Name: ________________________________

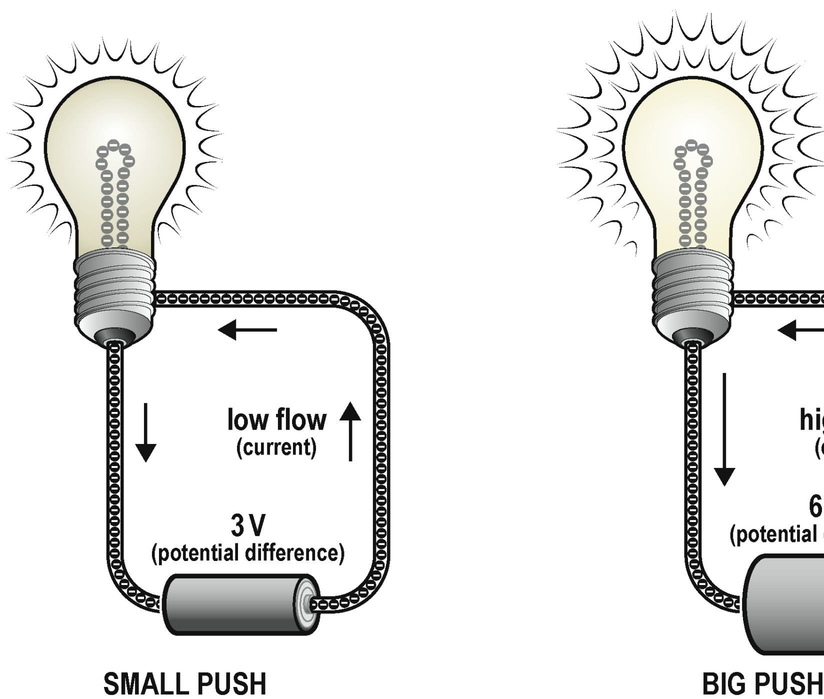
LabQuest App 3

Introduction to the Energy Sensor

When wind pushes against the blades of a turbine, the blades spin, and the generator inside the turbine causes electrons to move through the wires connected to the turbine. In this experiment, you will use an Energy Sensor to measure the electrons as they move. There are three values you will use to measure the movement of the electrons: current, potential difference, and power.

Current is the measure of the flow of electrons through the wires. When there is a high current, the electrons are flowing quickly through the wire. When the current is low, the electrons are moving more slowly. Current is measured in units of milliamperes, often called milliamps for short. The symbol used to represent milliamps is mA.

To make the electrons move through the wire, they need to be “pushed.” The amount of push is called the *potential difference*. Potential difference is measured in units of volts. The letter V is used to represent a volt. If you use a AA battery in a flashlight, the battery outputs 1.5 V. It pushes enough electrons to light up the small light bulb in the flashlight. Car batteries are usually 12 V. They push more electrons—enough to run the windshield wipers on a rainy day or defrost the windows when it is cold.



Power is the measure of how quickly energy is generated or used. In this experiment, power is measured in units of milliwatts. The symbol used for milliwatts is mW.

Power is a value that is calculated by multiplying the current and the potential difference

$$\text{power} = \text{current} \times \text{potential difference}$$

The data-collection software that you use in this experiment will do the calculation for you.

The following table summarizes the different measurements and units you will use in this experiment.

Measurement	Unit	Symbol
current	milliamp	mA
potential difference	volt	V
power	milliwatt	mW

OBJECTIVES

- Set up data-collection equipment.
- Measure current, potential difference (voltage), and power output of a wind turbine with an Energy Sensor.
- Use data-collection software to calculate mean (average) values.

MATERIALS

LabQuest
LabQuest App
Vernier Energy Sensor
Vernier Resistor Board
KidWind MINI Wind Turbine
Red Blade Set
2 wires with clips
safety goggles
multi-speed fan
centimeter ruler

VOCABULARY

Vocabulary term	Explanation
ampere	An ampere is the unit used to measure current. The symbol used to represent an ampere is A. In this experiment, we measure current in milliamps (mA). 1000 mA = 1 A
closed circuit	a closed loop that electrons travel through
current	the flow of electrons in a circuit
difference	the result of subtracting one number from another
electron	the negatively charged particles outside the nucleus of an atom
mean	The mean is the sum of a group of numbers divided by the total number of numbers in the group; the mean is also called an average.
ohm	An ohm is the unit used to measure resistance. The symbol used to represent an ohm is Ω.
volt	A volt is the unit used to measure electrical potential. The symbol used to represent a volt is V.
watt	A watt is the unit used to measure power. The symbol used to represent a watt is W. In this experiment, we measure power in milliwatts (mW). 1000 mW = 1 W

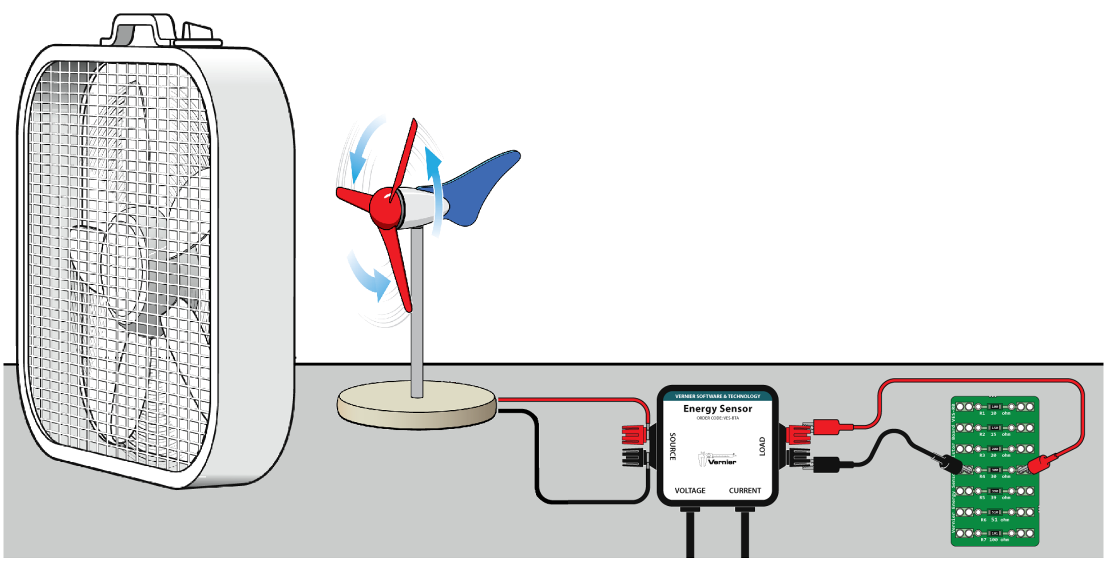


Figure 1

PRE-LAB ACTIVITY

In this experiment, there is a lot to learn. Cover up the Vocabulary section and the Introduction so you cannot see them! Do your best to fill in the missing spaces in the table.

Measurement	Describe in your own words	Unit	Symbol
current		milliamp	mA
potential difference		volt	
power			mW

PROCEDURE

1. Set up the fan and wind turbine.
   a. Assemble the turbine with the Red Blade Set (see Figure 1).
   b. Position the fan so the center of the fan is in line with the center of the hub of the turbine. The fan should be 15 cm from the turbine. The distance needs to be the same each time you collect data.
   c. Clear off your area and make sure that when the fan and the turbine are moving, nothing is in the way.

2. Connect the Vernier Energy Sensor Current and Voltage connectors to LabQuest (see Figure 2). Choose New from the File menu.

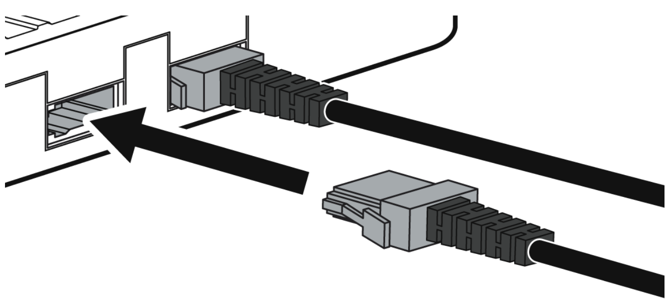


Figure 2

3. Zero the Energy Sensor.
   a. Connect the Energy Sensor Source terminals to each other with a wire, as shown in Figure 3.
   b. Choose Zero►All Sensors from the Sensors menu. **Note**: The resistance value is not meaningful when the current and voltage values are near zero.

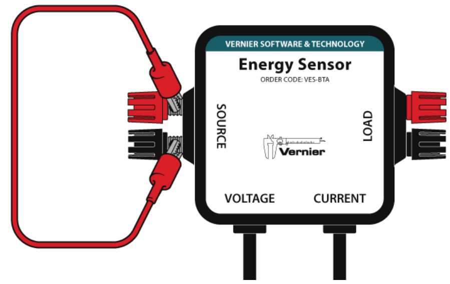


Figure 3

4. Connect the wind turbine to the Energy Sensor Source terminals.
   a. Disconnect the wire that is connecting the Source terminals.
   b. Connect the red wire from the turbine to the red Source terminal.
   c. Connect the black wire from the turbine to the black Source terminal.

5. Use two wires to connect the Resistor Board to the Energy Sensor Load terminals.
   a. Clip one wire to the black Load terminal and then to the hole on the left side of the 30 Ω resistor (see Figure 4).
   b. Use the other wire to connect the red Load terminal to the hole on the right side of the 30 Ω resistor. **Note**: The color of the wires does not matter when connecting the Resistor Board.

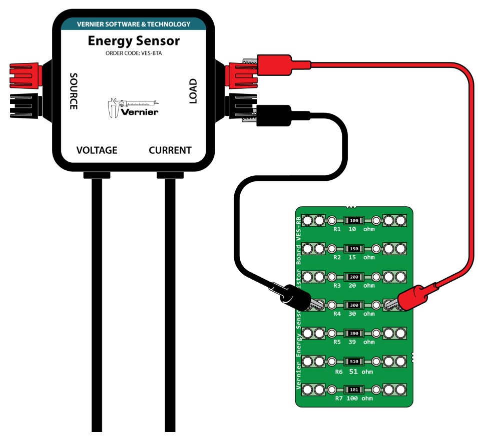


Figure 4

6. Get ready for data collection.
   a. Check that the fan and turbine are lined up correctly. Measure to make sure they are 15 cm apart.
   b. Put on safety goggles.
   c. Turn on the fan to the LOWEST speed setting. **CAUTION**: Do not stand in the plane of rotation of the wind turbine blades. If the turbine blades do not spin on the lowest setting, record 0 for the values in the data table and proceed to Step 11.

7. Collect data.
   a. After the fan has been on for at least 30 seconds, you are ready to collect data. Waiting 30 seconds ensures that the wind turbine is spinning at a constant speed. Start data collection. Data collection will stop after 30 seconds.
   b. When data collection finishes, turn off the fan.

8. Determine the mean power value.
   a. Choose Show Graph ►Graph 1 from the Graph menu. A single graph is shown.
   b. Tap the y-axis label and select Power. You will see a graph of power *vs.* time.
   c. Choose Statistics ►Power from the Analyze menu.
   d. Record the mean power value in the data table.

9. Determine the mean current value.
   a. Tap the y-axis label and select Current. You will see a graph of current *vs.* time.
   b. Choose Statistics ►Current from the Analyze menu.
   c. Record the mean current value in the data table.

10. Determine the mean potential difference (voltage) value.
    a. Tap the y-axis label and select Potential. You will see a graph of potential difference (voltage) *vs.* time.
    b. Choose Statistics ►Potential from the Analyze menu.
    c. Record the mean potential difference (voltage) value in the data table.

11. Collect data for the medium speed setting.
    a. Check that the fan and turbine are lined up correctly. Measure to make sure they are 15 cm apart.
    b. Turn on the fan to the medium setting. **CAUTION**: Do not stand in the plane of rotation of the wind turbine rotor.
    c. After the fan has been on for at least 30 seconds, start data collection.
    d. You are asked to store, append, or discard the latest run. Tap Discard.
    e. Data collection will stop after 30 seconds. When data collection finishes, turn off the fan.

12. Determine the mean potential difference (voltage) value.
    a. Choose Statistics ►Potential from the Analyze menu.
    b. Record the mean potential difference (voltage) value in your data table.

13. Determine the mean current value.
    a. Tap the y-axis label and select Current. You will see a graph of current *vs.* time.
    b. Choose Statistics ►Current from the Analyze menu.
    c. Record the mean current value in your data table.

14. Determine the mean power value.
    a. Tap the y-axis label and select Power. You will see a graph of power *vs.* time.
    b. Choose Statistics ►Power from the Analyze menu.
    c. Record the mean power value in your data table.

15. Collect data for the highest speed setting.
    a. Check that the fan and turbine are lined up correctly. Measure to make sure they are 15 cm apart.
    b. Turn on the fan to the high setting. **CAUTION**: Do not stand in the plane of rotation of the wind turbine rotor.
    c. After the fan has been on for at least 30 seconds, start data collection.
    d. You are asked to store, append, or discard the latest run. Tap Discard.
    e. Data collection will stop after 30 seconds. When data collection finishes, turn off the fan.

16. Determine the mean potential difference (voltage), power, and current values.
    a. Choose Statistics ►Power from the Analyze menu.
    b. Record the mean power value in the data table.
    c. Tap the y-axis label and select Current. You will see a graph of current *vs.* time.
    d. Choose Statistics ►Current from the Analyze menu and record the mean current value in the data table.
    e. Tap the y-axis label and select Potential. You will see a graph of potential difference (voltage) *vs.* time.
    f. Choose Statistics ►Potential from the Analyze menu and record the mean potential difference (voltage) value in the data table.

DATA TABLE

Fan speed setting	Mean potential difference (V)	Mean current (mA)	Mean power (mW)
Low			
Medium			
High			

DATA ANALYSIS

Analyze the potential difference data

1. Which fan setting generated the greatest potential difference? ________________________

2. Subtract to find the difference between the greatest potential difference and the least potential difference. Show your work.

3. Summarize what you learned about the relationship between fan setting and potential output.

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Analyze the current data

4. Which fan setting generated the greatest current? ________________________

5. Subtract to find the difference between the greatest current and the least current. Show your work.

6. Summarize what you learned about the relationship between fan setting and current output.

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Analyze the power data

7. Which fan setting generated the greatest power? ________________________

8. Subtract to find the difference between the greatest power and the least power. Show your work.

9. Summarize what you learned about the relationship between fan setting and power output.

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