CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

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Project Number

J0213

Project Title

Spira Mirabilis: Improving the Performance of Archimedes Wind Turbine with Logarithmic Spiral Concept

Abstract

Objectives

To develop higher efficiency of Archimedes Wind Turbines (AWT) by applying the logarithmic spiral concept for small-scale wind turbines below 30m.

Methods

AWT curvatures were remixed to incorporate different logarithmic spiral formulas from Desmos (2 Blades, 3 Blades A/B/C). Prototypes were 3D-printed, with a stand and generator connected for testing in three wind speeds and different latitudes/longitudes. Power is calculated by measuring the voltage and current using the multimeter. Efficiency is calculated by comparing AWT power to the wind power available in the sweep area and also compared to HAWT and VAWT from my prior science projects.

Results

Power generated is affected consistently by wind speed. However, a higher power doesn't always translate to higher efficiency. Efficiency increases by 17%-174% in 3.8 m/s compared to 2.6 m/s wind speeds in various turbines. 2 Blades outperforms 3 Blades in low wind speed. Latitude/longitude of the wind affects the power generated. The highest power is at 0,0; producing 83%-93% within 45 degrees and 15%-23% within 90 degrees, except 45 S and 90 S. The stand blocks some airflow and reduced the power by 20%-46% in 45 S. Logarithmic spiral wind turbine prototype (3 Blades B) efficiency is up to 27.4% at 3.8m/s wind speed, exceeding my HAWT, VAWT designs and one commercial AWT at 12m/s wind speed. Based on logarithmic regression prediction, 3 Blades B has the potential to reach up to 38% efficiency at 6-8m/s and up to 44% efficiency at 12 m/s; 10-20 percentage points higher than commercial AWTs.

Conclusions

My hypothesis was proven correct, as different blade curvatures produce different powers in the same wind speed and in different latitudes/longitudes of wind direction. Since the logarithmic spiral is a growth spiral, an increase in curvature results in more surface area to capture the wind energy spiraling from high-to-low pressure. However, an optimal point is reached as tighter curvature adds weight, diminishes the Coanda effect and power is reduced. Implementing a Logarithmic spiral in AWT is proven to generate higher efficiency and meets stated design criteria.

Summary Statement

I developed Logarithmic-spiral based wind turbine prototypes with high efficiency in relatively low wind speeds and in various latitude/longitude wind directions for urban settings.

Help Received

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