CDIO2: Wind Energy Harvesting: Sustainable Energy

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Building the Basics: Wind Turbines

The goal of this project is to design the most efficient wind turbine blade and optimize the power produced by analyzing the different parameters of the turbine.

As seen in *Figure 1*, the main degrees of freedom include:
Azimuth * Yaw * Pitch

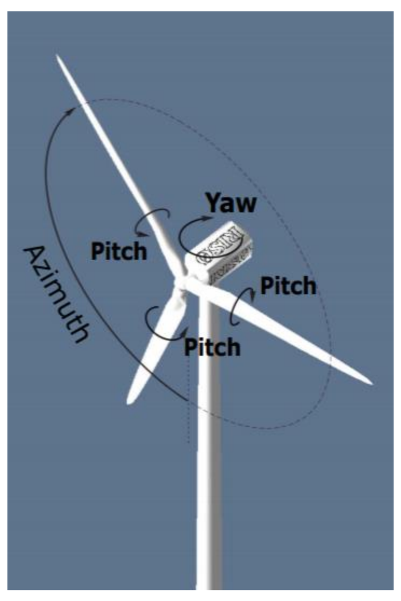


Figure 1: Degrees of Freedom Diagram

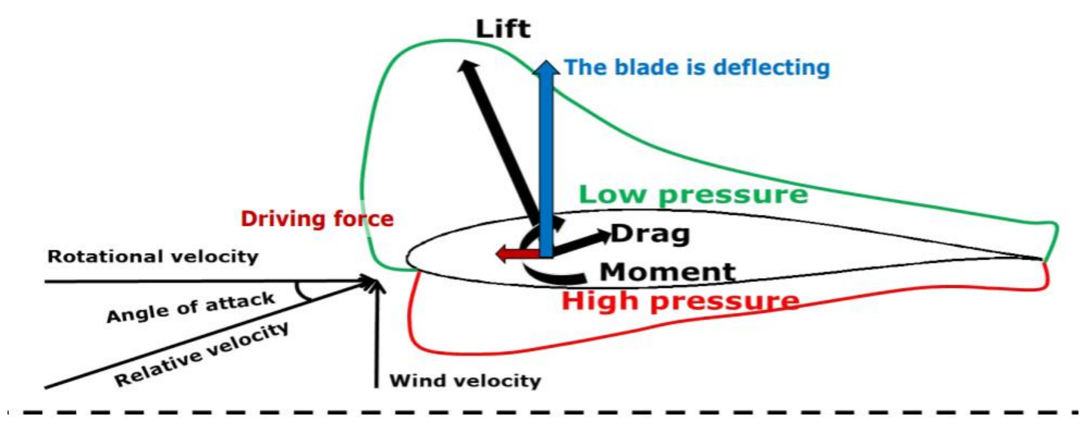


Figure 2: Lift/Drag Forces Diagram

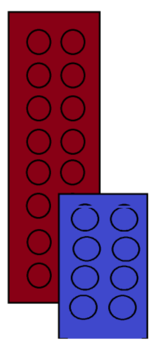


Figure 3: LEGO Blade Design

LEGO's & Cardboard:

- **Goal:** To learn first-hand about the lift & drag forces (*Figure 2*) as well as the dynamics involved in wind blade design.
- **Strategy:** Arrange LEGO's and Cardboard to experiment and learn about the general principles behind these concepts.
- **Design:** See *Figure 3* for the implemented design.

Yaw Lab

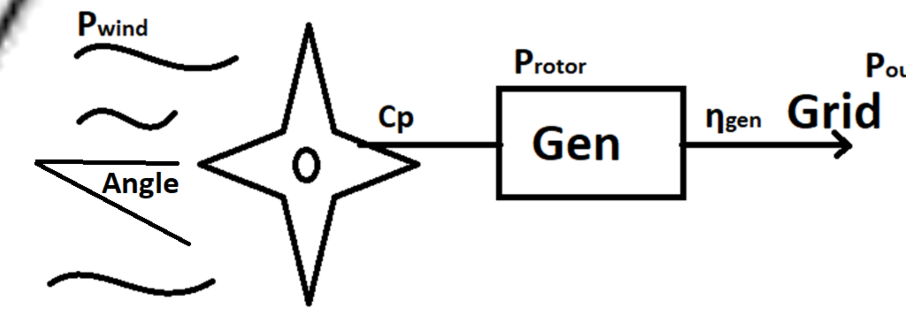


Figure 4: Yaw Block Diagram

The Yaw Error Analysis results in *Figure 5* display an overall trend in uncertainty using the setup as described in *Figure 4*.

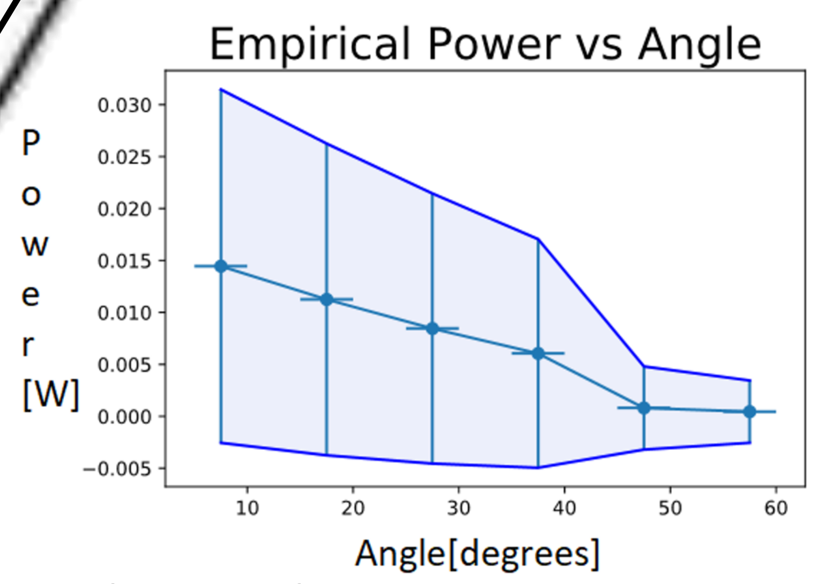


Figure 5: Yaw Error Analysis Graph

- If the wind is at a 90° angle to the blades, then maxi power will be produced.
- If the wind is at ~40° angle to the blades, then the blades stop rotating.
- These are approximations as there are large uncertainties in these calculations

Non-Yaw Lab

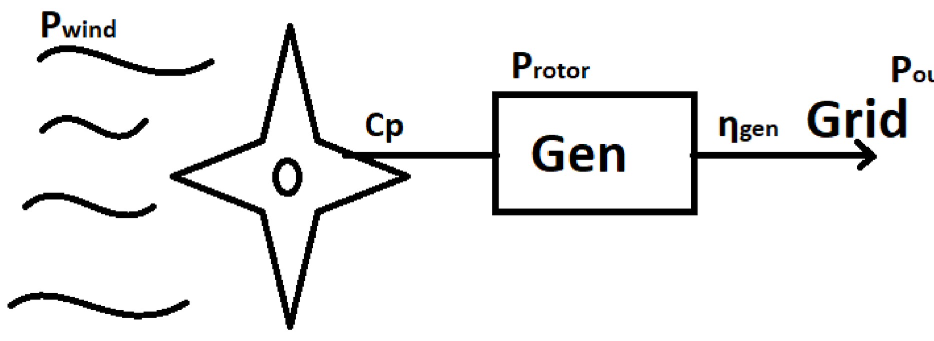


Figure 6: Non-Yaw Block Diagram

As seen by the diagram in *Figure 6*, the C_p & the power generated by the blades can be calculated by adding the P_{out} and the P_{rotor}.

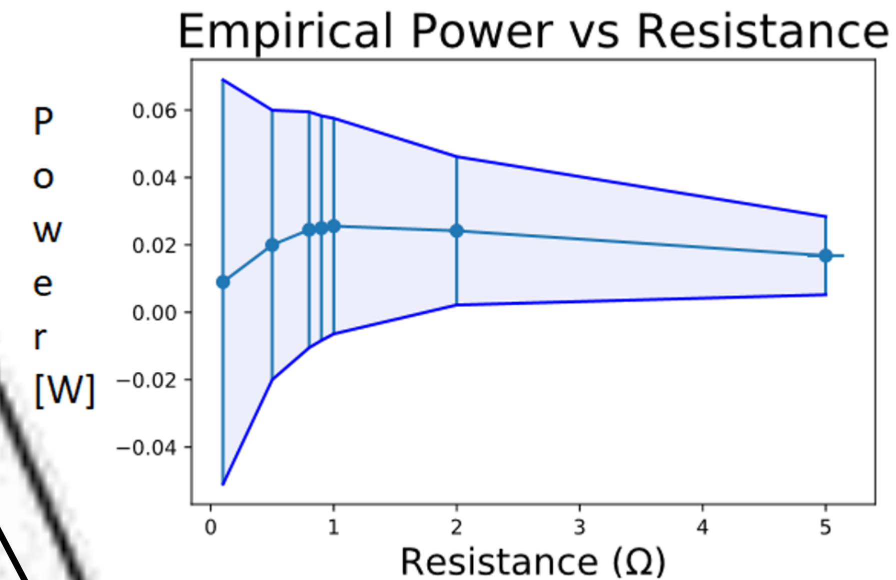


Figure 7: Yaw Block Diagram

The results as seen in *Figure 7*, from the Non-Yaw error analysis are impractical as the uncertainties are too large. Specifically, these large uncertainties make it possible that the first data point can have the exact same value as the last one.

3D Model Applications

Trial 1

The Parameters: Using the provided MatLab code to define thickness ratio, camber, and tip speed ratio.
The Goal: To optimize the Cp coefficient.

The Problem: Although this model has the highest theoretical Cp, it's thinness impeded it from attaining enough lift to rotate.
The Strategy: Increase the designs tip-speed ratio.

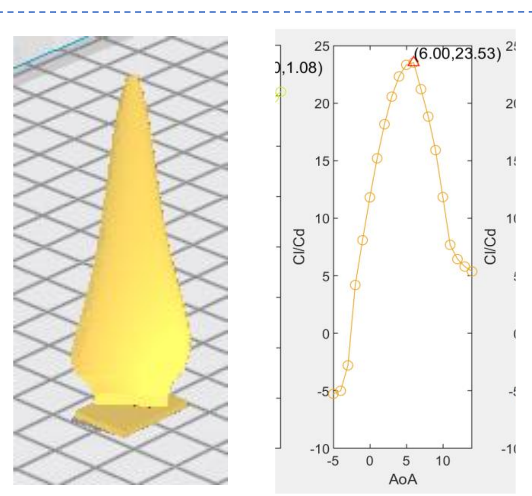
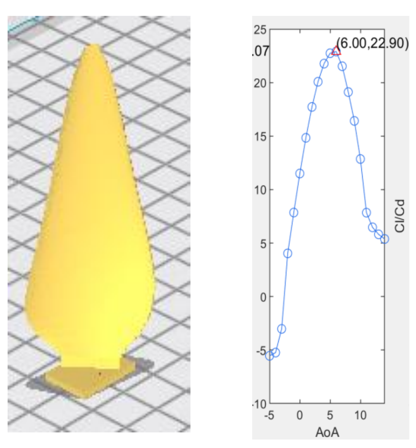


Figure 12: Trial 1 Blade Design

Trial 2

The Result: The wing blade was able to take advantage of the lift and rotate at low speeds.

The Parameters: Using the provided MatLab code to define thickness ratio, camber, and tip speed ratio.
The Goal: Create a rotating blade with an optimized Cp coefficient.



The Problem: This thickness was not enough to make the blade rotate in the 5m/s wind tunnel.
The Strategy: Increase the designs tip-speed ratio.

Figure 13: Trial 2 Blade Design

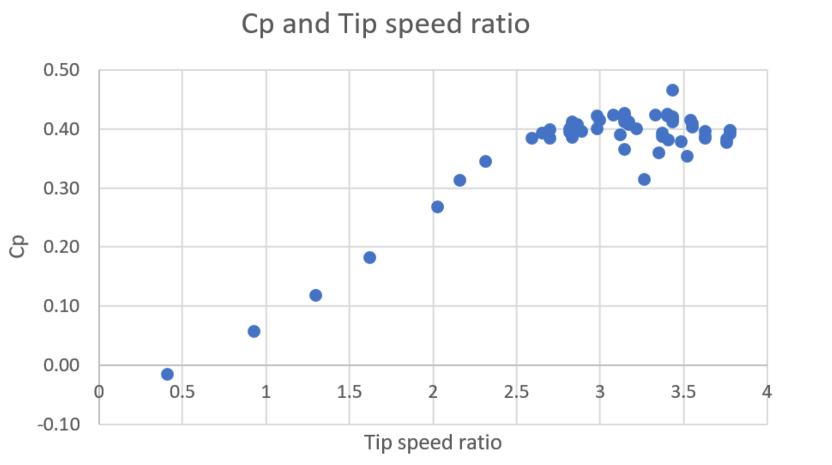


Figure 14: Trial 2 C_p & Tip Speed Ratio Graph

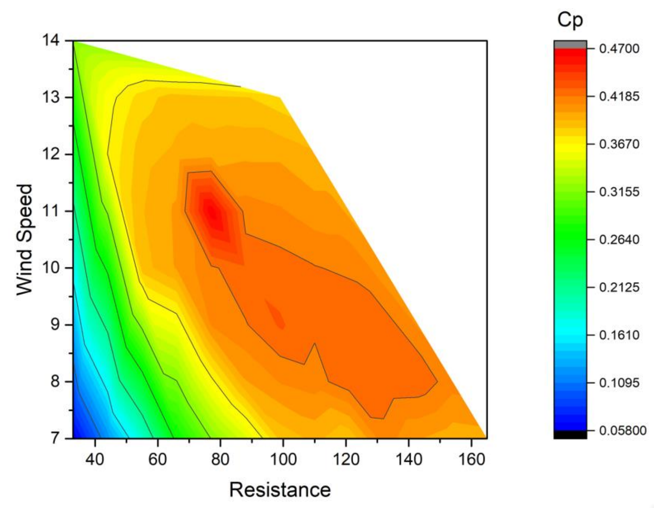


Figure 15: Trial 3 C_p Contour Plot

Motors & Generators Lab

No Load test

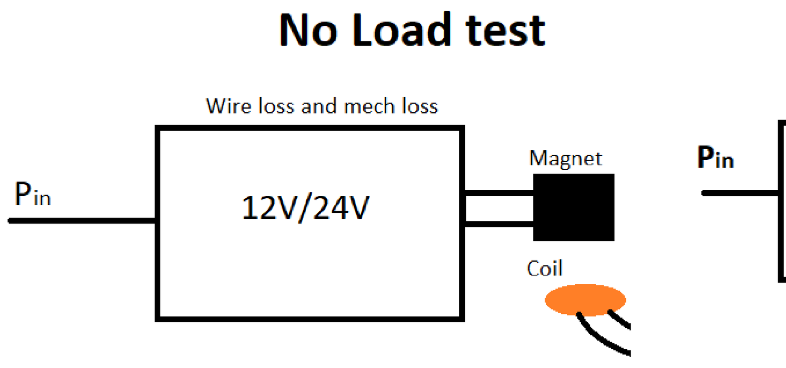


Figure 8: No-Load Block Diagram

Load test

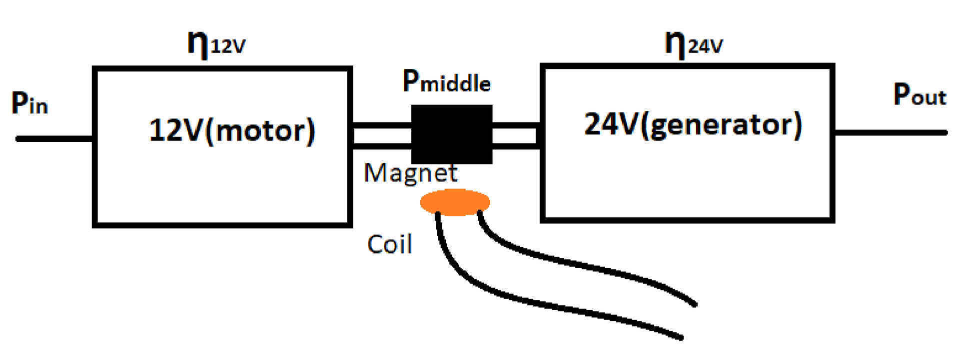


Figure 9: Load Block Diagram

The No-Load & Load lab set-ups are as described by the above block diagrams in *Figures 8 & 9*.

The two graphs below (*Figures 10 & 11*) characterize the No-Load 24V and 12V motors respectively.

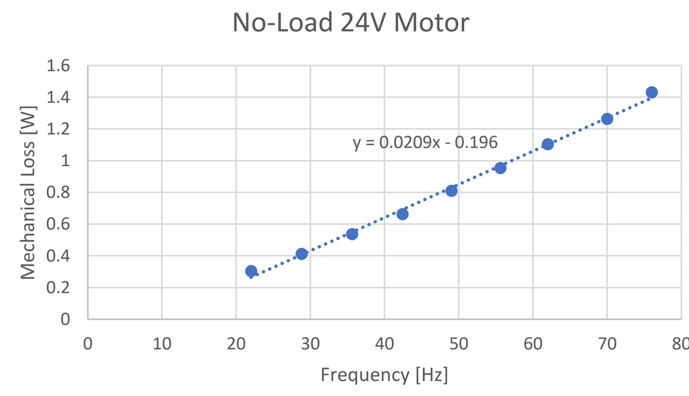


Figure 10: No-Load 24V Graph

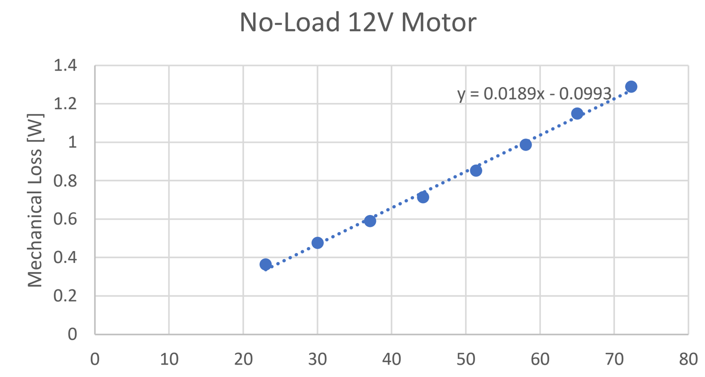


Figure 11: No-Load 12V Graph

Concluding Remarks

CONCLUDING STATEMENT OF RESULTS/SIGNIFICANCE/WRAP UP & GRAPH