PHYSICAL SCIENCE FAX!

FLINN SCIENTIFIC
"Your Safer Source for Science"
P.O. Box 219 • Batavia, IL 60510
(800) 452-1261 • Fax (866) 452-1436
www.flinnsci.com • E-mail: flinn@flinnsci.com

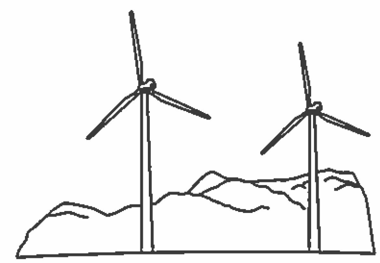
Catalog No. AP8051
Publication No. 8051

Generating Electricity with Wind

Flinn STEM Design Challenge™

Introduction

Wind is moving air. You cannot see air, but it is all around you. You can also not see wind, but you know it is there. Wind is energy in motion—kinetic energy—and it is a renewable resource. Wind turbines are being used today to harness the wind to power a generator and produce electricity.



Concepts

- Wind energy
- Wind turbines
- Energy transfer
- Electric generators

Background

Wind is a desirable energy source as it is both non-polluting and renewable. It does not emit air pollutants or greenhouse gases and using it does not diminish future supply.

So how does wind provide the energy to make electricity? Sunlight provides electromagnetic energy, which is absorbed by the Earth's atmosphere and converted into thermal (heat) energy. The Earth's surface does not heat uniformly and the uneven heating of Earth causes differences in temperature and air pressure. These pressure differences result in air moving from areas of high pressure to low pressure. Moving air is *wind*, containing mechanical energy. Mechanical *wind energy* pushes the blades of a *wind turbine*. That mechanical energy turns a coil of wire inside a generator within the turbine. The wire coil turns within a magnetic field, which causes electric current to flow in the wire. Figure 1 below is a flow chart that illustrates the transfer of each energy type throughout the process.

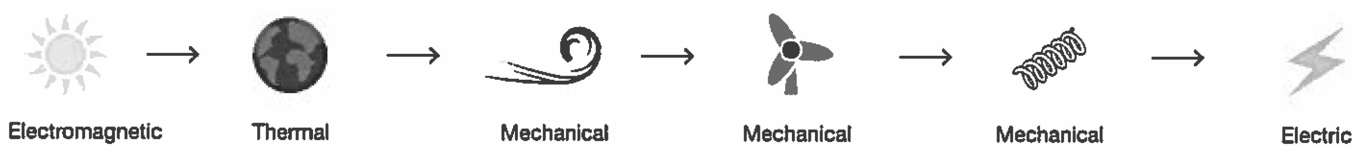


Figure 1.

A simple way to understand how wind turbines work is that they are essentially the opposite of an electrical fan. On a hot summer day a fan is plugged into an outlet and the electricity causes a motor to rotate, and the attached blades turn. With a motor, electric energy is converted to mechanical energy (see Figure 2). Conversely, wind turns the blades of a wind turbine that produces electricity. A *generator* converts mechanical energy to electrical energy (see Figure 3).

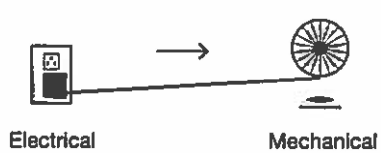


Figure 2. Electric Motor

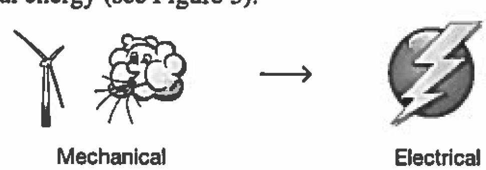


Figure 3. Electric Generator

The power output of a wind turbine is measured in watts (W) and can be determined by Equation 1.

$$P = V \times I \qquad \textit{Equation 1}$$

where

P = power measured in watts (W)
V = voltage measured in volts (V)
I = current measured in amps (A)

Experiment Overview

The purpose of this activity is to design and build a rotor (windmill blades attached to a central hub) out of the materials provided that produces the greatest amount of power. The voltage and amperage of the spinning rotor will be measured with a multimeter to determine the amount of generated power. Improvements will then be made to the rotor to increase the amount of power produced.

Pre-Lab Questions *(Answer on a separate sheet of paper.)*

1. Why is wind considered a renewable energy source?
2. A spinning rotor is attached to a multimeter. The meter displays 18 V and 6 A. How much power is produced by the rotor?
3. The current of the model rotors in this activity will actually be measured in milliamps (1 mA = 0.001 A) and the power output will be calculated in milliwatts (mW) using Equation 2.

$$P \text{ (mW)} = \text{V} \times \text{mA} \qquad \textit{Equation 2}$$

   a. Calculate the power output of a spinning rotor in mW with meter readings of 0.15 V and 7.8 mA.

   b. What is the power output of the rotor from 3a in watts?

Materials

Bamboo skewers	Cork
Blade material (choose from the following)	Glue or tape
Cardboard sheet	Ruler
Foam sheet	Sandpaper
Manila folder	Scissors
Polystyrene sheet	Testing station, shared amoung groups
Calculator	Timer or clock with second hand

Safety Precautions

Exercise caution when handling sharp bamboo skewers. Sandpaper may be used to smooth rough edges. Wear eye protection as rotor components may separate during testing. Never touch any bare wires in an electric circuit with a current. Please follow all laboratory safety guidelines.

Procedure

Part A. Designing and Building a Rotor

1. Read through the entire procedure before beginning.
2. Take 5–10 minutes to plan the rotor design using only materials provided by the instructor. Consider the following questions when planning the design:

   a. How many blades will the rotor have?

   b. How will the blades be attached to the hub (cork)? *Note:* The small end of the cork should face the fan that will be providing the wind.

   c. What material will be used to make the blades?

   d. What size and shape will the blades be?

   e. Will increased weight produce more or less power?
3. Once the group has determined the rotor design, obtain the necessary materials from your instructor.
4. Using the design plans from Step 2, assemble the rotor. *Note:* Do not glue the blades to the hub so adjustments may be made if necessary.

5. Take the completed rotor assembly to the testing station.
6. The instructor will attach the rotor to the motor at a set distance from the fan.
7. Turn the fan on high speed.
8. If the rotor turns, go on to step 9. If it does not turn, try to determine why not. Remove the rotor and go to step 13.
9. Set the multimeter to measure volts.
10. With the fan on high speed, note the highest voltage displayed in 20 seconds and record the value on the Generating Electricity with Wind worksheet. *Note:* If the voltage is a negative number, reverse the current by switching the connections to the multimeter.
11. With the fan still running, adjust the multimeter to register milliamps.
12. Note the highest amperage displayed in 20 seconds and record the value on the worksheet.
13. Observe other groups' rotors as they are tested.
14. Once each group has tested its rotor, adjust the height of the motor on the support stand so the rotor hub is half way between the center and the top of the fan. Repeat steps 9–12 with the rotor in this new position. If the rotor does not turn in this position, go on to step 15.
15. Calculate the power output in milliwatts for each test using Equation 2 from the Pre-lab Questions. Record the value on the worksheet.

Part B. Design Challenge

The challenge is to make adjustments to your group's rotor to increase the power output from Part A. If time allows, your enhanced rotor may be tested at the testing station to make sure it rotates and stays intact. This test will only determine functionality; the amps and volts will not be measured until the final test.

Consider the following as you redesign the rotor.

1. Make a list of problems, if any, the rotor experienced during testing and how modifications might be made to correct the problems.
2. If the rotor did not turn, then all forces acting on the blades were balanced, resulting in zero net force. How can the blades be modified to correct this?
3. The pitch of the blade is the angle of the blades in relation to the plane in which they are rotating. Was the pitch of the blades consistent throughout the testing?
4. Was the rotor well balanced and did it rotate smoothly? If not, how might the balance be improved?
5. How might changing the size or shape of the blades affect the outcome?
6. As other groups' rotors were tested, did you observe any common variables in the rotors that worked well?
7. Does it matter if the end of each blade touches the hub or if there is space between the hub and the blades?
8. Based on the results from Part A, choose where your rotor will be positioned for the final test—either in line with the center of the fan or raised up as in step 14.