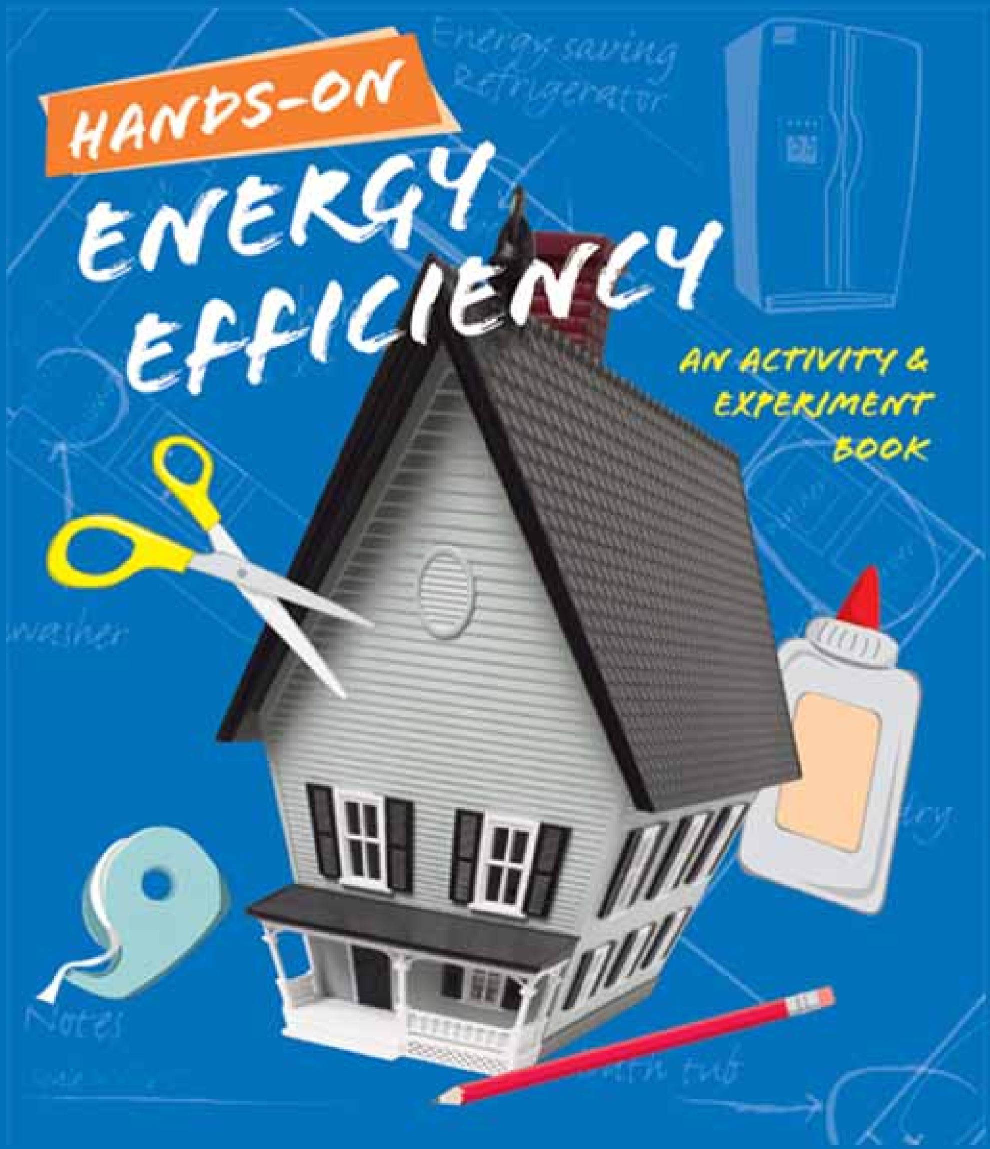


Teacher's Manual

Hands-On Energy Efficiency
Teacher's Guide

Introduction
The *Hands-On Energy Efficiency* activity booklet can be used to teach students the principles of wise energy use at home and at school. The content is appropriate for students in grades 5-7.

This presentation guide provides the objective for each page, background and ideas for classroom discussion, activity and puzzle answers, suggestions for experiment setup and completion, and follow-up activities.

All materials needed for activities are listed in the booklet. Most of the activities can be done with pencil and paper. Other necessary materials may already be on hand in the classroom; the rest are inexpensive and easily available at hardware stores.

Page 2: Why Save Energy?
Objective: Identify the primary benefits of conserving energy—saving money and safeguarding the environment.

Background/Discussion: Energy use affects the environment in a variety of ways. Much of the energy we use requires the burning of fuels. Burning coal, oil, natural gas, gasoline, wood, or any other fuel releases gases and particles that contribute to air pollution.

Burning these fuels also releases carbon dioxide (CO_2). CO_2 is one of the gases that cause the greenhouse effect. These gases act like a thin film that absorbs and traps heat from the sun inside our atmosphere. People's activities (such as burning fossil fuels for electricity, heat, and transportation) have increased the buildup of greenhouse gases in our atmosphere. When there are more greenhouse gases, more heat is radiated toward the earth's surface and our planet gets warmer. This is known as *global warming*. Some scientists prefer the term *climate change* because in addition to higher temperatures, the earth is experiencing other changes such as new weather patterns, glacier melt, habitat changes, droughts, and floods.

Point out to students that most electricity is generated in power plants that burn fossil fuels. As a result, every bit of electricity they can save helps reduce air pollution and global warming. Conserving other forms of energy (such as propane, heating oil, natural gas, gasoline, and diesel) does the same.

Ask: What kinds of energy do you use every day? *(For example: electricity for computers, appliances, air conditioners; natural gas for central heating and for some types of automobiles; gasoline for cars and trucks; wood or natural gas for fireplaces.)* Point out that none of these energy sources is free; we have to pay for the energy we use. For example, your family purchases electricity from a local electric utility. The utility generates electricity, or buys it from an electric generation company, and delivers it to you. A monthly bill from the utility tells you how much electricity you have used and how much you must pay for it.

Your Electric Bill: Talk students through the items on the utility bill pictured in the booklet. Help them locate and circle the service dates for this bill, the total amount this household will pay for natural gas and for electricity, and the total amount of the bill.

Follow-up: Have students complete a day's energy diary showing all the ways they use energy from the time they get up until they go to sleep.

Page 3: Find the Energy Users

Objective: Identify typical energy uses in the home and school.

Background/Discussion: Give students a few minutes to make a list of all the energy-using appliances, electronic, and equipment they can think of, or have them complete the list at home and bring it to class. Across the top of the chalkboard, write the six categories of household energy uses listed on the circle graph. Ask volunteers to share items from their lists and identify the category in which each item belongs. Add student contributions to the board so that, over the course of the discussion, a list of energy-using items is compiled for each category.

Circle Graph Questions:

- Ask: What is the total of all the percentages on the graph? *(100%)* If one category used exactly half the total energy used by a household, what would that percentage be? *(50%)* Which category listed on the chart uses the most energy? *(Heating and cooling)* How do you know? *(It uses almost half the total energy; all other categories use much less than half.)* Why does heating and cooling use so much energy? *(Because heaters and air conditioners must run for long periods of time to heat and cool homes, and the equipment requires a lot of energy to run.)*

- Point to the list already compiled on the chalkboard. Ask students to write down any other examples they can think of. *(Possible answers: TV, radio, stereo, computer, power tools, pump for aquarium or ornamental fountain, kitchen blender, microwave oven, coffee maker, waffle iron, electric shaver or toothbrush.)*

- Brainstorm: Give student pairs a few minutes to brainstorm energy-saving ideas and write them in the blanks provided. Ask them to share their ideas with the rest of the class. Alternatively, have students preview the rest of the book by scanning through it for energy-saving ideas that fit their chosen category. *(For example, Lighting: Use compact fluorescent light bulbs.)*

Page 4: Where Does Electricity Come From?

Objective: Explain how electricity is generated; identify energy sources used to generate electricity.

Discussion: Ask: How is electricity produced? *(It is generated at power plants using various fuels.)* No matter what fuels produce the electricity you use, do your lights shine, does your radio play, and does your computer run in the same way? *(Yes.)* Which fuels are used to generate most of the electricity used in the U.S.? *(Fossil fuels: coal, oil, and natural gas.)*

Background:

Coal, Oil, Natural Gas: Fossil fuels were formed millions of years ago, when plants and tiny sea creatures were buried by sand and rock. Their bodies decomposed and as a result of the earth's heat and pressure, they turned into fossil fuels. The processes that formed them are no longer occurring, so they are nonrenewable.

Nuclear Power: The uranium that runs nuclear power plants is mined from the ground. The amount of uranium in the earth is fixed; like fossil fuels, uranium supplies are nonrenewable.

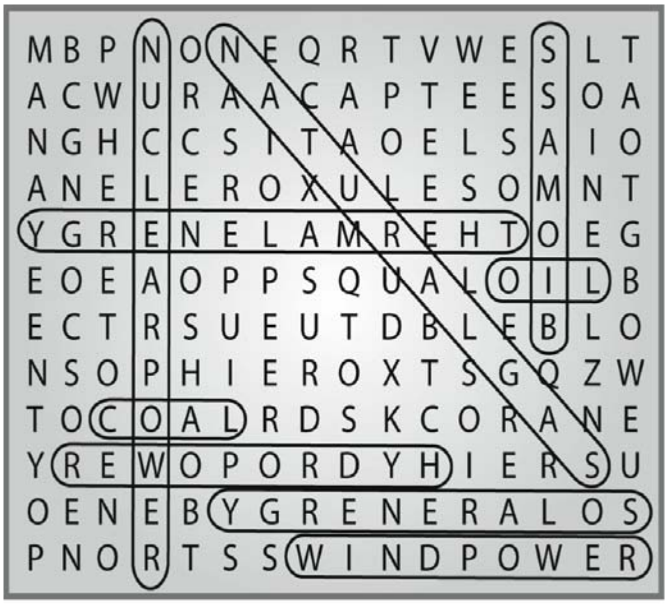
Hydropower: The most common form of hydropower uses a dam to retain moving water from a river and create a reservoir. As the water falls from the reservoir to the river below, it turns huge turbines that generate electricity. Hydropower is currently the world's largest and least expensive source of renewable energy.

Biomass: Biomass fuels are burned to produce steam that turns power plant turbines. Wood is the largest source of biomass energy, followed by corn, sugarcane wastes, straw, and other farming by-products. Because plants and trees need sunlight to grow, biomass is a form of stored solar energy. Although it is possible to use biomass faster than we produce it, more can be grown, so biomass is renewable.

Geothermal Energy: Comes from "geo" for earth and "thermal" for heat. The hot molten rock inside the earth is used to heat water to create steam that turns turbine blades in a power plant. Although geothermal energy is renewable, people must be careful not to draw steam or hot water out of the earth faster than it can be replenished.

Solar Energy: The sun will continue to shine for billions of years. Solar cells (photovoltaic cells) on panels transform sunlight into electricity. Though they work only when the sun is shining, solar power systems can store electricity in batteries for non-sunny days.
Wind Power: Wind turns the blades of giant windmills, called wind turbines, to generate electricity.

Word Search Key:



Follow-up: After students complete this activity, make a list on the chalkboard of renewable and nonrenewable energy sources.

Page 5: How Much Does Electricity Cost?

Objective: Define watts, kilowatts, kilowatt-hours; explain how electricity cost is calculated.

Background/Discussion: Help students understand how much energy a watt represents by comparing the wattage of familiar electric items. For example, a typical electric radio requires 14 watts to operate, a 20-inch television needs 115 watts, and most refrigerators need between 400 and 800 watts. An electric stove needs 3000-4000 watts.

On the chalkboard, write the abbreviations for watts (W), kilowatts (kW), and kilowatt-hours (kWh). Show students that a kilowatt equals 1000 watts by writing: 1000 W = 1 kW. Explain that a kWh equals one kW used for one hour. For example, one kWh is the amount of energy used by ten 100 W light bulbs in one hour, or the energy used by one 100 W light bulb over ten hours.

You Do the Math: Bring a recent home electricity bill to class, or obtain a recent bill received by the school. Have students locate the cost per kWh on the bill and use it to complete the table.

Answer Key: Multiply number of kWh for each energy use by the local cost per kWh. Answers will depend on local electricity cost.

Follow-up: After students have completed the activity, ask them how the members of this household could focus their energy-saving actions to save the most money. *(Actions that reduce energy used for water and space heating would reap the highest savings, because they represent the highest-cost energy uses in this household.)*

Page 6: ENERGY STAR® Helps You Save

Objective: Calculate the long-term energy and cost savings available from ENERGY STAR appliances.

Background/Discussion: Ask students what types of things might make one refrigerator more efficient than another. *(Answers will vary, and may include the following: More insulation in the walls of the refrigerator to keep the cold air in; a tighter seal around the door; a more efficient motor.)*

Before doing the activity, introduce students to the concept of lifetime cost calculations. Explain that the actual lifetime cost of an appliance must take into consideration not only the purchase price, but also the cost of energy needed to operate the appliance over its lifetime. Buying the lowest-cost appliance can end up being more expensive in the long run than paying for a more expensive model.

Activity Answers:
(Please note: This scenario is based on an imaginary appliance, not the refrigerators pictured.)
1. How much more does Appliance A cost to buy than Appliance B? *($260 - $200 = $60)*
2. How much less does Appliance A cost in energy per month? *($20 - $10 = $10)*
3. Appliance A can make up for its higher purchase price through dollars saved on energy bills. How many months will this take? *(If Appliance A saves $10 per month, it will take 6 months to equal $60.)*
4. Why is A the smarter choice in the long run? *(Answers will vary. Some students may recognize that at 6 months Appliance A has cost the same as B, and after that time Appliance A continues to save its owners $10 per month over its working lifetime.)*

Follow-up: Invite students to use the Internet or visit a local appliance store to compare prices and energy use of ENERGY STAR appliances versus less-efficient appliances.

Page 7: Let It Shine

Objective: Demonstrate the transformation of electrical energy to heat (thermal) and light (electromagnetic) energy in a light bulb; compare the energy efficiency of incandescent and compact fluorescent light bulbs.

Discussion: Review with students the forms of energy: mechanical (energy of motion), thermal (heat), chemical (energy in chemical bonds that hold compounds together), electrical (electrical charges), electromagnetic (visible light, X-rays, and other wavelengths of the electromagnetic spectrum), and nuclear (energy that holds atomic nuclei together). Remind students that energy cannot be created or destroyed, but can change from one form to another. Ask: What form of energy operates a light bulb? *(Electrical energy.)* What forms of energy does a light bulb emit? *(Light and heat.)*

Heat…or Light:
Safety Note: Caution students that a burning light bulb can burn skin or cloth. Have students use an oven mitt when holding the thermometer near either bulb.

Answer Key: Actual temperatures will vary. The incandescent bulb will produce significantly more heat than the CFL. The CFL is more energy-efficient, because less of its energy goes toward making heat and more of its energy goes toward making light.

Page 8: Do You Feel a Draft?

Objective: Demonstrate the flow of air and heat through cracks and holes in the walls of a building.

Background/Discussion: Ask: On a hot summer day, would you turn on the air conditioner AND open all the windows? Why or why not? *(No you would not. All the cooled air would escape, and all the energy used to cool the air would be wasted.)* Explain to students that the walls of a building are not usually airtight and heating and cooling energy can be lost to the outdoors. Hold a strip of tissue paper by one end near closed classroom windows or doors, or near baseboard molding or electrical outlets, to demonstrate how to locate tiny air leaks. If available, show students examples of caulk and weather stripping used to plug leaks.

Does Your House Leak? Ask students to describe what they found when they looked for leaks at home.

Follow-up: Invite students to research and report on the advantages of energy-efficient window technologies.

Page 9: Insulation Exploration

Objective: To demonstrate the effectiveness of insulation in resisting heat transfer.

Background/Discussion: Explain that heat is transferred from one material to another: heat always moves from a warmer object to a cooler one. Insulation is a substance that resists heat transfer. Show students a piece of the insulation they will use for their experiment. If available, show students examples of foam insulation with different R-values—the higher the R-value, the thicker the insulation.

Preparation: Students can conduct this experiment in teams of three or four. Before class, prepare one insulated box and one cardboard box that students can use as models of the boxes they are to fabricate. Emphasize the importance of making the boxes airtight (refer back to the "Does Your House Leak" activity on the previous page).

Safety Note: To avoid spills and the danger of scalding, have students bring jars, lids, and thermometers to the hot water source. After students have measured the water temperature and placed lids on their jars, they can carry them back to their workstations for placement in the boxes.

Data Analysis:

- *Jar A had the largest temperature change, because it had no insulation.*
- *Jar B had the least temperature change, because it had the most insulation.*
- *Jar B resembles an insulated house. Jar C resembles an uninsulated house.*

Page 10: Shade Keeps It Cool

Objective: Demonstrate heat transfer through glass windows.

Background/Discussion: Ask: Why does the inside of a car get so hot if it sits in the sun with all the windows closed? *(Heat from the sun enters through the windows and heats the inside.)* Explain that the same thing can happen with building windows.

The Window Test: The thermometer placed in the sun will show a significantly higher temperature. Results probably will be most dramatic if the activity is conducted using brightly lit south-facing windows during the sunniest part of the day. A distinct difference between the two windows can be detected even if the weather is cool, as long as the sun is bright.

Page 11: Save Energy on Heating and Cooling

Objective: Understand how adjusting indoor air temperatures can save energy.

Background/Discussion: Why should you set the thermostat lower during winter? *(You will use less energy for heating.)* Why set it higher during summer? *(You will use less energy for cooling.)*

Life without AC or Heat: Encourage students to interview older friends or family who may have used different technologies to stay warm or cool. Have students share their findings with the class. *(Students may report stories about people using stand-alone gas heaters, wood-burning stoves and fireplaces, or coal or oil furnaces to heat the indoors during winter; electric fans, swamp coolers, and dips in a nearby creek during summer.)*Safety Note: There is a danger of fire or carbon monoxide poisoning if people use unventilated gas, kerosene, or charcoal-burning devices indoors. Use only appliances specifically designed for indoor heating.

Pages 12-13: Be an Energy Detective

Objective: Identify ways to save energy in the kitchen and bathroom.

Background/Discussion: Go over the energy-saving tips on these two pages with students Ask: If the power goes out, what's the best way to make sure the food in the refrigerator stays cold as long as possible? *(Keep the door closed.)* Why does reducing hot water use in the kitchen, bathroom, and laundry room help reduce energy use? *(It takes energy to heat water, so if you use less hot water you use less energy.)*

Perform Your Own Inspection: Ask students to observe their family for a week before compiling their lists.

Inspire Your Household: Provide students with poster board, markers, scissors, and tape to use in creating their signs. Let students vote on the most inspiring, funniest, or most artistic signs and posters.

Page 14: Save Energy at School

Objective: Identify ways to save energy at school.

Background/Discussion: Go through the energy-saving tips on this page with students.

Energy Savers Teams: Give each team a different area of the school to investigate. Invite the class to compose a short letter to the principal to accompany their list of suggestions.

Page 15: You Have the Power

Objective: Identify energy-saving actions students can take as individuals.

Background/Discussion: Ask students to share their ideas about what each person can do to help save energy.

How Can You Help? Have each student choose one or two actions and make an "Energy Saver's Resolution" to follow through on those actions. After a month has passed, ask students to report on how well they are keeping their resolutions.

Back Cover

Objective: Communicate important energy conservation tips to family members.

Background/Discussion: Why should you share the tips on this back cover with your family? *(You might find ways that you and your family could save money and help the environment.)*

Homework: Ask students to take this list home and to try out the tips with their families. Emphasize that the dollar savings figures are estimates, and students' actual savings will vary based on their household's energy use habits. (For example, a family that already uses only cold water for their laundry will not notice savings on their energy bill by continuing that practice; however, a family that washes all clothing in hot water and then switches to cold water will probably notice a difference.)