



Harnessing Wind Power: Converting Mechanical Energy into Electricity

Overview

This lesson teaches students the basics of wind power and how it is generated. They are able to make their own wind blades, test them, and use the engineering process with specific design variables to improve their blade design. This activity would be appropriate to include in a unit on alternative energy, or in a unit on electromagnetism. This lesson could be in one block schedule class or two 50 minute periods. This activity is appropriate for 6th grade through high school.

Objectives

Students should be able to:

- Understand the concept of converting mechanical energy to electrical energy using generators.
- Define an electromagnetic generator
- Explain windmill blade variables that affect efficiency of power output
- (Optional) understand the difference between dependent and independent variables.

Oregon State Science Standards 2009

Interaction and Change

8.2P.2 Explain how energy is transferred, transformed, and conserved.

Engineering Design

7.4D.2 Design, construct, and test a possible solution using appropriate tools and materials. Evaluate the proposed solutions to identify how design constraints are addressed.

8.4D.1 Define a problem that addresses a need, and using relevant science principles investigate possible solutions given specified criteria, constraints, priorities, and trade-offs.

Student Pre-requisite Knowledge

Students must know the basic structure of an atom. Students should also understand electricity as the motion of electrons from one atom to the next. Multiplication of decimals is required.

Materials

- 3 sets of windmill stands (in pieces)
- 20 windmill hubs
- 3 motors
- 3 multi-meters
- 3 sets of alligator clips
- Bag of wooden dowels
- Blade Materials: There are many options for blade materials. We suggest using cardstock or collecting cereal boxes.

Teacher Preparation

If you have a lab space you may want to separate the parts for each windmill stand and space them out at the stations. You can either build the frames yourself or select a few students to put them together based upon the photo provided, or the video. Each station should include the windmill frame PVC parts, a motor threaded through the frame, alligator clips and a multi-meter. Each group of 2-3 students should have a hub, 8-12 dowels, a piece of large paper board, a ruler and a protractor. You should also be familiar with the power point presentation. Faraday's law will help you briefly describe how a current is induced in the electric coil of the generators. Here is the link for the You Tube video showing the wind turbine assembly <http://www.youtube.com/watch?v=OiRxYdOGTlo>

Procedure

1. **Anticipatory Activity-** It is nice to start this lesson with a demonstration using a motor and wand magnets. If you remove the casing and magnets of a small electromagnetic motor and attach the motor to a battery, the rotor fails to spin. Have a student assist you by slowly bringing two wand magnets on either side of the dissected motor. It will begin to spin when the magnets are brought close. Lead a brief discussion about the relationship of the magnetic poles on the coil of wire. If we took apart the generator in the frame of the windmills it would look similar. The main difference is that instead of using electricity from a battery to turn the motor we are spinning the rotor to generate electricity.

2. Introduce students to the activity with the power point presentation titled "Wind Power Point Presentation." You can find this presentation on the COSEY web site. There are notes provided on the Power Point to help identify the import of slides. Most of the verbal instruction is done using the power point. The key parts of electricity generation and the vital relationship between electricity and magnetism is explained during this presentation. This serves as an introduction to Faraday's law of induction.

3. After the presentation hand out the activity work sheets that describe the wind power challenge. You should take a moment to read through the worksheet with the students, answer any questions, etc. Define power using the following formula: power (watts) = current (amps) x voltage (volts). Students should be placed in groups of 2-3. Each group will make two sets of blades for the hub. Creating two

sets of blades allows the groups to isolate a variable. For example one set could be long, and one set short, but with the same width, pitch etc.

Blades can be designed using several design variables: length, shape, number of blades (3, 4 or 6 are recommended), weight, pitch or angle, and twist. Once students have a design, the blades can be cut out of cardboard and taped to the wooden dowels using duct tape. The wooden dowels are then inserted in the hub at regular intervals and the hub is attached to the generator located in the windmill frame.

4. When each group is finished, students can test their blades at one of the box fans. They should collect data on both the current, as well as the voltage. Both the current in mA and the voltage in mV can be measured using the provided multi-meters. A data table is located on the document titled "Blade Experiment Sheet". After testing, students can refine their blade design to increase current output and try again. As they redesign, encourage them to collect data as they change one design variable at a time.

Once an optimal blade design has been constructed, each group can compare current generated among the subgroups and discuss design characteristics. Optional- Award prizes to the highest amperage, highest voltage and most innovative design.

5. Closure- Ask the students to return to their desks. Review the calculation for power. Give the students time to finish their worksheets. Lead a discussion about isolating a variable. Ask the students if they were blade design engineers what would be their design recommendations?

6. Clean up- Make sure the students return all of their parts to the appropriate bins. This means breaking up the windmill frame, returning the black hubs, generators etc. Students may take their blades and attached dowels with them.

Extensions

The Kidwind.org web site contains a lot of free curriculum on this activity. One extension that we like is their lesson on calculating the swept area of the turbine. You can find their PDF at the following address: http://learn.kidwind.org/sites/default/files/swept_area_0.pdf.

Adaptations

Students can use many different materials to make their blades. For example many similar lesson plans use balsa wood, paper plates or thick plastic. Just remember that using sharp objects is dangerous in the case that one of the blades comes loose during testing. Students should wear safety goggles if this could be a possibility. This activity can be lengthened by incorporating materials as a variable, as well as incorporating aesthetic designs into the competition.

Credits

This activity was first used at OSU as described on the wonderful **Kidwind.org** web site. We use their supplies and support their company. We encourage you to check out their web site as well.