E

Investigating Wind Energy

4th Edition

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ELB-WIND

Vernier

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* Required only if collecting data with Vernier Energy Sensors (order code: VES-BTA); not required for Go Direct Energy Sensors (order code: GDX-NRG).

Name: ______________________________

LabQuest App 2

Exploring Wind Energy

Electricity can be challenging to study because, like wind, you cannot see it. To understand electricity, you need to first learn about atoms. Atoms are very, very small. Trillions of atoms fit into the period at the end of this sentence. Atoms are the building blocks of everything in the universe—each plant, building, and person.

Atoms are made up of three types of even smaller particles. These particles are called neutrons, protons, and electrons. In a material that conducts electricity, such as metal, electrons are shared among many atoms and are always moving around. When all of the electrons get a push in the same direction and move with the push, we call that electricity.

In a wind turbine, the energy of the wind is transformed into electrical energy by the generator. If you opened the generator, you would see magnets and coils of wire. When the turbine blades are moved by the wind, they cause the coils of wire to spin. The magnets push the electrons in the spinning coil of wire. These electrons flow out through the wires connected to the generator, generating electricity.

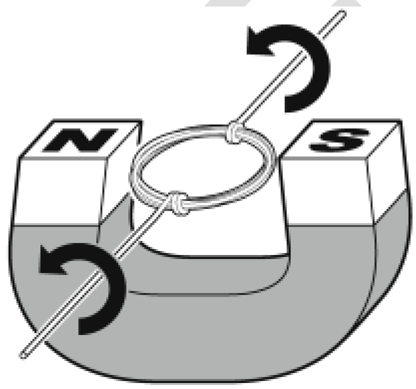


Figure 1

OBJECTIVES

- Use energy generated from a wind turbine to play a tune and light up LEDs.
- Explore the relationship between turbine speed and the ability to play a tune or light an LED.
- Verify that energy is transferred by electric currents.

MATERIALS

KidWind MINI Wind Turbine
Red Blade Set
KidWind Sound and Light Board
2 wires with clips
safety goggles
multi-speed fan
centimeter ruler

VOCABULARY

Vocabulary term	Explanation
atom	Atoms are the building blocks of the universe. Atoms contain protons, neutrons, and electrons.
electron	the negatively charged particles outside the nucleus of an atom
generator	a device that uses magnets and a coil of wire to generate electricity
variable	any factor that can be controlled, changed, or measured in an experiment

PRE-LAB ACTIVITY

1. Does Figure 2 show an open circuit or a closed circuit? ____________________

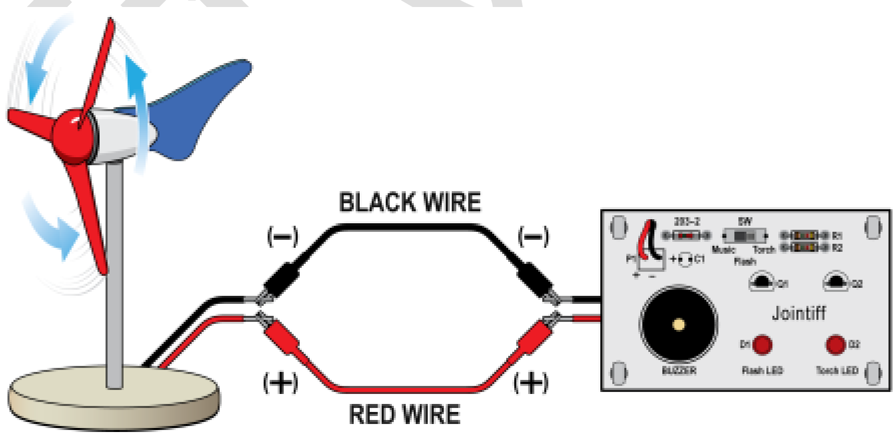


Figure 2

2. Draw arrows on Figure 2 to show the flow of electrons in the circuit.

PROCEDURE

Part 1 Set up and check the equipment

1. Connect the Red Blade Set to the wind turbine.

2. Connect the Sound and Light Board to the wind turbine.

   a. Move the switch marked with SW on the Sound and Light Board to Torch.

   b. Use a wire to connect the red wire from the Sound and Light Board to the red wire from the wind turbine, as shown in Figure 2.

   c. Use the second wire to connect the black wire from the Sound and Light Board to the black wire from the wind turbine.

3. Position the fan and the wind turbine.

   a. 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 about 15 cm from the turbine (see Figure 3).

   b. Clear off your area. Make sure that when the fan and the turbine are moving, nothing is in the way.

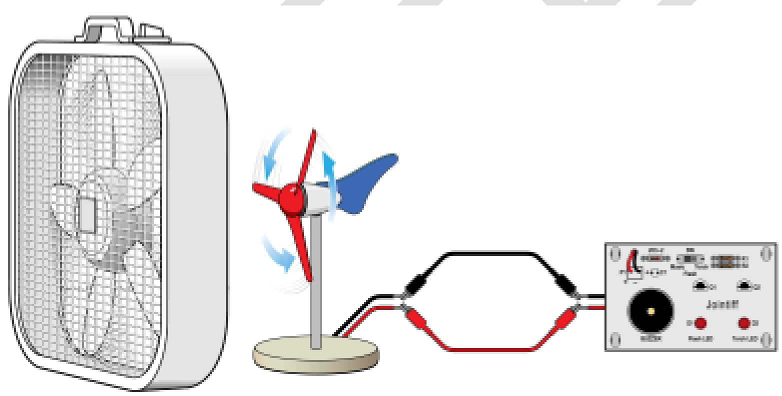


Figure 3

4. Check that everything is working correctly.

   a. Put on safety goggles and turn on the fan to its LOWEST speed setting. **CAUTION**: Do not stand in the plane of rotation of the wind turbine blades. If the blades do not turn, increase the fan speed setting.

   b. Wait 30 seconds for the fan to reach a constant speed.

   c. Does the Torch LED light up? If not, increase the speed of the fan until the Torch LED lights up. If you cannot make the LED light up, ask your teacher for help.

5. Turn off the fan.

6. The lowest fan speed setting that makes the Torch LED light up is (circle one)

low **medium** **high**

7. Light up the Flash LED on the Sound and Light Board.
   a. Move the switch on the Sound and Light Board to Flash.
   b. Find a fan speed at which you can make the Flash LED flash and then turn off the fan.
   c. The lowest fan speed setting that makes the Flash LED flash is (circle one)

low **medium** **high**

8. Play music using the Sound and Light Board.
   a. Move the switch on the Sound and Light Board to Music.
   b. Find a fan speed at which you can make the Sound and Light Board play music and then turn off the fan.
   c. The lowest fan speed setting that makes music play is (circle one)

low **medium** **high**

Part 2 Changing wind speed

9. Develop a plan to investigate how wind speed affects one of the components on the Sound and Light Board.
   a. Choose the component you will observe: Music, Flash LED, or Torch LED.
   b. Select one fan speed setting that you will use for your investigation.
   c. Discuss with your group how you could change the amount of wind that hits the blades, other than using the fan speed switch.
   d. Develop a plan and write it down. Include answers to the following questions:
      - Which component on the Sound and Light Board will you observe?
      - What fan speed setting will you use?
      - How will you change the speed?
      - What variable will you change?
      - What variables will you keep the same?

10. Ask your teacher to approve your plan.

11. Test your plan, and then describe what you observed about the music or the LED.

12. Summarize what you learned about wind turbine speed and the ability to play music and illuminate LEDs.

13. Was energy transferred from the wind? How do you know?

Name: ______________________________

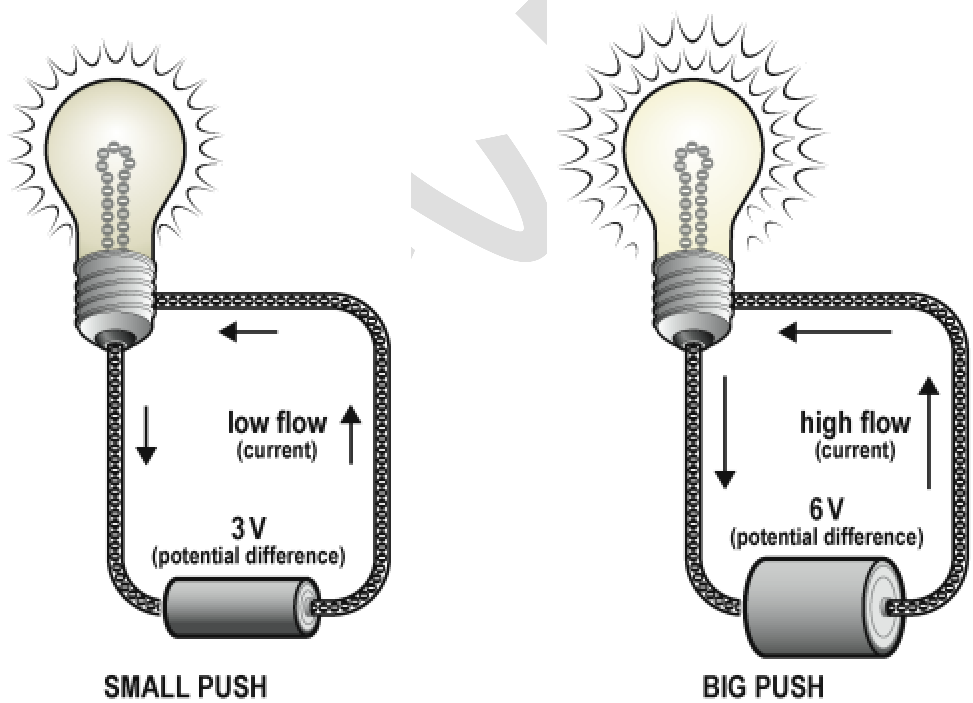
LabQuest App 3

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.



Introduction to the Energy Sensor

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

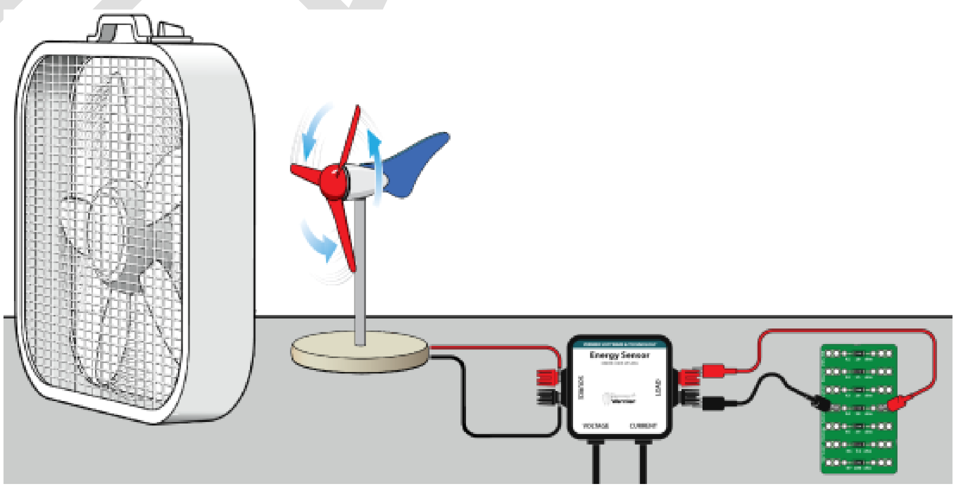


Figure 1

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.

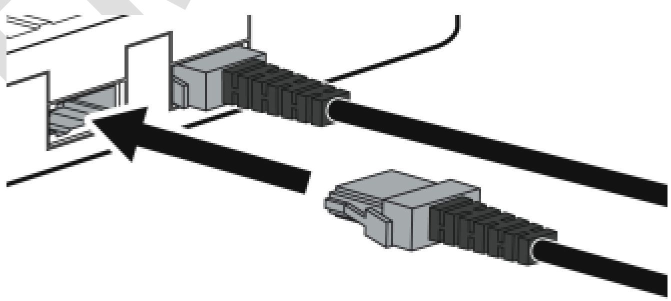


Figure 2

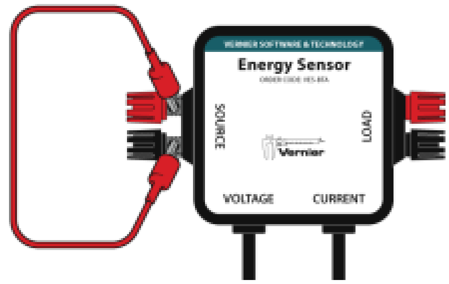


Figure 3

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.

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.

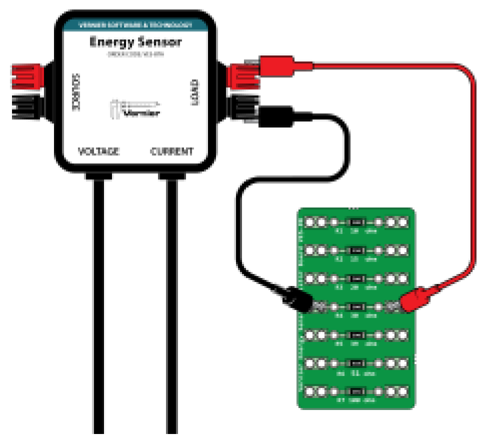


Figure 4

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.

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.

Introduction to the Energy Sensor

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

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.

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.