As the Rotor Turns: Wind Power & You (Lesson Plan)

(An Investigation of Wind Power as an Energy Resource in Pennsylvania)

Suggested Grade Level 6-8

Overview

Engineers of the future, step forth! Students will get acquainted with the basics of wind energy and power production by fabricating and testing various blade designs for table-top windmills constructed from one-inch PVC pipe and balsa wood (or recycled materials). The suggested time frame for this lesson is three to four (3-4) 50-minute class periods.

Standard Statements:

3.2.7 B Apply process knowledge to make and interpret observations.
3.2.7 D Know and use the technological design process to solve problems.
3.4.7 B Relate energy sources and transfers to heat and temperature.
3.5.7 B Recognize earth resources and how they affect everyday life.
3.6.7 C Explain physical technologies of structural design, analysis and engineering, personnel relations, financial affairs, structural production, marketing, research and design.
3.8.7 C Identify the pros and cons of applying technological and scientific solutions to address problems and the effect upon society.
4.2.7 A Know that raw materials come from natural resources.
4.2.7 B Examine the renewability of resources.

Content Objectives

Students will know that

1. Wind is an important form of energy because it is clean, safe and perpetually renewable.
2. Modern technology has improved blade design based on already successful technology of aircraft propellers and aircraft wings to increase the efficiency of wind turbines.
3. There are geographic, social and economic constraints affecting the placement and viability of wind farms.

Process Objectives

Students will be able to

1. Describe how wind is generated by the uneven solar heating of the earth.
2. Analyze the transformations of energy involved in electricity generation by wind machines.
3. Demonstrate how electricity is generated using a wind power generation device of their own construction and evaluation.
4. Discuss how the design of wind turbine components is related to the power it generates.

Assessment Strategies

1. Evidence of student understanding based on completion of written handout materials.
2. Participation in classroom and small group discussions.
3. Evaluation of student design and construction of table-top wind turbines.

Materials

Part 1:

- Teacher computer with internet connectivity
- Projection equipment
- Websites:
  - Wind Generation
    http://www.windpower.org/en/tour/wres/coriolis.htm
    http://www.pserie.psu.edu/academic/science/degrees/biology/energyfieldtrips/windIndex.htm
  - Beaufort Scale
    http://www.mountwashington.org/discovery/arcade/wind/beaufort.html
- Student Handouts
- Clipboards or writing surfaces for student groups

Parts 2 & 3:

- Pennsylvania map (paper or electronic: if electronic, you will need a teacher computer and projection equipment)

Per Group:

- Kidwind Basic PVC Wind Turbine Kit or comparable resources to build a table top wind machine (detailed list included on page 4 of the student handout)
- Multimeter
- Desktop-sized fan
- Blade materials (variable-student determined)
- Student Handouts

Multimedia Resources

Video Sequences:

1. Sequence 1: Wind Turbine Specifications & Construction
    1. Foundation [0:45]
    2. Building the Road [0:30]
    3. Bringing in Parts [0:43]
    4. Specs and Process [1:10]
    5. Blade onto Tower [0:54]
    6. Environmental Concerns [1:23]

2. Sequence 2: Capacity Factor
    1. Topography [0:48]
    2. Turbine Production [1:01]
    3. Turbine Type and Specs [0:33]
    4. Power Grid [0:49]

Additional Resources

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

- The American Wind Energy Association
  http://www.awea.org/
  This Web site has a well-written section of FAQ's as well as references to more technical applications of wind energy.
- Investigating Wind Energy
  http://sln.fi.edu/tfi/units/energy/windguide.html
  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.
- The National Renewable Energy Laboratory
  http://www.nrel.gov/
  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
  http://www.re-energy.ca
  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
  http://www.pbs.org/newshour/bb/environment/jan-june01/blowing.html
  This April 5, 2001 segment from THE NEWSHOUR WITH JIM LEHRER discusses business and legislative aspects of the wind power industry.
- WindPower.org
  http://www.windpower.org/composite-8.htm
  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.

Renewable Energy Glossary:

- http://www.horizonwind.com/forteacherskidsconsumers.asp?id=8

Procedures

Part 1: Filling Our Sails: Where Does Wind Come From? (1, 50 min Class Period, Hmwk)

1. Before students begin construction of their table-top wind turbines, allow them to go outdoors and make and record some observations in pairs about the current on page 1 of the student handout.
2. Return students to the classroom to elicit their ideas about how wind is generated.
3. After hearing a few student responses to the question, "How is wind created?" discuss the formation of wind currents with students using a simulation from The Danish Wind Energy site under the "Wind" tab: http://www.windpower.org/en/tour/wres/coriolis.htm or at Penn State Erie's "Renewable Energy Field Trips": http://www.pserie.psu.edu/academic/science/degrees/biology/energyfieldtrips/windIndex.htm.
4. Allow students to work in small groups to recapitulate their explanation of what is happening in the simulation of wind currents forming and prompt them to make additional notes from their group discussion on page 1 of the student handout or in any lab journals used in your classroom.
5. Reconvene to wrap-up the class period by sharing and clarifying observations.
6. Assign reading of "Power in the Wind…A Simple Look" [page 2 in the student handout] for homework.

Part 2: The Power Equation and Wind as an Energy Resource (30 minutes)

1. Review the power equation included in the reading and explain that engineers designing and developing wind turbines face the same challenges that they will in upcoming class periods as they construct a table-top wind turbine.
2. Show students a Pennsylvania map and allow them to assist you in finding the Bear Creek site near Wilkes-Barre, PA.
3. Share the first video sequence (Wind Turbine Specifications and Construction) of the Bear Creek Wind Farm tour with the class (approx. 6 minutes, in 6 segments).
4. Gather students' thoughts on the video and make a list or concept map of student ideas about wind as a renewable resource for producing electricity on the board. Concerns to include may be environmental, political, and economic.
5. If time allows, break students into groups for wind turbine construction that begins in Part 3.

Part 3: The *Construction & Evaluation of a Wind Turbine (2-3, 50 min Class Periods)*

1. Put students up to the task of building their own table-top wind turbine by working through Part 3 of the student handout (begins on page 3). This section is materials-intensive and it may be useful to invite students to gather and bring in materials in advance if you are not ordering wind turbine building kits for the lesson.
2. Before students move on to Steps 4-6 of Part 3, share Bear Creek video sequence 2 (Capacity Factor) to think about wind turbine design and the factors that affect power production (approximately 4 minutes, 4 segments).

3. Set students free to work through Steps 4 and 5 to get blades on their wind turbines and do some initial testing.
4. Once all student groups have had an opportunity to make certain that their blades are secure and that their turbine is worthy of producing power, demonstrate the procedure for measuring the power output of a turbine for the class.
5. Allow teams to proceed through Step 6 of the student handout to calculate the amount of power their individual turbines are producing.
6. Share out teams' results and discuss students' beliefs about how the power output for the wind turbines could be improved.
7. Allow student teams to decide whether they would like to explore wind speed or blade design and assist them in designing experiments (Step 7) to collect data about their claims. (If you would prefer to have students work through a more structured experiment with their turbines, please see www.kidwind.org's curricular materials section for lessons entitled, "Wind Power Curves" and "Wind Blade Design.")

Beaufort Scale

Beaufort number	Wind Speed (mph)	Seaman's term		Effects on Land
0	Under 1	Calm		Calm; smoke rises vertically.
1	1-3	Light Air		Smoke drift indicates wind direction; vanes do not move.
2	4-7	Light Breeze		Wind felt on face; leaves rustle; vanes begin to move.
3	8-12	Gentle Breeze		Leaves, small twigs in constant motion; light flags extended.
4	13-18	Moderate Breeze		Dust, leaves and loose paper raised up; small branches move.
5	19-24	Fresh Breeze		Small trees begin to sway.
6	25-31	Strong Breeze		Large branches of trees in motion; whistling heard in wires.
7	32-38	Moderate Gale		Whole trees in motion; resistance felt in walking against the wind.
8	39-46	Fresh Gale		Twigs and small branches broken off trees.
9	47-54	Strong Gale		Slight structural damage occurs; slate blown from roofs.
10	55-63	Whole Gale		Seldom experienced on land; trees broken; structural damage occurs.
11	64-72	Storm		Very rarely experienced on land; usually with widespread damage.
12	73 or higher	Hurricane Force		Violence and destruction.

Source: http://www.mountwashington.org/discovery/arcade/wind/beaufort.html