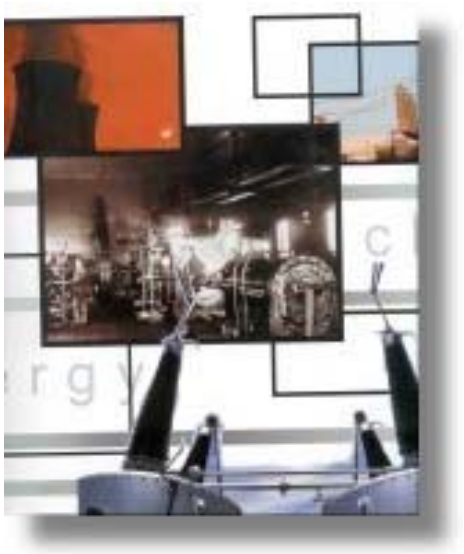
ACHIEVEMENT #3:

Power Generation

Teacher's Guide

Introduction



For centuries people had been aware of the phenomenon of electricity. But they didn't understand it well enough to put it to any use. Once they did, they began inventing motors, generators, telephones, appliances, and so on. The engineer's role was learning to unlock the power of natural resources hidden throughout the planet. They figured out how to design the machinery to extract or collect it, the processes to convert it to fuel, and the systems to transmit this power into our homes, schools and factories.

By the end of the century, electricity has become so important to our life style, we cannot imagine life without it. Engineers found the clues that made it possible. Finding energy sources, developing economical ways to make them useful and environmentally safe are challenges that will always be part of the future, because modern society cannot exist without electricity. Maybe you'll be one of the engineers who will continue to revolutionize the world's energy supply.

Lesson Focus: Reducing Energy Costs and Environmental Impacts

Lesson Synopsis: Students brainstorm a list of the ways they use electricity in their home, explore how to reduce home energy costs using the Energy Saver Website, consider the environmental impacts of power generation, and evaluate the potential effectiveness of roof overhang in reducing home cooling costs.

Related National Science Education Standards:

Content Standard B (Physical Science):

As a result of their activities in grades 5-8, all students should develop an understanding of Transfer of Energy. Fundamental concepts and principles that underlie this standard include:

- Energy is… associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical.
- Energy is transferred in many ways.
- Electrical circuits provide a means of transferring electrical energy when heat, light, sound, and chemical changes are produced.

As a result of activities in grades 5-8, all students should develop Understandings About Science and Technology.

Fundamental concepts and principles that underlie this standard include:

- Scientists propose explanations for questions about the natural world, and Engineers propose solutions relating to human problems, needs, and aspirations.
- Technological solutions … have side effects … and carry risks…

Related Benchmarks from Benchmarks for Science Literacy:

Section 8C (Energy Sources and Use):

By the end of 8th grade, students should know that:

- Energy can change from one form to another, although in the process some energy is always converted to heat. Some systems transform energy with less loss of heat than others.
- Different ways of obtaining, transforming, and distributing energy have different environmental consequences.
- Electrical energy can be produced from a variety of energy sources and can be transformed into almost any other form of energy. Moreover, electricity is used to distribute energy quickly and conveniently to distant locations.

Related Standards for Technological Literacy:

Standard 5 (Effects of Technology on the Environment):

In order to discern the effects of technology of the environment, students in grades 6-8 should learn that:

- Decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another.

Standard 16 (Energy and Power Technologies):

In order to select, use, and understand energy and power technologies, students in grades 6-8 should learn that:

- Much of the energy used in our environment is not used efficiently.

Glossary:

energy efficiency Using advanced and state-of-the-art technologies to provide better quality energy services with less energy, getting the most productivity from every unit of energy, getting the desired energy services - comfortable homes, profitable businesses, convenient transportation - with less energy use, less air pollution, and lower total cost.
Using energy wisely and eliminating energy waste.

upgrade An improvement in performance resulting from an addition or change.

retrofit To add new features such as new/better pollution controls to an existing device, manufacturing plant, or power plant.

Important Concepts:

- By increasing energy efficiency, it is possible to maintain the same standard of living while decreasing cost and pollution.
- Current power generation technologies have environmental impacts.

Materials for Each Inquiry Team:

Materials for Each Engineering Team:

Shoebox
Black construction paper
Thermometer
Lamp (optional)
Poster board
Scissors
Ruler

Procedure:

Engagement: Pass out page 1 of the student handouts and the Timeline and have students brainstorm a list of all the ways electricity is used in their homes.

Exploration:

1. Either have students take the Survey home and complete it for their own homes, or decide as a class on a "typical" home to investigate.
2. Have students use the Energy Saver Website to explore the factors contributing to energy costs in your area and ways to reduce these costs. (If online access is not available during class, information could be downloaded and photocopied ahead of time.)

Explanation: Have students examine the suggested home upgrades and rank them according to their cost, ease of change, etc.

Extension (Engineering Challenge): Have students do the activity "Using Roof Overhang to Reduce Home Cooling Costs."

Evaluation: Have students reexamine the Survey form and explain why each item makes a difference in home energy costs.

Ideas for Further Exploration:

Have students use the data shown on factors contributing to energy costs to create pie charts.

References:

- **The Energy Sourcebook (High School Unit)**, published in 1990 by TVA (out of print). (The activity **Using Roof Overhang to Reduce Home Cooling Costs** is taken from the activity Energy Efficient Structures.)

- **Middle School Lessons from the Alliance to Save Energy** are downloadable at: http://www.ase.org/educators/lessons/download.htm The Alliance to Save Energy is a nonprofit coalition of prominent business, government, environmental, and consumer leaders who promote the efficient and clean use of energy worldwide to benefit the environment, the economy, and national security. Founded and co-chaired in 1977 by Senators Charles H. Percy (R-IL) and Hubert H. Humphrey (D-MN).

- **The Home Energy Saver Website**, sponsored by the Department of Energy and the EPA, online at http://HomeEnergySaver.lbl.gov/

- **Consumer Energy Information, online at:** http://www.eren.doe.gov/consumerinfo/ Sponsored by the Department of Energy's Energy Efficiency and Renewable Energy Network. Provides links to fact sheets, a glossary, and information related to home, business, school, and transportation energy issues. The "Ask an Energy Expert" feature allows students to send in a question and receive a response by email in 2-3 weeks.

ACHIEVEMENT #3:

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Student Handout

The History of Electricity

Amber is fossilized tree sap, in which one occasionally finds embedded insects. When ancient people attempted to polish pieces of amber, for use as amulets or adornments, they would have discovered that rubbing the amber caused it to attract bits of fur and feathers, a phenomenon we now call static electricity. In fact, our word **electricity** comes from the word **elektron**, the Greek word for amber. By the early 1700's, "friction machines", which generated static electricity as you turned a handle to rapidly rub the surface of a polished sphere, were a common entertainment among wealthy people.

Ben Franklin's famous 1752 kite experiment was the result of his fascination with static electricity and with the Leyden jar, a device invented in Leyden, Holland, and that allowed storing up of electricity generated with a friction machine. The study of electricity continued for the next 100 years, but, as you can see by examining the Timeline for this lesson, it was Thomas Edison's work on the light bulb that created a need for power stations.

How Many Ways to Do Use Electricity?

Make a list of all the uses of electricity in **your** home. (It may help if you imagine walking from room to room, taking note of what items you plug into the various outlets.) Don't forget those uses that do not require you to plug something in, such as electric stoves, water heaters, central heating, and dishwashers. You may want to survey older relatives to determine how many of the items on your list were things they had when they were your age.

Ways to Save on Home Energy Costs

It is estimated that the use of electric appliances accounts for about 10% of the average person's electric bill. In Texas and other Southern states, 25-40% of annual home energy costs are spent on air conditioning.

To find out how various energy uses affect the average energy bill for homes in your area, go to the Home Energy Saver website at: **http://HomeEnergySaver.lbl.gov/.** Type in your zip code and then click on Go! (To customize the information for your own home, you will need to first complete the **Survey** sheet.)

Using the results for an average home in your zip code, your own home, or a set of values provided by your teacher, examine the list of Suggested Upgrades. Click on an upgrade to get more information. Attempt to rank the suggestions in terms of which would be the easiest or cheapest.

Environmental Impacts of Power Generation

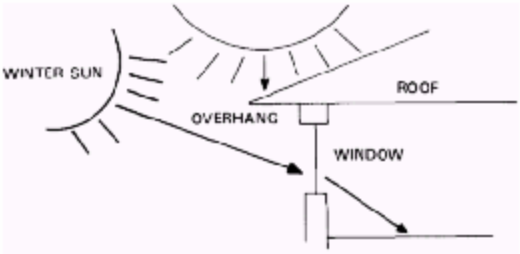
Electric power plants are the country's largest industrial source of the pollutants that cause acid rain (NO_x and SO_2), smog (NO_x), mercury poisoning in lakes and rivers, and global warming (CO_2). According to a 1998 report, U.S. electric generators are responsible for 28% of NO_x, 67% of SO_2, 36% of CO_2, and 33% of mercury emitted annually nationwide.

Pre-1980, coal-fired power units, which continue to rely on 20-40 year old emissions control and other technology, account for only 52% of national electricity generation but for over 80% of pollutant emissions from the utility industry. This is the case because older plants are less efficient than modern generating facilities and because most of these plants are exempted from the emissions limitations that apply to newer plants utilizing cleaner technologies and fuels.

Because power plants often have very tall smoke stacks, the pollution they release may be carried many miles from the plant. More than half of the acid deposition in eastern Canada originates from emissions in the United States.

As you can see, reducing home energy use not only saves money, but also can reduce pollution.

Engineering Challenge: Using Roof Overhang to Reduce Home Cooling Costs



Using the sun's heat in the winter and avoiding it in the summer can help reduce heating and cooling costs. A roof overhang can help shade windows in the summer.

Materials for Each Engineering Team:

Shoebox
Black construction paper
Thermometer
Lamp (optional)
Poster board
Scissors
Ruler

Student Handout (continued)

1. Cut a hole in one side of a cardboard box. This will be a window. Make sure the window is placed closer to the top of the box than it is to the bottom.

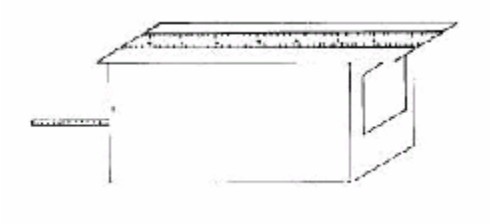
2. Paint all the inside surfaces of the box flat black or cover them with black construction paper.

3. Cut a piece of white poster board for the roof, long enough to make sure the roof covers the entire box and extends over the edge to completely shade the window.

4. Use plastic wrap to cover and seal the hole in the side of the box. Tape the plastic around the edges.

5. Make a small hole toward the back of the box. The hole should be large enough to insert the thermometer. Make sure the bulb of the thermometer is measuring the air temperature in the box. It should not be in direct sunlight.

6. Tape a ruler to the "roof" piece. This will allow you to easily measure the amount of roof overhang. Your model should look like this:



7. Set this model "house" up outside in direct sunlight around midday. The window should be facing south. Alternatively, use a lamp (shade removed) with a 100-W bulb.

8. Place the roof so that the window is completely shaded. Wait about 5 minutes (until the temperature has stabilized) and record the temperature in the box. Also record the air temperature outside the box.

9. Move the roof a few centimeters at a time so that the window is only half shaded and record the temperature after it stabilizes. Be sure to measure and record the outside air temperature, too.

10. Move the roof and measure the temperature of the box when its window is in full sun. Be sure to measure and record the outside air temperature, too.

11. Based on your data, would you recommend that roof overhang completely shade south-facing windows in the summer, or only partially shade them? Explain your reasoning.

Survey for Estimating Home Energy Costs

In what year was your house built? _____

How many square feet is your home? _____
(Do not count the basement if it is not heated or cooled.)

How many stories tall is your house (above ground)? _____

What direction does the front of your house face? _____

What type of foundation does your house have?

- Slab
- Vented crawlspace
- Unvented crawlspace
- Basement (is it heated/cooled?)

How many inches of insulation are there in the attic? _____

Are the walls insulated? _____ Is the floor insulated? _____

Do you have a clothes washer? _____

How many refrigerators and standalone freezers do you have? _____

What kind of water heater, heating, and air conditioning do you have?
(Use the back of the page if needed.)

Viewed from the front, how many windows are there in your house?

front ____ back _____ left _____ right _____

What are your base rates for electricity, natural gas, propane, and fuel oil?

How many occupants of your house are between 0 and 5 years of age? _____

How many occupants of your house are between 6 and 13 years of age? _____

How many occupants of your house are between 14 and 64 years of age? _____

How many occupants of your house are 65 years of age or older? _____

Timeline of Important Events Related to Achievement #3:

???	Discovery that rubbed amber attracts bits of fur.
1745	Leyden jar invented.
1752	Ben Franklin charges Leyden jars from a key attached to a kite flown during a thunderstorm.
1753	Russian physicist electrocuted trying to duplicate Franklin's experiment.
1800	Allesandro Volta creates world's first battery.
1829-1831	Joseph and Faraday discover that electricity can be produced by magnetism.
1860s	Dynamos, devices for generating electricity by moving wire coils in a magnetic field, are developed.
1881	Thomas Edison builds his steam-engine-driven dynamo for the 1881 Paris Electrical Exposition with the goal of providing an electrical distribution system to bring lighting into the home.
1882	Edison begins commercial operation of an electric power plant, in New York City. 26 days later, he begins operation of his first hydroelectric power plant, which uses water to rotate the blades of a turbine. This plant supplies power to two mills and one home.
1903	First electric power plant that uses a steam turbine, in which steam rotates the blades on a wheel, begins operation in Chicago.
1932	Construction begins on Hoover Dam, a giant hydroelectric project.
1933	Tennessee Valley Authority (TVA) is established.
1935	President Franklin Delano Roosevelt orders creation of cooperatives ("co-ops") that bring electricity to millions of rural Americans.
1942	Grand Coulee Dam on the Columbia River is completed.
1942	There are 800 rural electric cooperatives with 350,000 miles of lines.
1958	First US commercial central electric-generating station to use nuclear energy begins operation in Pennsylvania.