PBS: Wind Power for Educators

Grades: 5-8, 9-12

Topic: Wind Energy

Owner: PBS

This educational material is brought to you by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

For Educators:

Wind Power

More on This Lesson: Select One

Lesson Plan

This lesson is designed for physical science, earth science, or environmental science classrooms, grades 9-12. Middle school science teachers may also find this lesson helpful.

Lesson Objectives

By the end of this lesson, students will be able to:

1. Explain the use of wind power as a renewable resource.
2. Build models of wind turbines and experiment with the types of changes that will increase efficiency.

Related National Standards

Physical Sciences

Standard 9: Understands the sources and properties of energy

Standard 10: Understands forces and motion

Level IV, Benchmark 1
Knows that magnetic forces are very closely related to electric forces and can be thought of as different aspects of a single electromagnetic force (moving electric charges produce magnetic forces and moving magnets produce electric forces); the interplay of these forces is the basis for electric motors, generators, radio, television, and many other modern technologies

Level IV, Benchmark 8
Knows that laws of motion can be used to determine the effects of forces on the motion of objects (e.g., objects change their motion only when a net force is applied; whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object; the magnitude of the change in motion can be calculated using the relationship F=ma, which is independent of the nature of the force)

Nature of Science

Standard 12: Understands the nature of scientific inquiry

Level IV, Benchmark 2
Designs and conducts scientific investigations (e.g., formulates testable hypotheses; identifies and clarifies the method, controls, and variables; organizes, displays, and analyzes data; revises methods and explanations; presents results; receives critical response from others)

Level IV, Benchmark 5
Knows that conceptual principles and knowledge guide scientific inquiries; historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists

Standard 13: Understands the scientific enterprise

Level IV, Benchmark 6 Knows that creativity, imagination, and a good knowledge base are all required in the work of science and engineering

Estimated Time to Complete Lesson

One to three 90-minute block periods, depending upon which parts of the lesson you do in class and which are done at home

Materials Needed

Part One

- Handout: Wind Power Background Sheet (PDF file)
- Internet access, or copies of relevant pages
- Copy of the wind power story from the 12/13/02 NOW WITH BILL MOYERS broadcast and TV/VCR (Note: A free transcript of this segment is available on the NOW Web site. Teachers may also tape the broadcast off-air and use it in the classroom for one year. Alternatively, programs are available for purchase from ShopPBS (http://shop.pbs.org).)

Parts Two and Three

- Handout: Wind Machine Instructions (PDF file)
- Wind Turbine Construction Materials

Each classroom will need:

- small electric fan or hair dryer
- DC voltmeter

Each student group will need:

- small DC toy motor
- cork (at least 2 cm in diameter)
- stiff ruler or dowel
- 60 cm of thin electrical wire with alligator clips
- a rubber band

- scotch tape
- 6 paper clips
- wire cutters
- scissors
- pieces of cardboard of various thicknesses

Backgrounder for Teachers

Wind is caused by atmospheric pressure changes that occur because the sun heats air in some areas more than others. For more information on how wind forms, including some helpful graphics illustrating how air pressure differences start the wind blowing, see USA TODAY's Weather Basics section on Understanding Winds.

The power of wind energy can be harnessed to generate electricity. To make electricity, the shaft of a wind turbine is connected to an electrical generator at the top of the turbine's pole or tower. The generator converts the mechanical energy of the spinning turbine shaft to electricity and sends that energy down the tower along wires to a power grid or energy storage area. See the NOW Web site's close-up of a wind turbine for additional detail on how they work. The Related Resources section of this lesson plan also lists Web sites rich with information on wind turbines and wind energy in general.

This lesson plan outlines an inquiry-based activity that helps students discover the basics of wind power technology by building and refining a wind turbine. In addition, students examine the concept of renewable energy, identify the benefits and drawbacks of wind power, and compare its costs and impact on the environment with other energy sources.

Assumed Student Prior Knowledge

It is assumed that students will already be familiar with what causes wind and the basics of motion and mechanics. Students should also know how to calculate an average.

Teaching Strategy

Part One: What Is Wind Power and How Can It Be Used?

1. Have the students brainstorm a list of ways we can generate electricity. List student ideas where the class can see them. Then, ask students to examine the list and decide:

- Which way do they think most of the power is generated in their area?
- Which ways do they think are the most damaging to the environment?
- Which ways might be the least damaging?
- Which ways could be considered renewable, or inexhaustible?
- Which ways cost the most money? (See NOW's energy source cost comparison chart for helpful data.)

2. Explain to students that they will be exploring one renewable energy source - wind power -- in greater depth. To help students discover the basics of wind-generated power, send them to the computer and have them research the information needed to complete the Wind Power Background Sheet provided with this lesson. The Web sites they need for their research are listed on the worksheet itself. After completing the handout, follow up with a class discussion to clarify any questions students might have. Be sure they understand the concept of renewable vs. non-renewable resources as well as the actual construction of a wind turbine. It is also important that they understand the wind power will not work in all areas of the country. (See NOW's Wind Power Map of the U.S. showing where wind power is the most and least available.)

3. Next, show the approximately 8-minute long in-depth NOW with BILL MOYERS story on wind power. To focus student viewing, ask students to watch for answers to the following questions:

- What are the benefits of wind power as a resource?
- What drawbacks do you see?
- In what ways can power production be compared to a crop?
- If you were a farmer, would you be interested in making money from the wind?

4. After watching the video, discuss the answers to the questions above. The NOW Web site's summary of benefits and drawbacks to wind power, as well as the story's transcript, provide

information to support this discussion.

Part Two: Building a Wind Turbine

1. Explain to students that they will work together to build a simple wind-powered turbine. Let them know that groups that design the most effective wind turbines will receive a prize.

2. Divide students into groups of three or four. Try to make each group as homogenous as possible, pairing strong students with weaker ones.

3. Distribute the Wind Machine Instructions handout to students. For more ideas, you may also wish to provide students with some of the Web sites listed in the Related Resources section of this lesson plan. Be sure each group also has the basic materials needed to construct their wind turbines. Remind students that they are limited to the use of those materials.

4. Once groups complete the initial construction of their turbines, they should experiment with variables to produce what they expect to be the best turbine. Variables can include changing length and width of blades, using different weights of cardboard for the blades, using different angles for the blades, even changing the number of blades used.

5. Allow about 90 minutes for the construction of this device. You will need to vary the time based on the abilities of your students. Students should be allowed to do preliminary testing as they design. If time is limited, assign the construction for outside of class and allow for preliminary testing at the beginning of the next class.

Part Three: Testing the Designs

1. Determine which group has constructed the most effective wind turbine by testing each machine and noting which one produces the greatest number of volts. During the testing, students should use goggles.

2. To test, set each turbine 30 cm from an artificial wind source, such as a fan or hair dryer. Turn on the wind source and measure the voltage produced. Each turbine should have three trials so that an average voltage can be calculated.

3. You can also measure which turbine requires the least amount of wind for start up by testing the turbines at various distances from the wind source.

4. Award prizes to winners for both competitions.

Assessment Recommendations

Students should be asked to write a one or two page report on the process of building and refining their wind turbines, including their subsequent conclusions. Evaluation of the report should be based on completeness, depth of understanding, and correct use of terminology. Consider awarding bonus points to those students with prize-winning designs.

Extension Ideas

1. Be sure to review NOW's Starter Activities and Take Action ideas related to this lesson's topic.

2. Students may wish to extend this lesson by producing other models of wind turbines, possibly for a science fair. A Savonius, or vertical, wind turbine can be built with plastic water bottles by following the detailed instructions at the Renewable Energy Web site. You can also download free plans for building wind turbines at the PicoTurbine Web site.

3. For elementary students, the turbines can be built in advance with the exception of the blades. Students can then vary the shape and weight of blades more easily and with a minimum of difficulty. Such a project would be a good opportunity to have older and younger students working together.

4. Students can research the applications of wind power technology in various countries around the world. Such research could be an excellent way to include ESOL students and their culture in the classroom. (NOTE: NOW's Web site provides a graphic showing and comparing the use of wind power in the U.S. and Europe.)

Related Resources

Below are some sites that provide useful information related to this lesson's topic.

The American Wind Energy Association
This Web site has a well-written section of FAQ's as well as references to more technical applications of wind energy.

Energy Quest: Energy Education from the California Energy Commission
This site is provides activities and information targeted to younger students, but has extensive references for teachers as well. The site addresses all the forms of energy and compares them in depth.

Investigating Wind Energy
This site is an elementary level unit from the Franklin Institute in Philadelphia on investigating wind energy. It includes many cross-curricular activities as well.

Lecture Notes: Physics 162
The University of Oregon has posted a page of college notes from a Physics 162 lecture on, "Wind Energy." It outlines the basics/properties of winds, windmills and its efficiency, energy calculations, costs of wind energy and goals for wind power.

The National Renewable Energy Laboratory
This site for the U.S. Department of Energy's lab for renewable energy research and development includes many links to other sites and activities. This lesson's directions for building wind turbines were adapted from this site.

Re-Energy
This site is provided by the Pembina Institute in Canada, which describes itself as a non-profit think tank and activist organization. It features backgrounders on renewable energy and technology, as well as detailed construction plans for renewable energy models, including a complex wind turbine model suitable for high school science projects.

Wind Power
This April 5, 2001 segment from THE NEWSHOUR WITH JIM LEHRER discusses business and legislative aspects of the wind power industry.

WindPower.org
The Danish Wind Energy Association has produced an excellent site listing information, activities, and a FAQ. It has a special section entitled, "Wind with Miller" that focuses on explanations and activities for students.

About the Author

Claudia Fetters is a 21-year veteran of science education, having taught biology, earth science and astronomy during her career. She currently teaches at Westfield High School in Chantilly, Virginia. She also works with a group at Purdue University to develop instructional CD's on biology topics.

12.13.02

Science and Health:

Wind Power Now

More on This Story: Select One

Wind Power Primer

According to the International Energy Agency, as of the year 2001, renewable energy sources (water, solar, geothermal, combustible and waste renewables, and wind) comprised 13.8 percent of the world's primary energy supply and 19 percent of all electricity production. Of that 13.8 percent, wind power accounted for only .0026 percent.

That doesn't seem like much, but wind power is one of the fastest-growing sources of energy in both the United States and abroad. While the use of renewable energy sources as a whole has annually by 2 percent since 1971, wind-power generation has increased at an average of 52.1 percent every year between 1971 and 2000.

The American Wind Energy Association estimates that an additional 6,500 megawatts of wind-energy generating capacity were added worldwide in 2001, accounting for about $7 billion in electricity sales. The U.S. alone added 1,700 megawatts worth of generating equipment.

Talk Back Now

"I don't think any American wants to use an inefficient energy source. The problem is that there are no effective alternatives to fossil fuels." "Talk back on the boards.

Wind Power Plus and Minus

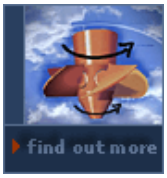
Advantages

- Wind energy is free.
- It is a renewable energy resource.
- There are no dangerous emissions.
- Wind power can be used in remote areas.
- Wind power can be used in conjunction with other renewable energy resources such as solar energy.

Disadvantages

- Wind turbines are site dependent i.e. they need to be built in areas where there is a reliable source of wind.
- Wind speed can fluctuate. The wind speed can be too fast or slow which means that electricity is not produced.
- Also the wind does not blow all the time.
- Wind farms can be a visual eyesore and may create excess noise.
- Wind turbines can be expensive to maintain.

- Energy storage devices, e.g. batteries, are sometimes necessary.



Wind Turbines

"People always ask, 'Well, how do you make electricity? Where does electricity come from?' They think it comes from the electric outlet. And it's really actually not very complicated. You just need to spin a turbine. Make a turbine turn. That's how electricity's made. So, you can turn a turbine with hydropower. And you can make that steam by burning coal, or burning natural gas, or — splitting atoms. But you can also turn a turbine by putting it up on a tower in a windy place. It's a pretty simply way to make electricity."-- Michael Noble, Minnesotans for an Energy Efficient Economy, ME3.

U.S. Wind Potential Map

The potential for wind power varies throughout the United States, from region to region. However, wind potential doesn't only exist in areas like the Great Plains. The U.S. government's National Wind Technology Center shows in this map that moderate- to high-wind potential is actually dispersed throughout the lower 48 states.

Wind power ranges from Class 1 to Class 7, with each class representing wind-power density or mean wind-speed. Areas designated Class 4 or greater are suitable for advanced wind-turbine technology under development today. Class 3 areas, while generally not used for production, may be suitable for wind-power technologies in the future.

Wind Power Now

Consumption of energy grew in the 1990s, with great disparities in usage between the developed and developing world. If global energy use continues at its present rate, consumption will be double the 1998 rate by 2035, and will triple it by 2055. Electricity's share of this total will increase to 38 percent. However, even with rapid growth in wind energy production rates, by 2020 electricity production from renewable energy sources other than hydropower is projected to provide only 2.3 percent of total electricity needs. The biggest producers of wind energy are Germany, the United States, Spain, Denmark and India.

E-mail this page to a friend

Sources: National Wind Technology Center; International Energy Agency, "Renewables in Global Energy Supply;" American Wind Energy Association "Fact Sheet," Global Wind Energy Market Report; United States Energy Information Administration; U.S. Department of Energy, Wind Energy Program; The World Energy Council, Survey of Energy Resources 2001; Sustainable Minnesota

More on estimated future world energy needs.

print this page

Related Stories:

Select One

About | Feedback | Pledge

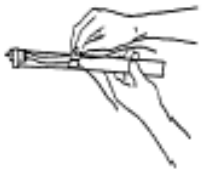
WIND MACHINE INSTRUCTIONS

This sheet tells you how to build your own wind machine for generating electricity.

First, get a small motor and a ruler or piece of wood from your teacher. Attach the motor to the end of the ruler by wrapping it with a rubber band.

Second, cut two 30-cm pieces of electrical connecting wire. With a pair of scissors, take off 2 cm of rubber insulation from both ends of the two wires. Do this by pinching softly with the scissors on the rubber casing, cutting it slightly; then pull the scissors towards the wire's end, pulling off the casing.

Next, attach one end of each wire to one of the motor's outlets. Tape the wires to the molding, at the end without the motor. Attach the other two ends of the wire to alligator clips. We will use these later to attach to the voltmeter.



Now you're ready to build the actual wind propellers.

Take six paper clips. Snip off part of each clip with pliers or wire cutters. Straighten out the bottom part of each clip.

Then cut out six pieces of cardboard 1 cm x 3 cm. Glue /or tape central part of each paper clip to the bottom of a cardboard piece. Leave time for glue to dry (20 min.). Here is where you can vary the size, shape, weight and alignment of the blades. You can change the number as well.

Take a cork and poke the wind blades into it. Insert the blades at about 5 mm from the end, spaced equally around the circumference of the cork. To loosen up a hole, you may want to stick a pin in beforehand.

Place the cork end furthest away from the wind blades on the motor's shaft. Make sure the shaft goes in the exact center of the cork and do not wiggle it (this will loosen its hold on the motor).

Connect to the voltmeter and test your design. Be sure to wear goggles to protect your eyes.

Source: Adapted from the booklet found at http://www.nrel.gov/docs/gen/fy01/30926.pdf


NOW
WITH BILL MOYERS

NOW
WITH BILL MOYERS

Wind Power Background Sheet

For questions 1 and 2, provide answers using information from the class discussion and your own previous knowledge.

1. Define and give examples of the following sources of energy.

Renewable:

Non-Renewable:

2. Why would the global community need to come up with alternatives to fossil fuels?

For questions 3-6, use the Web sites indicated to answer the questions.

3. Label the correct parts of the wind turbine below and describe its specific function. (Refer to the Wind Turbine Close-Up at http://www.pbs.org/now/… or the Crash Course in Wind Energy at http://www.windpower.org/en/kids/index.htm)

Tower:

Rotor:

Nacelle:

Transformer:

Foundation:

4. How do you calculate the amount of power available at a given wind speed? (See the resource at http://www.awea.org/faq/windpower.html)

5. Where would be a good place in the U.S. to build a wind turbine? Why? (For questions 5 and 6, see the Wind Power Map at http://www.pbs.org/now/… or the Wind Power Resource Atlas of the U.S. at http://rredc.nrel.gov/wind/pubs/atlas/chp2.html)

6. Where in the U.S. would you not want to build a wind turbine because of the lack of wind?