VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
http://studentorgs.vanderbilt.edu/vsvs

Wind Energy

2018-2019 VINSE/VSVS Rural

Goal: To become familiar with the wind mill assembly to be used in a future assembly, and to determine the ideal operating conditions for a given wind speed

I. Introduction
Explain what a wind mill is and how it works

II. Investigation of Wind Energy

A. Determine the ideal wind speed for a lightly curved windmill blade
Students will use 4 different blade shapes to determine which causes the highest electricity generation at a low wind speed

B. Determine the ideal wind speed for a moderately curved windmill blade
Students will use 4 different blade shapes to determine which causes the highest electricity generation at a moderate wind speed

C. Determine the ideal wind speed for a highly curved windmill blade
Students will use 4 different blade shapes to determine which causes the highest electricity generation at a high wind speed

D. Charging the fuel cell with the wind mill
Students attach the wind mill to the fuel cell to see how long the car will run when charged by the wind mill.

III. Discussion

Students will work in groups. There are 6 sets of materials, so divide the class into enough groups to use all the materials.

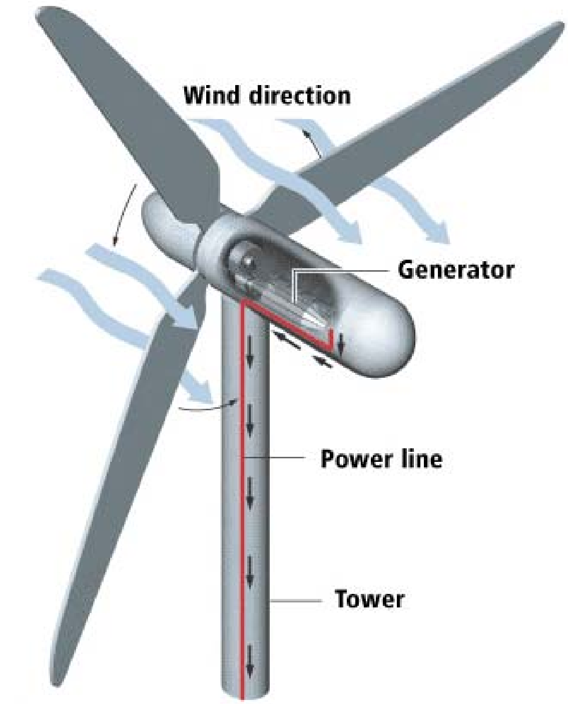
I. Introduction

Windmills use natural air currents to perform work. Ancient windmills were used to perform some tasks, like milling grain into flour or pumping water. Windmills now are primarily used to generate electricity, but are still occasionally used to move water in some form. The windmill provided for the lesson can generate enough energy to power the fuel cell car.

Wind energy can use the natural air currents to move a turbine and generate electricity. This is a transfer of kinetic energy to electrical energy. The wind source we will be using in our investigations today is a standard fan, but in practical applications the local air currents are used.
Wind will blow strongly enough at various times to be able to produce electricity, but as we often need electricity when the wind is not blowing strongly enough, we want to have the ability to collect as much energy as possible and be able to store it.
One way this is done is by having many windmills placed in one location that gets more wind than average. A **wind farm** consists of many individual wind turbines which are all connected either to an energy storage facility or into the regular electrical power transmission network to one energy storage facility or into the regular electrical network. These wind farms can have hundreds, or even thousands of individual windmills.
It is also important to make sure that the windmill itself is made in the best way to generate the most electricity. If the wind mill is connected to an electrolyzer, the kinetic energy of the wind can be stored as

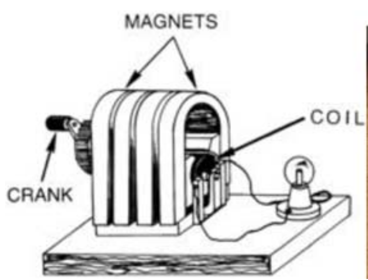
hydrogen and oxygen gas. A fuel cell can use these gases to make electricity when it is needed.

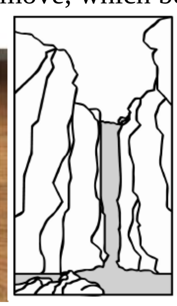
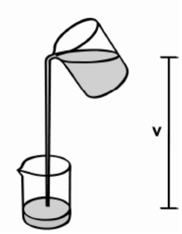
The principle of a wind mill is that it converts a stream of air into a stream of electrons (electricity). The conversion or transfer of energy from one form to electricity is the principle behind any electrical generator. Electrical generators include wind mills, diesel or gas engine generators, hydroelectric turbines and fuel cells.



A wind mill consists of a set of rotatable blades, a generator, and a tower. Air moves faster above the surface of the earth, and so a much greater amount of electricity is able to be generated when the turbine, consisting of the blades and the generator, are lifted off of the ground. When wind causes the blades to begin to move, they spin a shaft that leads into the generator. In the generator, there is a magnet surrounded by a coil of wire. When the magnet is rotated within the coil of wire, it causes electrons to move inside of the metal, and moving electrons are electricity. As the wind blows faster, more electrons will move in the surrounding wire coil, causing more electricity to be generated.

This is similar to the way a hand generator works. Give each group a hand generator to look at and to see how it can generate enough electricity to make the light bulb glow.
A hand crank has three critical components: A coil of wire, several magnets, and a way to make one of those two things spin, typically the wire. When the coil of wire is rotated inside of the magnets, the magnetic field from the magnets causes the electrons in the wire to move, which becomes electricity.



This flow of electrons may be thought of as similar to a waterfall and has two values that are easily measured. One measurement is like the height of the waterfall, which is a fixed value. In electrical units, this is the electric potential, measured in volts. The other measurement is like the amount of water that falls down the waterfall, and allows us to actually do work with the water. In electrical units, this is called the current, measured in amperes (or simply amps). Thousandths of an ampere are called milliamperes, or mA.

II. Investigation of Wind Energy

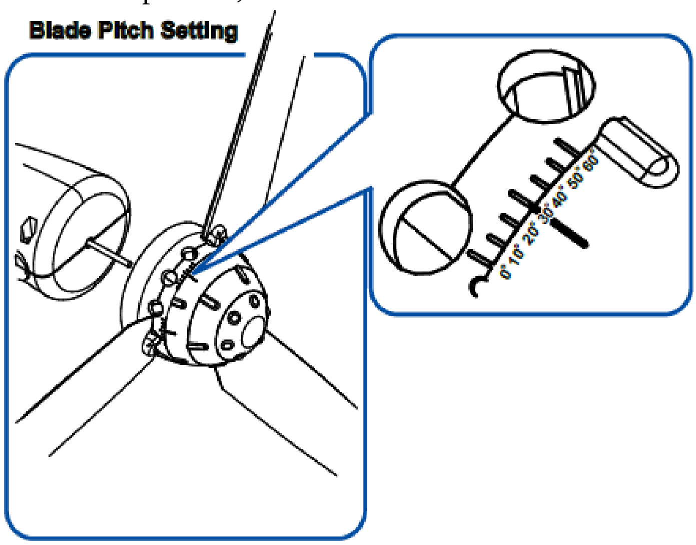
Materials

6 assembled windmills
6 sets of windmill blades (3 blades each of 2 types, in addition to the ones already installed in the windmill)
6 loosening tools
6 large fans
6 load measurement boxes
6 sets of patch cables (1 red and 1 black)
6 student handouts

Give each group all materials

A. Determining the ideal blade shape at low wind speed

1. Have the student place the windmill as assembled on a table. Place the fan on the table about 2 feet away.
2. Look closely at the blade holder assembly. There is a series of small notches along the side at several intervals around the fan assembly. These allow the pitch, or how much of an angle the windmill blades are at, of the windmill to be adjusted. The pitch of the windmill should be set to 30 percent, as shown.



3. Students should locate the trailing wires from the base of the windmill and attach the ends of the alligator clips to them. The red clip should be attached to the red wire and the black clip should be attached to the black wire.
4. The other end of the alligator slips should be attached to the ends of the patch cables. Once again, the red clip should attach to the red cable and the black clip should attach to the black cable
5. Attach the other ends of the patch cables into the load measurement box CURRENT terminals – red to red and black to black.
6. Turn the selectable LOAD knob on the box to SHORT CIRCUIT. This will ensure that no added resistance is added to the circuit, and that an accurate measure of the current is made.
7. Turn the box on, and ensure that a number appears in the "A" window. If nothing

appears, check the connections to be sure they are tightly made. If a negative number appears, then you have the connections reversed and should change them.

8. Turn on the fan to its lowest speed, and wait for the fan to reach a steady speed.
9. Record the current displayed in the provided table.
10. Turn the fan to its medium speed, and wait for the fan to reach a steady speed.
11. Record the current displayed in the provided table
12. Turn the fan to its highest speed, and wait for the fan to reach a steady speed.
13. Record the current displayed in the provided table.

B. Determine the ideal wind speed for a moderately curved windmill blade

1. Repeat steps 8 through 22 of section A for the second blade shape

C. Determine the ideal wind speed for a highly curved windmill blade

1. Repeat steps 8 through 22 of section A for the final blade shape

III. Discussion

Ask students some or all of the following questions:

1. What is an ampere? What is a milliampere?
   An ampere is a measurement of electrical current. A milliampere is one one-thousandth of an ampere.
2. Is the milliampere a useful measure to see at which angle the wind mill works best?
   The milliampere is a useful measurement of the best working angle of the solar panel as it is a small measure suited to the solar cell array and it is sensitive enough to allow us to see how the angle of incidence of the light source affects the current flowing from the solar panel.
3. What is the energy transfer taking place in a windmill?
   Kinetic energy is being transferred to electricity.
4. Looking at your data, which blade type would be best to use at a high wind speed? Which one at a low wind speed?
   ______________*need to fill in from data*
   ____
   ____
5. Why are windmills built to have the blade assembly high above the ground?
   Windmills are built to have the blade assembly high above the ground because air currents move more freely without buildings and other surface features to disrupt it, and as such moves faster. This allows for more energy to be produced.
6. What advantages does a windmill have as a source of energy?
   The energy produced is better for the environment than means of producing energy utilizing coal or natural gas. As well, it is possible to provide energy in to remote locations where it would not otherwise be possible.
7. What disadvantages does a windmill have as an energy source? What can be done to overcome them?
   The wind does not always move at a fast enough speed to provide efficient energy generation. It is not possible to always rely on it as a sole source of energy. However, if combined with a second form of energy it can be quite helpful. Solar energy in particular is well suited to pair with wind energy as the weather conditions which cause high energy

production from a windmill are generally opposite to those which cause high energy production from a solar panel. This means that the two can coordinate into good energy production more or less consistently.

8. What are other factors that could be changed which might improve the performance of a windmill?
   The number of blades could be changed, as well as the pitch of the blades. Other blade shapes could also be tried.