Humidity Levels And Wind Turbine Performance

Carlito Okey and Edward Rorigi
Toledo Technology Academy of Engineering

Introduction

Renewable energy sources, such as wind power, are becoming increasingly important in the global push for a sustainable and low-carbon future. According to Weipeng Yue et al., contributors to *International Journal of Rotating Machinery* state,"High humidity combined with rain, foggy weather, and icing can cause turbine performance degradation, especially in offshore wind farm development" (p.15). This quote relates to our project by examining the different factors in wind turbine performance. Among the various factors that influence wind turbine performance from past research and has been proven humidity has emerged as a significant environmental parameter that can impact air density, aerodynamics, and overall turbine efficiency. According to Salih et al. (2012), results are graphed with the previously mentioned parameters, "The wind turbine is affected by many parameters whether internal (electrical connection, rotor size, copper and iron losses, efficiency of wind generator and blade shape) or external (wind speed, weather parameters, location and height of wind tower). Understanding the relationship between humidity and wind turbine performance is crucial for optimizing energy output, improving design strategies, and implementing effective maintenance practices. This study aims to investigate the effects of humidity on wind turbine performance, with the goal of contributing to the efficient utilization of wind resources and further advancing the development of renewable energy technologies.

Hypothesis

The hypothesis is higher humidity levels will cause wind turbine to have lower output results due to humidity's weight and damage it can cause.

Objective

The purpose of this analysis is to find how humidity levels will affect the output and overall performance of a wind turbine.

Methods

Our methods include the following:

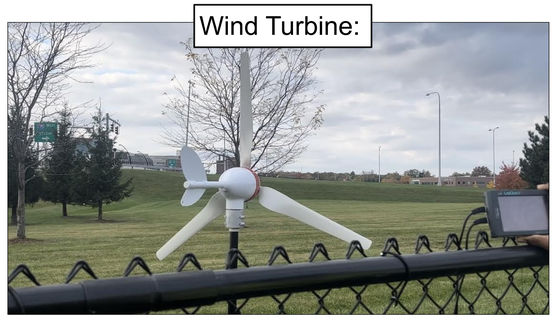
- (Wind Turbine, Anemometer Psychrometer, Data Sheet, and Webquest)
- Set up Wind Turbine in the designated test area-away from buildings and trees
- One person will take the Anemometer and the Psychrometer and collect the data via Data Sheet-convert turbine output to amps/volts into watts
- Collect the data of the Wind Turbine from the Webquest
- Repeat for the next time you collect the data
- Finally enter the data into the **GLOBE WEBSITE**
- We used Stats blue website to enter variables to look for correlations, Stats blue uses the equation ($Y=C+a*X_1+b*X_2$) to determine the correlation

Correlation:
watts= 0.0331 + 0.0358 * voltage-0.006 * humidity + 0.002 * speed

How does humidity affect wind turbine output? Humidity can weigh down wind turbines performance.

Psychrometer Humidity Testing:

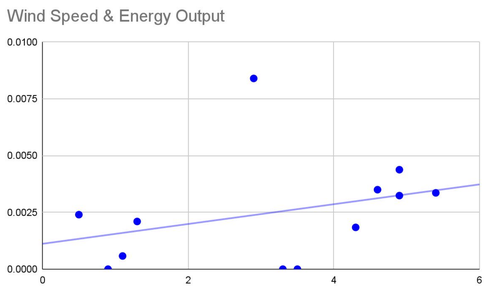
Wind Turbine:

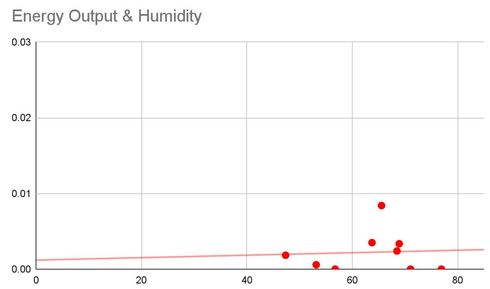


Project Testing:

Map (TTA)

Testing Site





References

Salih, S. M., Taha, M. Q., & Alawsaj, M. K. (2012). Performance analysis of wind turbine systems under different parameters effect. *International Journal of Energy & Environment*, *3*(6), 895–904.

Mert, İ., Karakuş, C., & Üneş, F. (2016). Estimating the energy production of the wind turbine using artificial neural network. *Neural Computing & Applications*, *27*(5), 1231–1244.

Abstract

Humidity also impacts the overall efficiency of our wind turbines. Higher the humidity levels increase the water content in the air, which can lead to erosion and wear on the turbine blades. This deterioration can result in decreased aerodynamic efficiency and lower overall efficiency of the wind turbine system.

Results

There have been several studies conducted to examine the effect of humidity on wind turbine performance. According to Weipeng et al., "It is found that, at high temperature, the high humidity effect on air density cannot be ignored for annual energy production calculation" (p. 15). His quote shows high humidity can have a significant impact on energy production, and must be taken into account in calculations. Yue also states, "Blade contamination and icing due to water condensation may have significant effects on turbine performance degradation" (p. 15) His quote highlights the importance of understanding the indirect effects of high humidity on turbine performance. Our data suggests higher humidity levels have also been found to reduce the power output of wind turbines. This is because humid air is denser than dry air, leading to increased air resistance and higher aerodynamic losses. As a result, our wind turbine performed worse on days with higher humidity levels.

Conclusion

In conclusion, high humidity levels can negatively impact the performance of wind turbines. It can increase air density, causing more drag on the turbine blades and reducing their efficiency. Our charts show the correlation on how humidity and wind speed affect wind turbine performance. Through research we have found water droplets on the blades can also add weight and further decrease performance. Additionally, humidity can contribute to corrosion and icing issues, leading to structural damage and safety concerns. Our hypothesis indeed did reach overall expectations.

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