CALIFORNIA STATE SCIENCE FAIR
2003 PROJECT SUMMARY

Name(s)
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Project Number
J0126

Project Title
Turbines and Tunnels: Spacing Turbines in Wind Farms

Abstract

Objectives/Goals
To investigate how the spacing between two inline wind turbines affects their performance by modeling them as two propellers in a wind tunnel and varying the spacing between them.

Methods/Materials
A wind tunnel consisting of diffuser, accelerator, test chamber, decelerator, and drive sections was constructed from melamine coated hardboard glued and taped together, plastic egg-crate light panels, and a 20 inch electric fan. The removable test chamber held two propellers with a position indexing system built from LEGO. A infrared emitted/detector pair in the path of each propeller passed through a SPDT selector switch to a digital frequency meter.

The following measurement procedure was used:
1. Set fan speed to high, turn on power supply, frequency meter, and fan.
2. Set rear prop to position 0 (79.6 mm from front turbine).
3. Record speed of back prop (in Hz).
4. Press the SPDT switch and record speed of the front turbine.
5. Move rear prop to next position (16 mm farther away)
6. Go to step 3 and repeat until index position 14 (303.6 mm)
7. Repeat steps 2 through 6 for a total of five trials.
8. Increase load on front prop (add friction) and repeat steps 2 through 7

Results
To reduce the impact of time varying influences on measurements, the ratio of the front to back turbine frequency was computed and then averaged across all five trials. The average ratio ranged from 1.053 at the first (closest) position to 1.037 at the last (farthest) position on the first test set and from 0.940 to 0.885 at on the second set.

Conclusions/Discussion
Per expectation, the ratio of the front prop speed to back prop speed decreased steadily with distance. On the no load test, the ratio stayed above 1.00 while on the loaded test the ratio stayed below 1.00. Upon further investigation, I learned that the limitations of my test setup make an imperfect model of real world wind farm turbines largely because my propellers were very near the diameter of the wind tunnel, making my system a ducted fan whose behavior is different from a propeller in free air.

Summary Statement
This project models the effect of spacing between two inline wind turbines by measuring the speed of two inline propellers in a wind tunnel while varying the distance between them.

Help Received
Father helped design and build wind tunnel and explain the electronics; mother helped create backboard and record data; brother helped take photos, assemble wind tunnel, and record data.