<sup>2</sup> ( $\pm 31$ ) add uncertainty.

Temperature vs. Wind: With every 1 degree Celsius increase in temperature, there is an increase in wind speed of 0.36 meters/second ( $\pm 0.14$ ). While this may not seem like much, one needs to keep in mind that wind power is proportional to the cube of the wind speed.

Humidity vs. Solar: Demand for energy also increases as humidity increases in accordance with temperature. Our data concludes that with every 1 degree Celsius increase in dew point, the solar radiation increases by 231 Watts/m<sup>2</sup> ( $\pm 71$ ). Thus, as humidity and temperature increase, there is a significant increase in the amount of solar power available.

Humidity vs. Wind: With every 1 degree Celsius increase in dew point, there is an increase in wind speed of 0.32 meters/second ( $\pm 1.6$ ).

Although our results proved that there will be more wind and solar energy available, when demand is highest, there are a few possible limitations that could have affected our data. The fact that we only collected data from one location could pose a problem in trying to accurately represent the amount of wind and solar power that can be harvested from all of La Jolla. We were also only able to collect data during one season: summer. This limits the ranges of temperatures in our data sets, meaning our data is only applicable during the summer instead of all year round.

### Acknowledgements

We would like to thank Joel Norris and Megan Jones for assisting and guiding our experiment. We also would like to thank Prof. Jan Kleissl and Mr. Filipe Mejia for providing the tripod and other materials for our experiment.