Wind Turbine Efficiency

Goals

- Assemble a wind turbine
- Modify it to increase efficiency
- Make calculations based on data

Background

Wind turbines are quickly becoming a major source of electricity in countries around the world looking to decrease their dependence on harmful fossil fuels. In consistently windy areas, they can provide cheap, clean power nearly constantly. But is the common three-blade design that you may have seen before in wind farms really the best choice for maximizing the power that we can get out of these electricity generators?

Humans have used wind as a power source for millennia. From sailing ships to grinding grains in mills, wind power has had many uses. But it's really only in the last 30 years that major use of wind turbines to generate electricity has become commonplace. Nations like Denmark, with wind to spare, have been generating so much electricity that they actually sell the surplus to their neighbors.

With a miniature, working wind turbine, you can simulate conditions that wind turbines have to face as they generate electricity: different wind speeds and wind from different directions.

Your turbine is adjustable to try and compensate for these situations. There are three different shapes of turbine blades available for you to use. They can each be tilted to three different angles and you can have up to six blades on your rotor.

During this activity, we will experiment with different types of blades, different numbers of blades, and different angles of blades to try and maximize the power produced by our wind turbine.

Procedure

1. Look at the three different types of blades available (labeled A, B, and C). How are they similar? How are they different? Discuss with your group which type of blade you think would work best with your turbine and record your observations below.

2. Select the type and number of blades you want to test. Why do you want to test this type of blade first? Do you think it will be better or worse than the other types?

3. Check that the blades are in the same position using the three notches near the white bases of the blades. Rotate the individual blades if needed to get all the blades into the same position. Would your turbine still work if the blades were in different positions?

4. Insert the blades into the Rotor Base and put the Blade Holder and the Blade Assembly Lock, then attach the Blade Unit to the metal shaft of the turbine. Can your blades be positioned backwards? How do you know if there's a "right way" for a blade to be positioned?

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5. Connect the base of the turbine to the LED lights using the black and red wires. Why do you think the lights need two wires to work?

6. Turn on the fan and position it in front of the turbine. It will work best if you keep the fan close to the turbine and line up the center of the fan with the center of the turbine. Why would changing the position of the fan affect the wind hitting the turbine?

7. Record your observations in the Data Table below: Did the lights turn on? Were they dim or bright?

8. Discuss what you observed with your group and discuss what you want to change: the number of blades, the angle of the blades, the type of blades, or some combination of those.

9. Repeat steps 1-8 with as many changes as you can think of.

Observations

Data Table:

Blade Type (A, B, C):	Number of Blades:	Blade Angle (6°, 28°, 56°):	Observations:

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Experimentation

1. Based on your data from the previous experiment, keep the angles of the blades the same and try different numbers of different types of blades to see which works best. Record your observations below:

Trial:	Turns:	Time (sec):	Observations:
1			
2			
3			
4			

According to your data, how many seconds of running time do you get per turn of the generator?

Number of Each Type of Blade:	Observations:

What combination worked best?

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2. If you used a combination of different types of blades, try changing the arrangement of the blades (A, B, A, B or A, A, B, B, for example) to try and get the rotor to turn faster. If your rotor spun fastest with only one type of blade, you can skip this experiment.

Blade Order:	Observations:
1	
2	
3	
4	

What arrangement worked best?

3. Move your fan farther back, to reduce the speed of the wind hitting your turbine. Test different configurations of blades and record your observations below.

Blade Type (A, B, C):	Number of Blades:	Blade Angle (6°, 28°, 56°):	Observations:

Was the best arrangement the same as at the higher wind speed?

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4. What's the farthest distance you can move your fan and still turn your turbine? Use your ruler to measure how far your fan is from your turbine blades. Try different arrangements to see if you can get the turbine to turn at even farther distances.

Blade Type (A, B, C):	Number of Blades:	Blade Angle (6°, 28°, 56°):	Observations:

Measurement

For this section, you will need a multimeter or the Horizon Renewable Energy Monitor. For an introduction to using a multimeter, click here.

1. Move the fan closer to the turbine and record the current in Amps and highest voltage in Volts produced while the turbine is powering the LEDs. Record your answers below:

Current: _____ A

Voltage: _____ V

2. Voltage is equal to the current in amps multiplied by the resistance in ohms (V = IR), so according to your data what is the resistance of the LEDs in ohms?

Resistance: _____ Ω

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3. Try to maximize the output of the current and voltage by changing the different characteristics of the blades. Record your results below:

Blade Type (A, B, C):	Number of Blades:	Current (A):	Voltage (V):

Analysis

1. Make a scientific claim about what you observed while running your wind turbine.

2. What evidence do you have to back up your scientific claim?

3. What reasoning did you use to support your claim?

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4. Design an experiment that would determine the best height for a wind turbine's support pole. Explain the steps of your experiment below:

Conclusions

1. Did your turbine would work better at faster or slower wind speeds? Explain:

2. How would you calculate the percentage of kinetic energy from the wind that was transformed into electrical energy by the wind turbine?

3. Do you think wind turbines would be a good way to generate power for your school? Explain your reasoning.