# Humidity's Effects on The Output of a Wind Turbine

Andrew Cook and Ethan Pendergraff
Toledo Technology Academy of Engineering

## Introduction

Humidity's Effects on The Efficiency of a Wind Turbine
Air density and energy generation efficiency are impacted by humidity, which is an important factor in wind turbine performance. Sometimes scientist need to measure the humidity, as stated by David Schecter, writing for Journal of the Atmospheric Sciences “relative humidity above an area covering the central and uptilt regions of the boundary layer 43 vortex.” (3) For example, they need to measure it during hurricanes or tornadoes by finding the humidity. Enforcing this, Schecter states “relative humidity in the core of the PD vortex is moderately enhanced relative to the environment.” (Schecter 7) Optimizing wind energy output requires understanding parameters like humidity, which is crucial as renewable energy sources develop. In a society that is increasingly getting more energy-focused, this study explores the effects of changing humidity levels on wind turbine efficiency, providing insight into what can be enhanced in design and operating techniques.

## Hypothesis

It was believed Increased humidity reduces the output of wind turbines by affecting air density and drag on the blades, leading to decreased aerodynamic performance and lower energy output.

## Objective

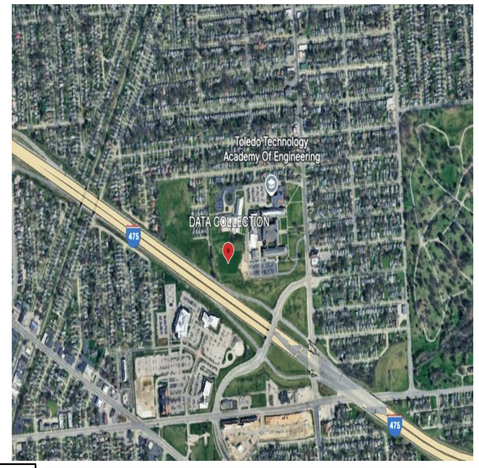
The purpose of the research is to investigate how varying levels of humidity influence the efficiency of wind turbines.

## Methods

- Use Go Direct weather stations to measure humidity levels and assess their effect on the turbine power efficiency.
- Gather the kite and Kestrel Weather Station.
- Use the Kestrel Weather Station to measure from the ground then fly the kite and attach the Kestrel at the required height.
- Collect and share data with one another to analyze and create graphs, ensuring a clear visualization of the results.
- Put the data in the GLOBE website and use stats website for graphs.
- Safety is a top priority throughout the process, use personal protective equipment including gloves when handling equipment, flying kites, and collecting data outdoors.

## The impact of humidity levels in the air on the output of a wind turbine.

Ethan Pendergraff taking ground wind data

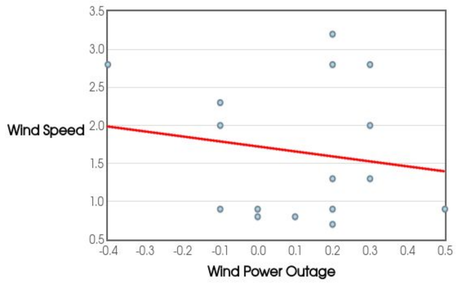


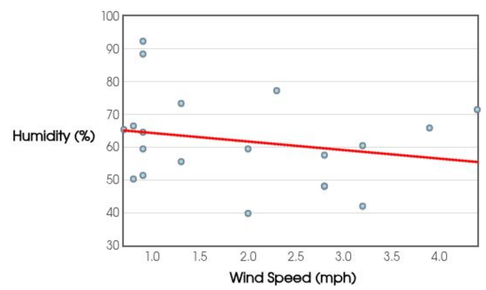

Neighborhood around testing area

Andrew Cook and Ethan Pendergraff collecting data using the kite

Picture of all the data

| | Date | Time | Location | Initials of Collect | Wind Turbine Power Output | Humidity (%) | Wind Speed(mph | Additional Notes | Observations |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 10/7/2024 | 10:30-10:40 | EV lab field | A A E | Power: 0.5 mW | 51.4 | 0.9 | Not enough wind to fly kestrel | |
| 3 | 10/8/2024 | 10:30-10:40 | EV lab field | A A E | Power: 0 mW | 50.3 | 0.8 | Not enough wind to fly kestrel | |
| 4 | 10/9/2024 | 8:56-9:06 | EV lab field | A A E | Power: 0.1 mW | 66.5 | 0.8 | Not enough wind to fly kestrel | |
| 5 | 10/15/2024 | 10:00-10:40 | EV lab field | A A E | Power: 0.2 mW | 42 | 3.2 | Kite crashed into tree | Wind speed measurement may be incorrect |
| 6 | 10/16/2024 | 10:00-10:40 | EV lab field | A A E | Power: 0.2 mW | 57.6 | 2.8 | Not enough team members to fly kite | |
| 7 | 10/17/2024 | 10:00-10:25 | EV lab field | A A E | Power: 0.5 mW | N/A | N/A | Not enough wind to fly kestrel | Kestrel did not send data |
| 8 | 10/18/2024 | 10:30-10:40 | EV lab field | A A E | Power: 0.2 mW | 65.4 | 0.7 | Not enough wind to fly kestrel | |
| 9 | 10/21/2024 | 10:30-10:40 | EV lab field | A A E | Power: 0.4 mW | 48.1 | 2.8 | Not enough wind to fly kestrel | |
| 10 | 10/23/2024 | 10:30-10:40 | EV lab field | A A E | Power: 0.3 mW | 48.1 | 2.8 | Not enough wind to fly kestrel | |
| 11 | 10/24/2024 | 10:30-10:40 | EV lab field | A A E | Power: 0.2 mW | 55.6 | 1.3 | Not enough wind to fly kestrel | |
| 12 | 10/25/2024 | 10:30-10:40 | EV lab field | A A E | Power:  0.0 mW | 92.4 | 0.9 | Not enough wind to fly kestrel | |
| 13 | 10/28/2024 | 10:30-10:40 | EV lab field | A A E | Power: 0.1 mW | 39.8 | 2 | Not enough wind to fly kestrel | |
| 14 | 10/30/2024 | 10:30-10:40 | EV lab field | A A E | Power: 4660.5 mW | 65.9 | 3.9 | Flew the kestrel | |
| 15 | 10/31/2024 | 10:30-10:40 | EV lab field | A A E | Power: N/A | 71.5 | 4.4 | Too much wind to fly kestrel | Wind turbine did not cooperate |
| 16 | 11/1/2024 | 10:30-10:40 | EV lab field | A A E | Power: N/A | 59.5 | 0.9 | Not enough wind to fly kestrel | Oxygen |
| 17 | 11/4/2024 | 10:30-10:40 | EV lab field | A A E | Power: N/A | 60.5 | 3.2 | Flew the kestrel | Oxygen |
| 18 | 11/6/2024 | 10:00-10:10 | EV lab field | A A E | Power: 0.1 mW | 77.3 | 2.3 | Not enough wind to fly kestrel | |
| 19 | 11/12/24 | 9:58-10:08 | EV lab field | A A E | Power: 0.1 mW | 64.6 | 0.9 | Not enough wind to fly kestrel | |
| 20 | 11/13/2024 | 10:00-10:10 | EV lab field | A A E | Power: 0.3 mW | 59.5 | 2 | Flew the kestrel | |
| 21 | 11/14/2024 | 10:30-10:40 | EV lab field | A A E | Power: 0.2 mW | 88.5 | 0.9 | Not enough wind to fly kestrel | |
| 22 | 11/15/2024 | 10:30-10:40 | EV lab field | A A E | Power: 0.3 mW | 73.4 | 1.3 | Not enough wind to fly kestrel | |




## References

Wong, J. (2023). Feeling the humidity. *New Scientist*, *260*(3463), 44.,, Schecter, D. A. (2024). Two Types of Transitions to Relatively Fast Spinup in Tropical Cyclone Simulations with Weak-to-Moderate Environmental Vertical Wind Shear. *Journal of the Atmospheric Sciences*, *81*(9), 1513–1541.

## Abstract

Using a kite and the Kestrel Weather station, date on the humidity and speed of the wind is recorded. Using the data, the correlation between the power output of the wind turbine and the humidity is stated.

## Results

It was believed that the humidity would lower wind energy levels. The results indicated that humidity has a minimal effect on the output of wind turbines. Variations in atmospheric moisture levels did not significantly impact the output or efficiency of the turbines. Overall, humidity isn't a major factor in how well wind turbines produce energy.

## Conclusion

The hypothesis included humidity making a significant difference in lowering the wind speed. It was hypothesized that high humidity would equal low wind speeds and low humidity would equal high wind speeds. After collecting data, it was concluded that humidity does not have a significant impact on the speeds of wind. After using all of the methods for finding data, it was concluded that there would be no correlation between the humidity and wind speed after all. If there were more time, changing methods and the measurements used would get different results to have more correlation in the data.Understanding humidity patterns empowers us to build a more resilient and sustainable future

## Acknowledgments

Grant Wilson, Laura Kubiak, Gladwyn Richardson, A.R.E.N, UT, G.L.O.B.E, N.A.S.A