

Be "Sun-sible" about Heating Water

Curriculum: Solar Power; (Electromagnetic radiation, conduction/convection, efficiency, Energy transformation, thermodynamics)

Grade level: K-4

Whole class or small groups (3 to 4)

Time: 120 minutes

Summary: In this inquiry-based lesson, students will work in groups to build a solar water heater and will investigate which colors absorb more radiant heat and transmit it to the water, and study the relationship between insulation and heat loss. Teacher background, assessment questions, and extensions are provided. The expected out come in this activity is for students to understand how solar energy can reduce the hot water energy bill.

Developed by Tennessee Valley Authority

Provided by the Department of Energy's
National Renewable Energy Laboratory
and BP America Inc.



BE “SUN”-SIBLE ABOUT HEATING WATER

OBJECTIVES

The student will do the following:

1. Construct a simple solar water heater.
2. Investigate color and heat.
3. Investigate insulation and heat.

SUBJECT:

Science, Math

TIME:

120 minutes

MATERIALS:

juice cans, paint (white, black, green, red), very hot water, food colors, ice cubes, thermometers, construction paper (white, black, green, red, blue), watch, quart jars, cardboard boxes, newspaper, glue or rubber cement, aluminum foil, razor knife, clear plastic wrap, dowel, duct tape, tape, 1-qt. can, flat black spray paint, student sheets (included)

BACKGROUND INFORMATION

Heating water for use in the home is a major contributor to the home energy bill. One way to reduce energy use by the heater is to turn its thermostat back; settings of 120 to 140 degrees will save energy and still provide water hot enough for all the various purposes for which it is used. Another way to reduce energy consumption by the home water heater is to use less hot water. Cold or warm water performs satisfactorily for typical laundry loads. One can take shorter showers or shallower baths. Repairing dripping hot water faucets can save a surprising amount of hot water.

Using the sun's energy is another way to reduce the hot water energy bill. The sun's energy is free, so the cost of solar heated water is less than that of conventionally heated water. Home solar water heaters usually consist of a solar collector, pipes through which water circulates from the collector to the water heater, and a highly efficient water heater similar to a conventional one. The collector, often mounted on the roof, is a dark-colored, glass-faced box in which the sun's heat is trapped. This trapped energy heats the water being pumped through the systems pipes, which pass through the collector. The heated water returns to the water heater, where it is perhaps heated further and is stored for use. The entire system is well insulated, so as to avoid losing heat. Solar water heaters can help lower the high cost of heating water.

Terms

Insulation: material that hinders the flow of heat energy.

solar collector: any device used to trap the sun's energy and change it into heat energy.

PROCEDURE

I. Setting the stage

- A. Have the students consider the energy used to heat Water for home use. Give each student a copy of the student sheet “JONES FAMILY ELECTRICITY USE” (included). Have the students examine the graph, and discuss with them the questions on the sheet.
- B. Share with the class the related information from the background information furnished.

II. Activity

- A. Have the students investigate color and heat.
 - 1. Have the students do the activity on the student sheet “WHICH COLOR HOLDS HEAT LONGEST?” (included).
 - a. Help the students make graphs and record data as they follow the instructions on the student sheet.
 - b. Discuss the results with the students.
 - 2. Have the students investigate color and the time required for ice to melt. (Do this yourself as a demonstration or have groups of students do it.)
 - a. Have squares of construction paper in the following colors—white, black, green, red, and blue. Place an ice cube on each square of colored paper.
 - b. Time how long it takes for each ice cube to melt.
 - c. Discuss with the students the results of the investigation.
- B. Have the students investigate insulation and solar water heating.
 - 1. Divide the students into groups of three or four each. Give each group a copy of the student sheet “INSULATION REALLY WORKS” (included), and have the groups complete the activity as instructed.
 - 2. Review the definition of the term “insulation” and relate it to water heating and storage.
- C. Have the students build model solar water heaters.
 - 1. Divide the students into groups of three or four each.
 - 2. Distribute the student sheet “HOW TO MAKE A SOLAR WATER HEATER MODEL” (included) to each group and provide the materials they need.
 - 3. Have them build the model solar water heater models according to the instructions on the sheet.
 - 4. Have the students experiment with different colors or kinds of containers for the water.

III. Follow-up

- A. Ask the students the following questions:
 - 1. What are some ways energy is used in the home? (heating, water, air conditioning, appliances, and so on.)
 - 2. What are some ways to reduce the amount of energy used to heat water? (turn water heater thermostat down; use less hot water; repair dripping hot water faucets)
- B. Have the students complete the following:
 - 1. Define solar energy.
 - 2. Define insulation.
 - 3. Describe how a solar water heater model works.

- C. Ask the students the following questions:
1. How can we use the sun's energy to heat our homes and water? (Heat from the sun can be gathered by solar collectors and stored until needed.)
 2. Which reach a higher temperature more quickly when placed in direct sunlight—light-colored or dark-colored objects? (dark)
 3. How does a solar collector work? (A solar collector is a box-like device with a glass (or similar material) face and a black interior. It traps and absorbs the energy of the sun's rays. Water piped through the collector is heated and sent to a storage device)

IV. Extension

- A. Have interested students make posters or a bulletin board of warm and cool fabrics.
- B. Have the students write to the U.S. Department of Energy's Assistant Secretary for Conservation and Renewable Energy for further information on solar energy (Address: 1000 Independence Avenue, SW, Washington, DC 20585)
- C. Invite someone to speak to the class about solar energy.

Resources

Alabama Solar Energy Center. "Energy Fact-sheet/Solar Water Heaters." Huntsville, AL: Author, n.d.

_____. "Solar Homes for Alabama." Huntsville, AL: Author, n.d. (p.2-3)

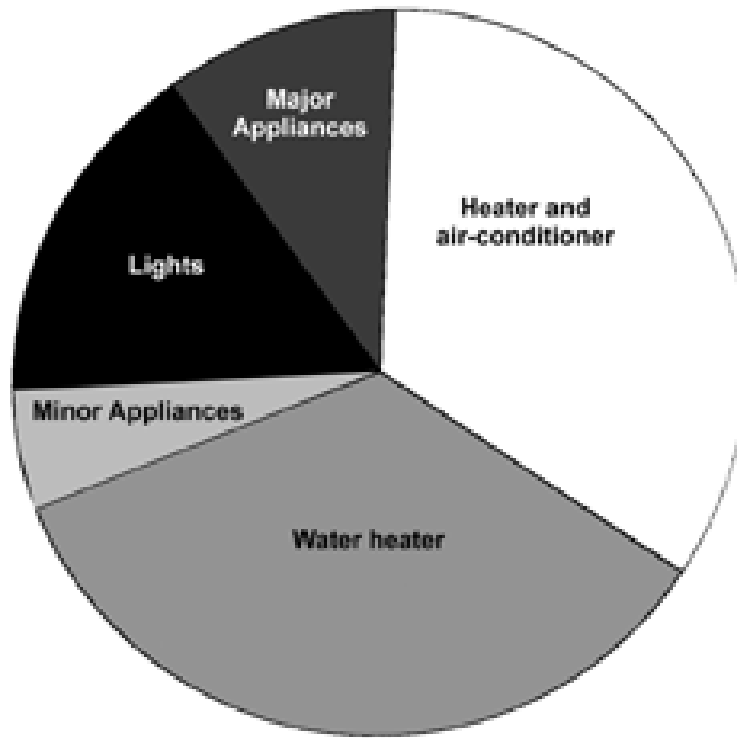
Barufaldi, J. P., G. T. Ladd, and A. J. Moses. Heath Science, Levels 3-5. Lexington, MA: Heath, 1984.

National Appropriate Technology Assistance Service. "How to Make a Solar Water Heater." Connections. A Curriculum in Appropriate Technology for 5th and 6th Grades. N.p.: U.S. Department of Energy, 1986. (Address: NATAS, P.O. Box 2525, Butte MT 59702-2525. Telephone: 1-800-428-2525.)

Tennessee Valley Authority. "Seasonal Sun and Home Orientation." (Adapted from Solar Home, Brick House Publishing Company.) N.p.: Author, 1981. (Out of print.)

U.S. Department of Energy. Energy Use in Homes and Stores: Your Energy World. Unit Three. Washington, D.C.: Author, February 1978.

Jones Family Electricity Use



The Jones family made a circle graph to study electricity usage at their house. The graph shows that a large portion of their bill is for heating water.

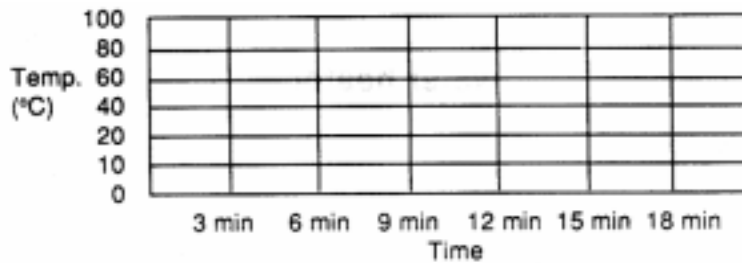
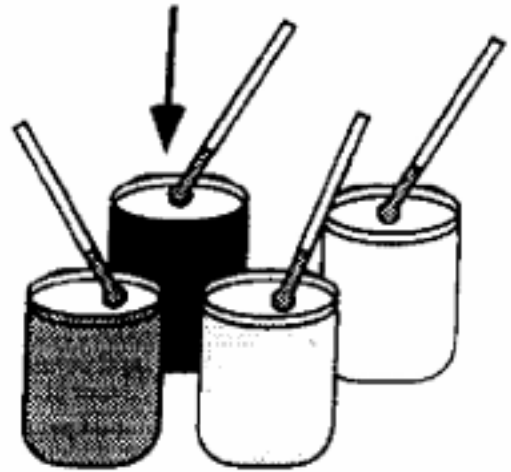
What are some ways the Jones family could decrease their electric bill?

Is there an alternative method for heating water?

WHICH COLOR HOLDS HEAT LONGEST?

Materials: 4 juice cans, 4 colors of paint (white, black, green, and red), very hot water (close to boiling), 4 thermometers, food colors

1. Paint each can a different color.
2. Fill each can with the same amount of hot water.
3. Add food coloring to the hot water; add drops of all the colors together to get black.
4. Put a thermometer in each can.
5. Read and record the temperature every three minutes until the water cools.
6. Make a graph of the results.



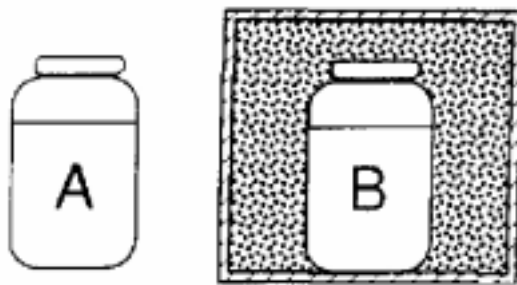
Which color held heat best? _____

INSULATION REALLY WORKS

Fill two one-quart jars with hot tap water and put a thermometer in each jar to measure the temperature of the water.



Record the starting temperature on the chart below. Next, place one of the jars in a cardboard box. Cover it and surround it with shredded newspapers. The other jar remains as is.



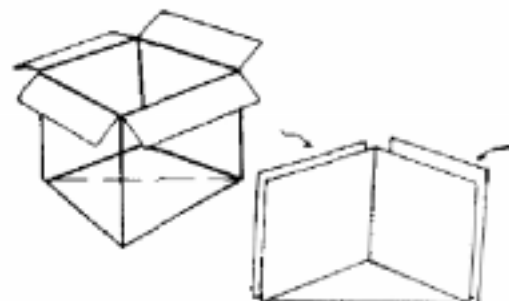
After one of the jars is “insulated,” read and record the temperature of each jar every 10 minutes. After 30 minutes have passed, compare the results.

	Jar A	Jar B
Starting temperature		
After 10 minutes		
After 20 minutes		
After 30 minutes		

HOW TO MAKE A SOLAR WATER HEATER MODEL

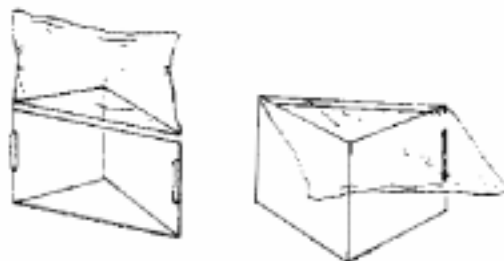
1. Cut a cardboard box in half diagonally.

Cut the box in half along the diagonal as shown, leaving a triangularly shaped top and bottom. Then cut off the top triangle. The leftover piece has two sides that can be cut out to fit flat onto the sides of the remaining box. Then tape them to the sides of the half-box. These side-pieces will add some thickness to the walls and help keep heat inside. Glue aluminum foil to the inside of the box (sides and bottom) with rubber cement (be sure to read the directions on the label).



2. Glazing the box.

Tape a small stick of wood (a dowel) across the top corners of the heater box as a brace. Use silver duct tape. Tape clear plastic wrap to the bottom and sides of the box as shown. Make sure it is long enough to have some left over to fold over the top. The fold-over flap can be used as a door to get into the box. You can tape heavy weights to the corners for holding it shut or you can tape the corners down.



3. Prepare the water can.

Use any can that is one quart in size and has no leaks. Spray paint it with flat black paint.

4. Set up the water heater.

Open the top of the heater box. Fill the water can, cover the top of it with clear plastic wrap and put a rubber band around the top of the can to seal it. Place the filled can on the bottom of the heater box and close the top flap. Be sure it is well sealed. Face the front of the box to the south and wait for it to heat up. You can test the temperature of the water by sticking a thermometer into it. You can also experiment with different colors or different kinds of cans and jars.

