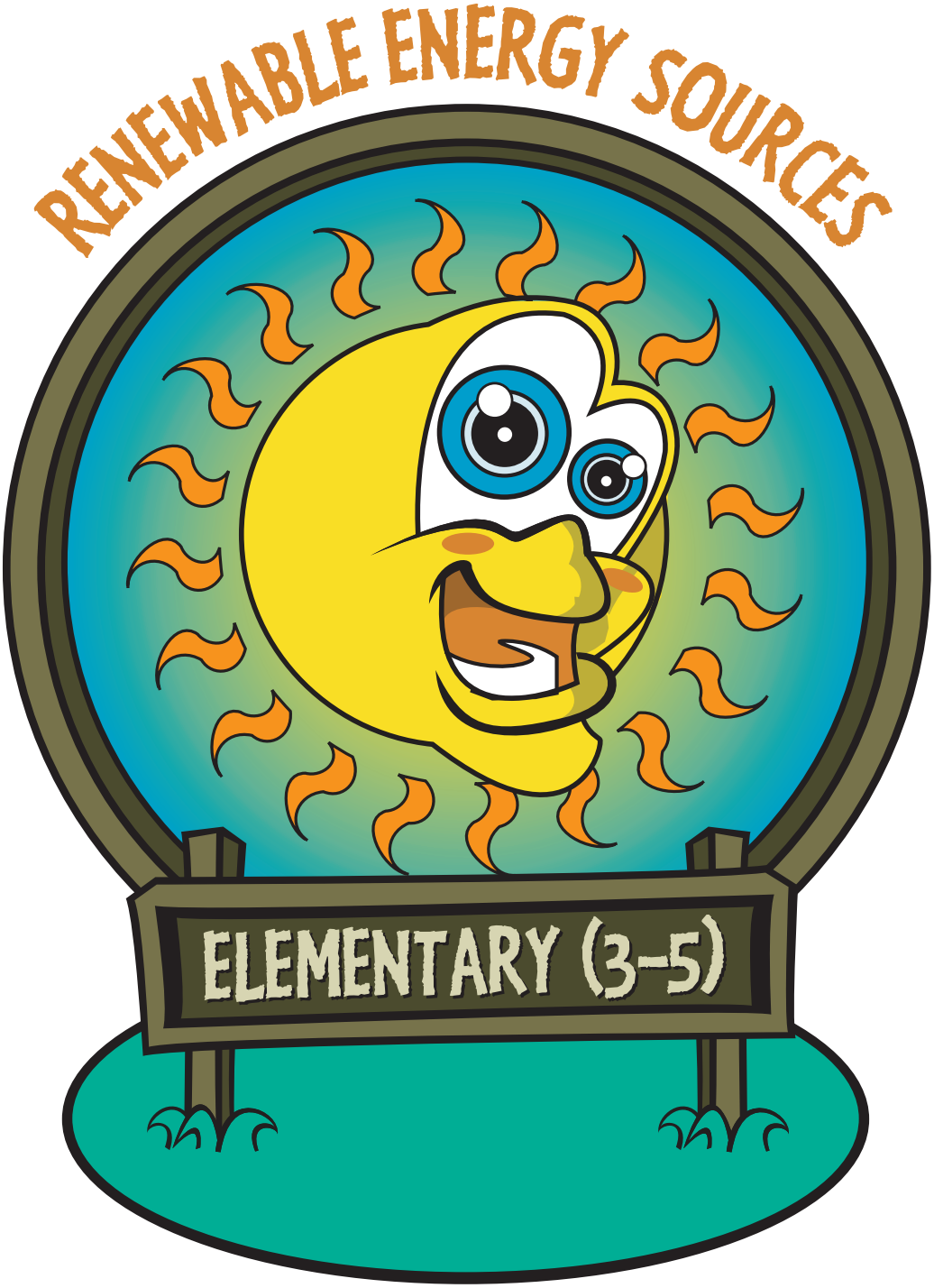
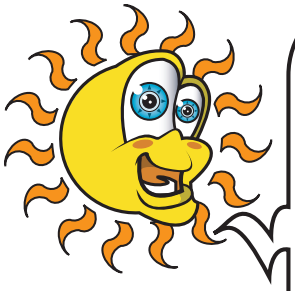

RENEWABLE ENERGY SOURCES
ELEMENTARY (3–5)

THEN AND NOW



SUBJECTS: Science, Social Studies, Art

TIME: 100 minutes

MATERIALS: shoe boxes, pictures of inventions, scissors, glue, assorted craft materials *(for building floats)*, crayons or markers, student sheets

Objectives *The student will do the following:*

1. Identify the three major fuel eras – wood, coal, oil – in their historical order.
2. Compare the three major fuel eras in energy history.
3. Examine energy use today.

Background Information

Throughout human history, the development of new energy sources has been linked to human progress. Fire and bodily strength were all primitive people had to use. Harnessing new sources of energy and building new machines to use them changed our lifestyles dramatically. The study of our energy past reveals three major energy time periods – the wood era, the coal era and the oil era.

Before 1885, wood was the most important energy source *(although wind and water were also used)*. Extensive forests provided easy-to-get and inexpensive wood. It was used for light, warmth, cooking, and heating water. Trains and steamboats used wood for fuel and blacksmiths burned it for heat needed to make horseshoes and tools. By the 1860's, wood was less plentiful near the cities where so much of it was needed. It became more expensive because it had to be transported greater distances.

Around 1885, city dwellers and manufacturers began to use coal because wood was more difficult to get and more expensive. Coal was used as fuel for steamboats, trains and home furnaces. It was used in the steel industry and, later, in the production of electricity. It was the concentrated energy of coal that fueled the industrial revolution. The coal era was a time of great industrial and railroad expansion.

After about 1950, oil replaced coal as the source of most of our nation's energy. The automobile was the reason that oil became an important source of energy. Gasoline and diesel fuel are made from oil. Besides making fuel for vehicles, other major uses of oil are burning it to make electricity and run industrial machines. At one time, heating oil was commonly used to heat buildings and homes. Natural gas also grew in importance during this era as it was often found underground along with oil. Because it burns cleanly, natural gas has now become the foremost fuel for heating buildings.

Throughout most of history, people relied on wood to supply their meager energy needs. Wood is a renewable resource; that is, trees can be grown to replace the wood burned for fuel. In the last 100 years, we have become dependent upon coal and oil – fossil fuels. These are nonrenewable resources; once we use them, they are gone forever. It is important we consider the implications this holds for the future.

Terms

coal: a major fuel resource formed from the remains of ancient plants.

nonrenewable: not able to be restored or replenished.

oil: a mixture of liquids formed from the remains of ancient living things; the source of many important fuels *(such as gasoline, diesel fuel and kerosene)* and other substances.

renewable: able to be restored or replenished.

Procedure

I. *Setting the stage*

A. *Introduce the lesson by leading the students in the following discussion.*

1. Ask the students the following questions:
   a. What is energy? *(the ability to do work)*
   b. How do you think early people got their work done; that is, what energy forms did they use? *(bodily strength, fire, animal power and so on)*
   c. Have the students give a definition for fuel. *(something consumed for energy)*
2. Share the background information about energy eras with the class, explain the concept of energy eras and discuss each era as you proceed. List the major uses of the chief energy source for each energy era on the board.

B. *Discuss the ancient use of fire with the students.*

1. Read the statement about fire by Pliny *(plinnee)*. There were two famous Romans named Pliny. They were relatives. One was called the Elder and was a famous writer. His book called NATURAL HISTORY is one of the most famous ancient books. Pliny the Elder died in the volcanic eruption that buried the city of Pompeii in 79 A.D.

   We cannot but marvel at the fact that fire is necessary for almost every operation. It takes the sands of the earth and melts them, now into glass, now into silver, or minium, or one or other lead, or some substance useful to the painter or the physician. By fire minerals are disintegrated and copper produced; in fire iron is born, and by fire it is subdued; by fire gold is purified; by fire stones are burned for the binding together of walls of houses... It is only when ignited and quenched that charcoal itself acquires its characteristic powers, and only when it seems to have perished that it becomes endowed with greater virtue.

   PLINY, NATURAL HISTORY, VOL. XXXVI

NOTE: Explain to the students that "*minium*" means red lead, a lead oxide used as a paint pigment. Smelting is the word we use today for the process by which we use heat to get copper, iron and other minerals from the rocks in which we find them. "*Subdued*" means tempering iron or altering its hardness. "*Stones are burned*" means making the lime used in mortar and cement from rocks and shells.

2. Tell the students we have used fire for thousands of years. In fact, we can see that we have used fire to do many of the same processes for a long time. Today we still have many uses for fire, and all of them require a fuel of some sort. The earliest common fuel was wood. Then came the coal era and the oil era. Today we are developing ways to use nuclear energy.

C. *Tell the students that nuclear energy is our newest energy source.*

Nuclear energy is fundamentally different from all the major fuels. We use it to produce electricity and, although the process requires uranium as *"fuel,"* there is no fire involved. Read this Isaac Asimov statement concerning nuclear power to the students.

> *"Nothing in the history of mankind has opened our eyes to the possibilities of science as has the development of atomic power. In the last 200 years, people have seen the coming of the steam engine, the steamboat, the railroad locomotive, the automobile, the airplane, radio, motion pictures, television, the machine age in general. Yet none of it seemed quite so fantastic, quite so unbelievable, as what man has done since 1939 with the atom....there seem to be almost no limits to what may lie ahead; inexhaustible energy, new worlds, everwidening knowledge of the physical universe."*
>
> ISAAC ASIMOV

II. *Activities*

A. *Have the students make floats from shoeboxes for an energy history parade.*

1. Divide the class into three groups – one each for the wood, coal and oil.
2. Have each group design its floats to depict lifestyles characteristic of each era in as many ways as possible. Each group should do several floats.
3. The sun should be used as the leading float *(Grand Marshall)* to show that it is the major source of all energy. The wood, coal and oil era floats should follow in that order. You should make the sun float yourself.

B. *Have the students investigate energy history further.*

1. Have the students make a giant *"Energy History"* collage by cutting out and/or drawing pictures of inventions made possible by the discovery and harnessing of new energy sources through history. The collage should be mounted on a large sun shape to show that the sun is the source of almost all the energy we use.
2. Have the students choose energy inventions and design shadow boxes to show how life was made easier as a result of those inventions. Divide the class into three groups – one each for the wood, coal, and oil eras. Each student is then to write a story in the first person *("I")* describing his/her group's shadow box scene.

C. *Have the students review energy history.*

Distribute copies of the student sheet *"Energy in Use."* Discuss their answers to the questions.

III. *Follow-up*

A. *Give each student a copy of the student sheet "What Makes it Go?"*

Specify how many energy sources and inventions used in each era they are to draw on the sheet.

B. *Have each group write a skit about the different fuel usage eras.*

Divide the class into four groups – wood era, coal era, oil era, and common, everyday fuel usage. The students should present their plays to the class; costumes, props, and sets may be as simple or elaborate as you wish.

IV. *Extensions*

A. ***Have the students write an energy history-related acrostic (word square) for the words "Energy History."***

B. ***Some students may design an energy history mural.***
(Be sure they include the sun as the source of almost all the energy on earth.)

C. ***Interested students may pursue energy history further.***

1. Some students may research the lives and careers of some of the following people famous in energy history: Andre-Marie Ampere, Edwin L. Drake, Henry Bessemer, Thomas Edison, Michael Faraday, Robert Fulton, William Kelly, Benjamin Franklin, William Hart, George Ohm, James Watt, Allesandro Volta, Albert Einstein, Ernest Rutherford, Isaac Asimov and others.
2. Some students might be interested in collecting energy stamps. They may write to: TECHNICAL INFORMATION CENTER, P.O. Box 62, Oak Ridge, TN 37830. The center can send a booklet called STAMPS TELL THE STORY OF NUCLEAR ENERGY, by Joseph A. Angelo, Jr. *(Library of Congress Catalog Card Number: 73-600332)*. The booklet could then be shared with the class.

Resources

Abruscato, J. HOLT SCIENCE SKILLBOOK.
New York: Holt, Rinehart, & Winston, 1984.

Asimov, I. SOLAR POWER.
New York: Walker& Co., 1981. *(pp. 9-42)*

The Energy Source Education Council. POWER SWITCH (*learning unit*).
Lakewood, CA: Author, 1984.
(Address: 5505 East Carson Street, Suite 250, Lakewood, CA 90713.)

Foilman, I. L. and H.C. Jackson. LIGHT, UNIVERSE, PLANTS, ENERGY.
St. Louis, MO: Milliken, 1979. *(pp. 19-21)*

Georgia Environmental Project. SOLAR ENERGY (*pamphlet*).
Atlanta: Author, 1987.

Energy in Use

Fill in the blanks below by choosing from the listed words **Coal, Oil, Wood.**

1. In 1850,_____was used to heat most homes.

2. Diesel fuel is made from_____and is used by farmers for their tractors.

3. Gasoline is made from_____and is used to run automobiles.

4. Kerosene was used in lamps to light houses in the early 1900s. Kerosene is made from_____.

5. _____was used to heat water for washing clothes in the early 1800s.

6. In 1900, one-room schoolhouses were often heated by_____.

7. _____and_____are used in power plants to produce electricity.

8. _____is the fuel that prehistoric people used.

9. _____is the fuel the people of Pliny's day would know best.

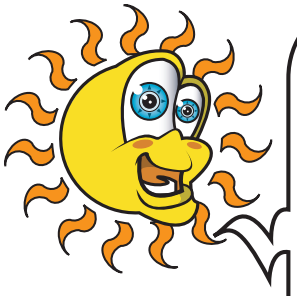
10. Steam engines that pulled trains and paddled ships in the late 1800s were powered by_____.

What Makes it Go?

Draw and label the energy sources, uses, and inventions used most in each era.

Wood (before 1885)	**Coal** (1885 – 1950)	**Oil** (1950 – present)

OH! HOW THE WIND BLOWS!



SUBJECTS: Science

TIME: 50 minutes plus 30 minutes per day for a week

MATERIALS: butcher paper, crayons or markers, student sheets

Objectives *The student will do the following:*

1. Describe the effects of the wind.
2. Estimate the speed of the wind using the Beaufort Wind Scale *(page 21)*.
3. Record the wind speeds at different times of the day.
4. Infer the time of day at which the strongest winds usually occur.

Background Information

Wind results when the sun's heat causes air masses to expand and rise. Cold air rushes in to replace the less dense warm air and wind is created. Wind power can be harnessed to provide some or all of the power for many tasks such as pumping water or generating electricity.

Terms

gale: a very strong wind.

hurricane: a storm with violent wind and *(usually)* heavy rain; forms over the ocean in tropical regions; term "*hurricane*" is used in the Western Hemisphere; term "*typhoon*" is used in the Eastern Hemisphere.

wind vane: a device used to indicate the direction of the wind.

Procedure

I. *Setting the stage*

A. *Have the students think about wind and energy.*

1. Ask the students the following questions about wind:
   a. What are some things that you see outside that tell you the wind is blowing?
   b. Describe how you look when the wind is blowing against you.
2. Share with the students the background information about wind power.

B. *Give each student a copy of the student sheet "The Beaufort Wind Scale."*

Read and discuss each Beaufort number, description, and observation with the students. Define any terms with which they are not familiar.

II. *Activities*

A. *Have the class estimate wind speed.*

1. Take the students outside and have them observe the effects of the wind – for example, swings moving, students' hair blowing or leaves rustling.
2. Using the student sheet *"The Beaufort Wind Scale,"* have the students estimate the speed of the wind.
3. Ask the students the following questions:
   a. What if the wind began blowing very hard? What would the schoolyard look like then?
   b. What should you do for safety in high winds?
4. When the students return to the classroom, ask them to draw a mural depicting a windy playground scene.

B. *Have the students estimate and record wind speeds.*

1. Distribute copies of the student sheet "*Estimating Wind Speed*."
2. Have the students observe and estimate *(using the Beaufort Wind Scale)* the wind speed at three different times each day for one week. The estimated wind speeds are to be recorded in the data chart on the student sheet.
3. After the five days of data collection, discuss with the students the wind speeds they observed.

C. *Using the collected data, complete the following:*

1. Have the students make a bar graph showing the morning, noon, and afternoon speeds for each day. *(Each day should be represented by three tightly grouped bars; there will be five groups of three bars each.)*
2. After the students have completed their bar graphs, ask them if there seems to be a time of day at which the fastest winds usually occur.

III. *Follow-up*

A. *Discuss the completed data charts with the students.*

Orally compile their various answers. Using the "*Beaufort Wind Scale*," identify the different activities happening at the Beaufort Numbers they selected. Ask about other things they might have seen.

B. *Discuss the completed charts and bar graphs with the students.*

Ask them to consider the times of day in which the highest speeds occurred. If their community decided to use wind power as a source of energy, what appears to be the best time of day to produce the most energy? Why?

IV. *Extensions*

A. *Have the students write a story entitled "I Cannot Believe What I Saw the Wind Doing."*

B. *Have interested students write a poem about the wind.*
Have groups brainstorm for words that rhyme with wind. The words should be written on the board for students who need extra help.

C. *Have each student write a haiku about the wind.*
These could be written on posters and illustrated.

D. *Have the students make and test a windmill.*
Use the student sheet *"How to Make a Windmill" (page 23)*.

E. *Some students may research wind power and write reports about the advantages and disadvantages of using wind power.*

F. *Have the students make weather vanes.*
Each student will need a straight pin, a pencil, scissors, a straw, some clay, and construction paper. Provide patterns so the students can cut the arrows and tails of their wind vanes from construction paper. They will then make a cut at each end of the straw and insert the arrow in one end and the tail in the other. The pin is to be stuck through the center of the straw and pushed into the eraser end of a pencil. The pencil point into be inserted into a cone-shaped lump of clay so that it will stand upright. The weather vanes the students will have made can be put outside the classroom to show the direction of the wind.

G. *Have the students use maps, weather statistics, and other resources to determine where in the Tennessee Valley one could most likely make use of wind power.*
Have them explain why this is the case.

Resources

American Museum of Science and Energy. "At What Time of Day Is There Enough Wind To Make Electricity Where You Live?" Science Activities in Energy. Oak Ridge, TN: Oak Ridge Associated Universities, n.d.

American Museum of Science and Energy. "Where Is the Windiest Spot on Your School Ground?" Science Activities in Energy. Oak Ridge, TN: Oak Ridge Associated Universities, n.d.

National Science Teachers Association. The Energy We Use Grade 1. (*Energy, Environment, and the Economy.*) Oak Ridge, TN: U.S. Department of Energy, 1976. *(p. 42)*

The Beaufort Wind Scale

Beaufort No.	Description	Observation
0	Calm (0 – 1 mph)	Smoke rises vertically.
1	Light air (2 – 3 mph)	Leaves rustle; wind vanes move.
2	Slight breeze (4 – 7 mph)	Leaves rustle; wind vanes move.
3	Gentle breeze (8 – 12 mph)	Twigs move; dust and flags extended.
4	Moderate breeze (13 – 18 mph)	Branches move; dust and paper rise.
5	Fresh breeze (19 – 24 mph)	Twigs move; dust and paper rise.
6	Strong breeze (25 – 31 mph)	Large branches sway; wires whistle.
7	Moderate gale (32 – 38 mph)	Trees in motion; walking difficult.
8	Fresh gale (39 – 46 mph)	Twigs break off trees.
9	Strong gale (47 – 54 mph)	Branches break; roofs damaged.
10	Whole gale (55 – 63 mph)	Trees snap; damage evident.
11	Storm (64 – 72 mph)	Widespread damage.
12	Hurricane (73 – 82 mph)	Extreme damage.

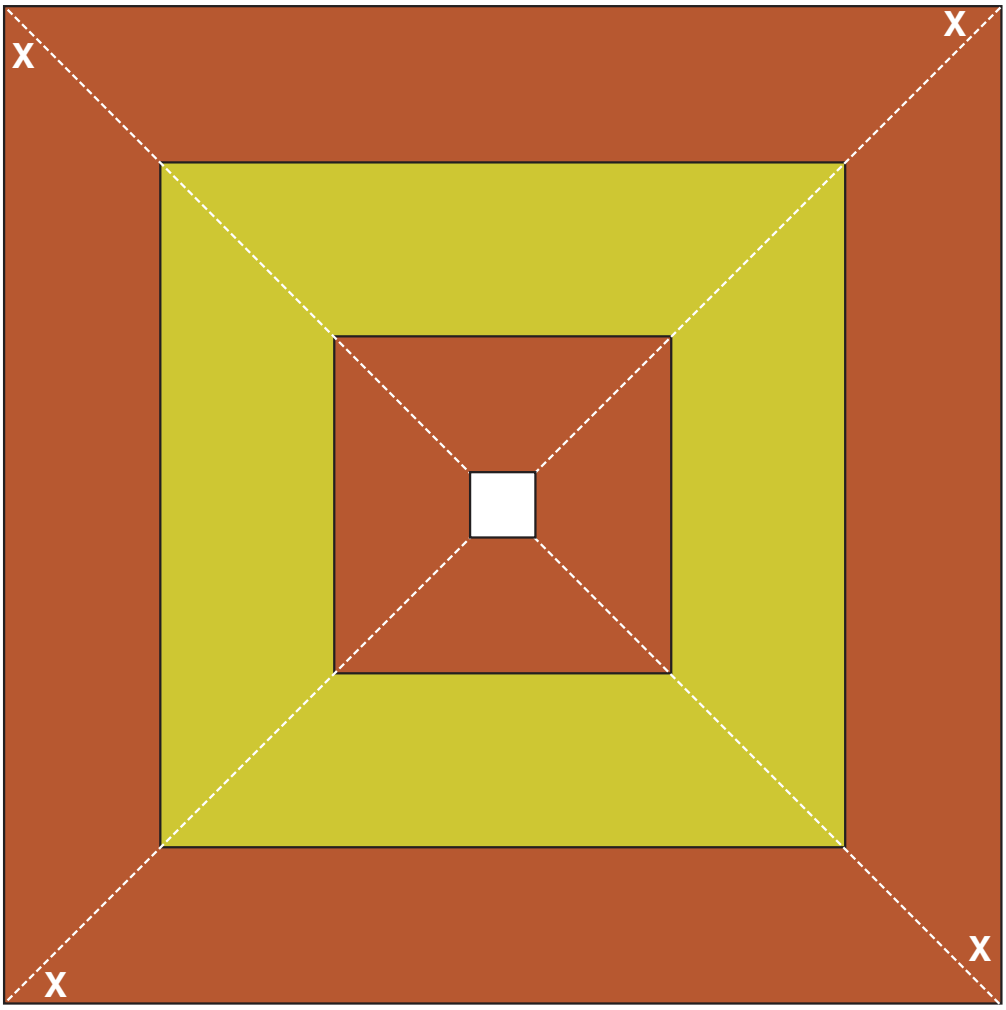
Estimating Wind Speed

Observe the wind at 8:00 a.m., 11:00 a.m., and 2:00 p.m. each day for five days in a row. Use the Beaufort Wind Scale to estimate the wind speed. Record the Beaufort number in the chart each time the wind is observed. For example, if you observe leaves rustling on Monday at 8:00 a.m., record "2" in the 8:00 a.m. Monday box.

	Monday	Tuesday	Wednesday	Thursday	Friday
8:00 a.m.					
11:00 a.m.					
2:00 p.m.					

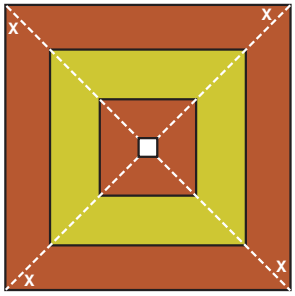
How to Make a Windmill

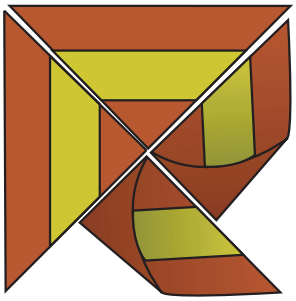
Materials: windmill pattern, straight pin, pencil with an eraser, scissors
Directions: First cut in at each corner, fold up corners marked X, pin corners to the center, then pin onto eraser of pencil.



Does the pinwheel move faster when you blow harder? Why?

Can you see a problem in the use of wind as an energy source?





A BOX OF SUNSHINE

SUBJECTS: Science

TIME: 150 minutes

MATERIALS: glass jars with lids, scissors, glue or tape, razor knife, cardboard, thermometers, styrofoam cups, disposable pie pans, flat black paint, newspaper, measuring cups, plastic wrap, watch, yardstick, paint brushes, shellac, thumbtacks, scissors, string, duct tape, masking tape, student sheets

Objectives *The student will do the following:*

1. Explain why seasons occur.
2. Define solar energy.
3. Demonstrate how solar energy can be trapped.
4. Construct a simple solar air heater.

Background Information

People have been using the sun's warmth for thousands of years. In ancient civilizations around the world, people learned how to build their homes and other buildings to maximize the sun's warmth in the wintertime and minimize it in the summertime. More recently, we have learned to build devices that trap the sun's warmth, making use of "*free*" energy from the sun – rather than a fuel – to warm water or air. These solar collectors can be built a number of different ways and may serve a variety of purposes. We have also learned more about designing buildings to take better advantage of solar energy.

Effectively collecting the sun's warmth means that the device or building trapping the solar energy must be positioned so that it receives the maximum amount of energy in the winter – when our Northern Hemisphere is tilted away from the sun, making its warmth less intense. The collector or structure must be faced with a material that lets the sun's rays enter but does not let their warmth escape; glass is the most commonly used material. The collector or structure also usually has a material that helps absorb heat energy. For example, black surfaces absorb heat very well.

Terms

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

solar energy: the energy we get directly from the sun's rays, especially the heat energy we can trap and use.

passive solar system: a device or structure that does not require mechanical parts to collect, store and make use of solar energy.

Procedure

I. *Setting the stage*

A. *Examine with the students the seasonal variation of the sun's path across the sky.*

1. Use a globe and a flashlight to help them understand how the tilt of the earth on its axis causes seasons. In winter, the sun appears lower in the sky because the Northern Hemisphere is tilted away from the sun. The heat of the sun is more spread out – is less intense – than it is in the summer. The opposite is true in summer, when the sun appears higher in the sky. The differing tilt of the earth makes the land and seas warmer in the summer and cooler in the winter.
   NOTE: Calendars are just our way of measuring the time it takes for all these things to happen.
2. Distribute copies of the student sheet "*The Sun's Daily Path*." Have the students examine the diagram. Discuss it with them, verifying their understanding of it.

B. *Tell the students that passive solar design principles have been known and used for a long time.*

This means that for thousands of years, people have known how to construct buildings so that they trap heat when it is needed in the winter but prevent heat gain in the summer. For example, ancient Indians in the American Southwest built homes into the south face of cliffs, so that they would be heated by the winter sun, but sheltered from the summer sun. Some ancient Greek homes had overhanging ledges or roofs for summer shade and winter heat collection. Some of the famous Roman baths were heated by the sun.

1. Have the students do the activity for which the directions follow.
   NOTE: Better results will occur during fall and spring months rather than winter months unless the classroom has a window facing south.
   a. Divide the students into groups of three or four students each. Give each group two thermometers and a glass jar with a lid.
   b. Make a chart that looks like the one below on the chalkboard. Have the students copy the chart and record their data on their copies.

Time	Temp. inside jar	Temp. outside jar
0 min.		
5 min.		
10 min.		
15 min.		
20 min.		

c. Each group is to place a thermometer in the glass jar and screw on the lid. Each jar is to be placed in direct sunlight and a second thermometer placed next to the jar.
d. The students are to read both thermometers and record the beginning temperatures at 0 minutes. They are to read and record the temperatures every 5 minutes for 20 minutes.

2. Have the students draw conclusions about the activity. Ask them the following questions:
   a. What happened to the temperature inside the glass jar during the 20-minute period?
   b. What happened to the temperature outside the jar during the same time?
   c. Which temperature was higher after 20 minutes?
   d. How did the glass jar affect the heat from the sun?
3. Tell the students that some people use heat from the sun to heat their homes. Ask them to find out about solar collectors. How are the collectors like the jars used in this activity?

II. *Activities*

A. *Have the students further investigate collecting solar energy.*

1. Discuss how the angle of the sun's rays is related to temperature. You might have the students repeat the experiment above at different times of the day *(e.g., early in the morning, at midday and at midafternoon)*.
2. Have the students do the activity below.
   a. Divide the students into groups of three or four and give each group a watch, two thermometers, two styrofoam cups and some water.
   b. Make a data chart on the board for the students to copy and use. *(See I.B. for an example.)*
   c. The students are to fill both cups with equal amounts of cold water and place a thermometer in each one.
   d. They are then to measure the temperature for each cup of water and record it. After putting one cup in the shade and one in the sun, they are to check and record both temperatures after 5, 10 and 15 minutes.
3. Have the students draw conclusions about the activity and answer the following questions:
   a. Where is it cooler *(sun or shade)*?
   b. How many degrees cooler is it?
   c. What happens to water standing in the sun all day?
   d. Would solar energy be a good means of heating a house in the woods?
4. Explain that the sun's energy can be captured most effectively by solar collectors placed on the south side of a house or other building, because the south side receives the most direct sunlight. Of course, it is very important that there is no shade to block the sun's rays.

B. *Have the students build and test simple solar collectors.*

1. Share the following information on solar heating: Huge amounts of energy come from the sun. We can make use of this energy by changing it into heat for our homes. Some houses have boxes on their roofs. These boxes, called solar collectors, have glass tops and are black inside. Water flows through them and is heated during the day by the sun's rays. When it is warmed, the water then flows to an insulated tank where it is stored for later use.
2. Have the students do the activity below.
   a. Divide the students into groups of three or four each. Give each group two disposable pie pans, flat black paint (*not water soluble*), a thermometer, a measuring cup, some clear plastic wrap, tape, two styrofoam cups and a small stack of newspapers.
   NOTE: To save time, you may want to spray paint the pans flat black beforehand.
   b. Make a chart on the chalkboard like the one below. The students are to copy it and record their data on their copies.

Time	Temp. in the sun	Temp. in the shade
0 min.		
15 min.		

   c. Each group is to paint both pans black and let them dry.
   d. They are then to pour 1/3 cup water into each pan, and to measure and record the temperatures of each on the chart. The plastic wrap is to be used to cover the pans tightly. *(The wrap should be taped to ensure a tight seal.)* One pan is to be set in a sunny area and the other in a shaded area. Both pans should be set on several sections of newspaper to keep the ground's temperature from affecting that of the water. After 15 minutes, each group is to pour the water into the two cups and measure the temperatures.
3. Have the students draw conclusions about the activity and answer the following questions:
   a. Which pan had hotter water?
   b. Why were the pans painted black?
   c. What purpose did the plastic wrap serve?
   d. Why pour the water into cups before measuring the temperature?

C. *Have the class build simple solar air heaters.*

1. Divide the class into groups of five or six students each. Each group is to construct a solar air heater, using the directions on the student sheet "*Build a Solar Air Heater*" *(page 31)*. Provide each group with cardboard, a yardstick, shellac, flat black paint, paint brushes, thumbtacks, scissors, duct tape, plastic wrap, a razor knife and masking tape.
2. When the air heaters have been completed and tested as directed on the student sheet, have the students evaluate the performance of their heaters.

III. *Follow–up*

A. *Have the students demonstrate knowledge of the following solar energy concepts:*

1. Explain the seasons. *(In winter, the sun is low in the sky. Its heat is more widely dispersed and less intense than it is in summer. In summer, the sun appears higher in the sky. Its rays are more direct, making the land and seas warmer in the summer than in the winter. These changes are due to the differing tilt of the earth on its axis. In winter, the Northern Hemisphere is tilted away from the sun; in summer, it is tilted toward the sun.)*
2. Define solar energy. *(Solar energy is the energy we get from the sun's rays; it can be used to heat homes or water.)*

B. *Have the students explain passive solar heating.*

(A passive solar heating system is one which relies largely on the natural flow of heat to collect and store heat from the sun's rays. It does not have pumps, fans, or other devices to help in this process. Simply put, a passive solar system is a building or a device that traps solar energy for use.)

C. *Have the students list some important factors in collecting solar energy.*

(Something to trap heat [a collector], a location free from shading, black surfaces to increase heat collection and so forth)

III. *Extensions*

A. *Some students might collect pictures and newspaper or magazine articles related to solar energy.*

These should be displayed and a presentation made about them. Some may wish to make a scrapbook on solar energy.

B. *Students may make crossword puzzles or word search puzzles about solar energy.*

These may be duplicated and copies given to classmates or other teachers' students

C. *Students may read books or stories about solar energy.*

This activity should be completed by doing one of the following:

1. Designing a poster advertising the books they read.
2. Making a *"filmstrip"* about the book on a long sheet of white paper. *(Adding machine tape works well.)*
3. Writing a summary of the book.

D. *Some students may wish to research solar energy-related careers.*

(This may lead to an investigation of possible solar energy applications for the future.)

Resources

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Franklin Watts, NY: Impact, 1985. *(pp. 57-62)*

Mallinson, Mallinson, Valentino, and Smallwood. Science – Grade 4.
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Mason, J. Power Station Sun.
East Grinsted, Sussex, England: BLA, 1987. *(p. 7)*

National Appropriate Technology Assistance Service.
Connections: A Curriculum in Appropriate Technology for 5th and 6th Grades.
N.p.: U.S. Department of Energy, 1986.
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Spetgang, Tilly, Wells, and Malcolm. The Children's Solar Energy Book.
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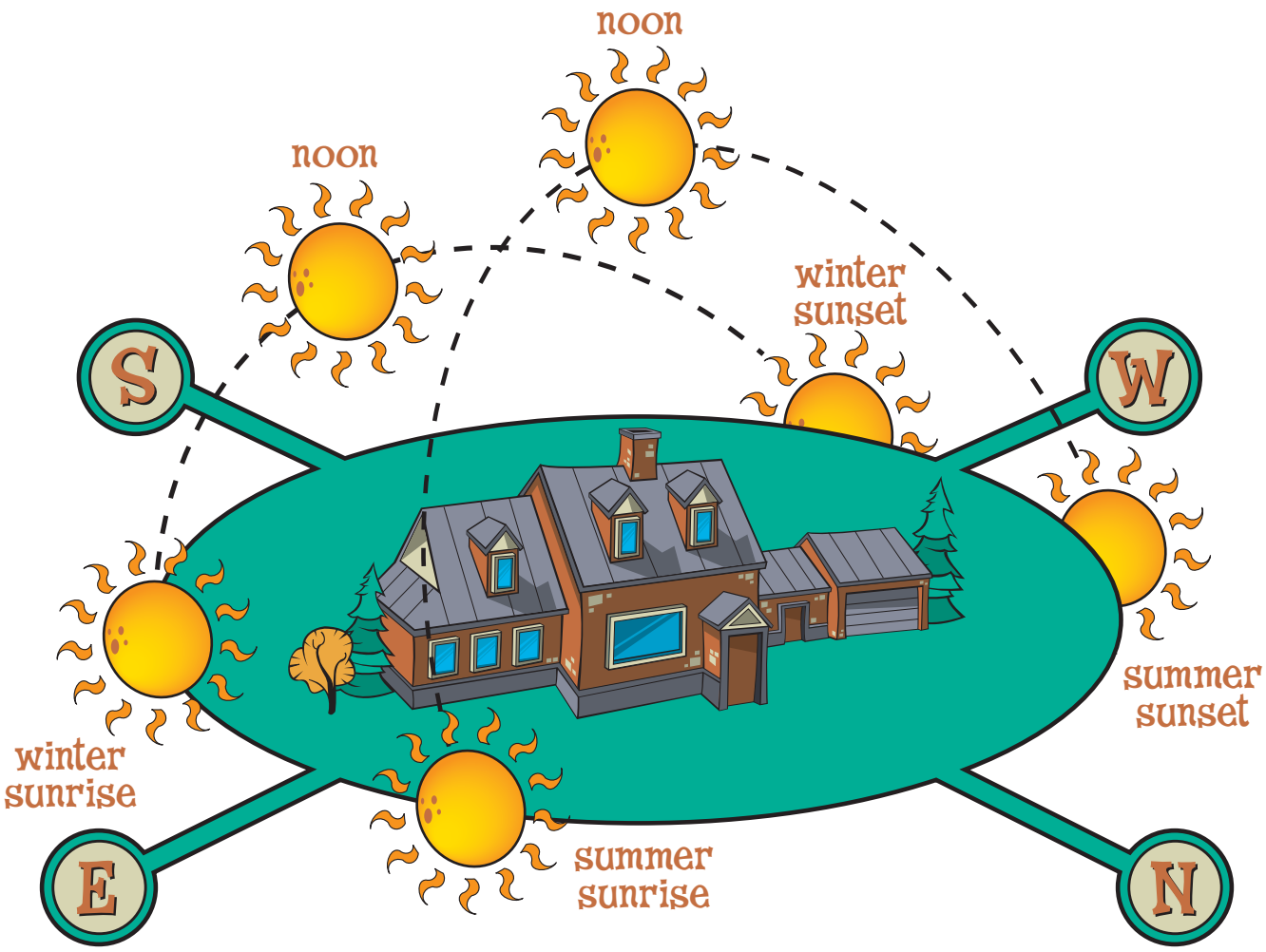
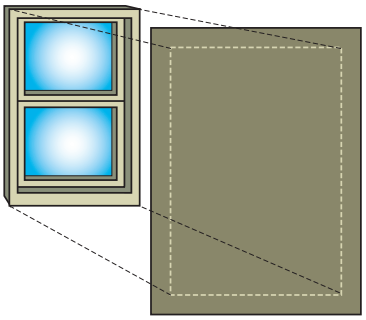
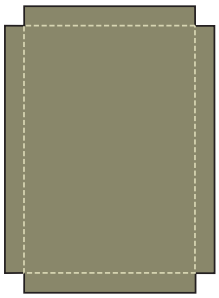
The Sun's Daily Path



Build a Solar Air Heater

I. *Prepare to build a solar air heater.*





A. Use a compass to find a window that faces due south.

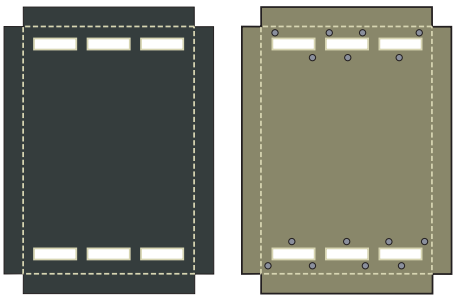
B. Measure the window to be used and get a piece of cardboard large enough to cover it overlapping at least 5 inches all the way around.

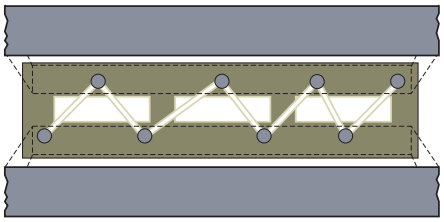
C. Mark off the exact size of the window on the cardboard. Add 5 inches all the way around the window size and cut out the heater as shown in the diagram.

D. Fold back the 5 inch flaps and test the box-like heater for a snug fit inside the window frame.

E. Cover one side of the cardboard with shellac. After letting it dry for 5-7 hours, paint it with flat black paint. Let the paint dry completely.

II. *Make the vent holes in the heater.*





A. Cut vents at least 3 inches high near the top and bottom of the heater, as shown.

B. Push thumbtacks into the cardboard around the vent holes as shown *(Put them in the unpainted side)*.

C. Weave some thin string around the thumbtacks, crossing the vent holes.

D. Cover the thumbtacks with strips of silver duct tape to keep them from falling out.

E. Get some thin plastic film *(like food wrap – do not use wax paper)* and cut strips large enough to cover the vent holes.

F. Tape the plastic to the outside *(black side)* of the bottom vents and to the inside *(string side)* of the top vents.

III. *Install the heater in the window.*

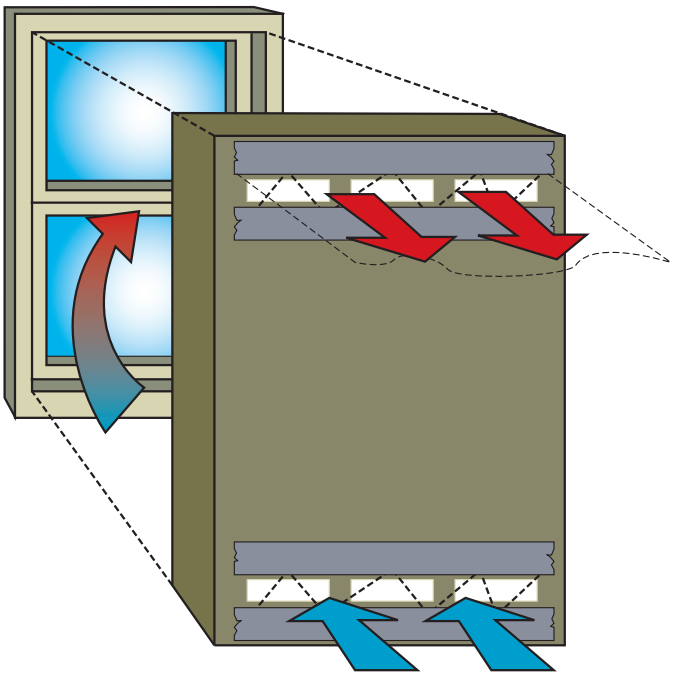
A. Place the heater – black side facing the window, top vents up *(so that the plastic flaps hang down over the vent holes)* – inside the window frame. Then tape it to the window frame with masking tape.

B. Leave an air space between the glass and the cardboard, but none around the edges of the cardboard.

C. After the heater has been in place for several class periods, check to see if warm air is coming out of the top vents.

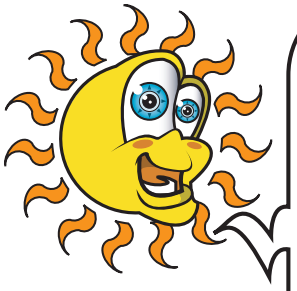
D. Don't leave the masking tape on the window frame too many days; it may pull the paint off with it when you remove it.

E. A smaller model can be made using a cardboard box taped to the window, leaving an airspace between the glass and the back of the box. Just follow the above directions.



CREDIT: Adapted from *Connections*, developed by NATAS. *See the listing of resources at the end of the teacher materials for this activity.*

FROM THE SUN TO YOU



SUBJECTS: Science, Health

TIME: 50-100 minutes

MATERIALS: crayons or markers, student sheet

Objectives *The student will do the following:*

1. Trace the flow of solar energy.
2. Recognize the relationship between the sun and the food chain.

Background Information

Energy from the sun is the basis for life on earth. Green plants must have the sun's energy in order to make sugars and other substances from carbon dioxide and water. The energy stored in the plants is then passed on to animals that eat the plants and is passed up the food chain as more *"eaters" (consumers)* participate in the food chain. The basis of every food chain is a green plant, and the sun provides the energy the plant must have.

Terms

food chain: a path by which energy and materials pass from one living thing to another in the form of food.

solar energy: the energy *(heat and light)* received from the sun.

Procedure

I. *Setting the stage*

A. *Ask the students the following questions:*

1. How many of you have eaten a hamburger before?
2. From where does the hamburger meat come?
3. What do cattle eat to live and produce hamburger meat? *(hay, grass)*
4. What makes hay and grass grow? *(sun, water, soil)*

B. *Define for the students the terms solar energy and food chain.*

C. *Share the background information with the students.*

II. *Activities*

A. *Give each student a copy of the student sheet "Food Chain."*
Discuss the illustrated food chain with them. Stress that the food chain begins with the sun and ends with the students.

1. Let the students color the student sheet *(if desired)*.
2. Divide the students into small groups. Let each group select a food the members like to eat and draw a food chain showing their consumption of that food. They may choose any meat, fruit, vegetable, grain or dairy product. *Guide their choices so that their selected foods are not too complicated; a simple food should probably be chosen*.

B. *Have the students write a short paragraph explaining how each food chain step is related to the sun.*

C. *Ask the students to think about things they use at school each day (such as pencils, paper, or books).*
Have them trace the object's origins back to the sun.

III. *Follow-up*

A. *Have the students define the terms solar energy and food chain.*

B. *Ask the students in each group to explain their food chain picture.*
Ask what food they chose and where we get this food. How does this animal or plant grow?

IV. *Extensions*

A. *Have the students investigate further the sun's importance to life on earth.*

1. Have some students design a bookmark explaining how it *(the bookmark)* originated from the sun.
2. Have the students write advertisements beginning *"Help Wanted: Need the Sun."* Limit the number of words so that the ads sound real. These may be collected and made into a *"Help Wanted"* page.
3. Some students may make collages of magazine pictures showing things we get from the sun.

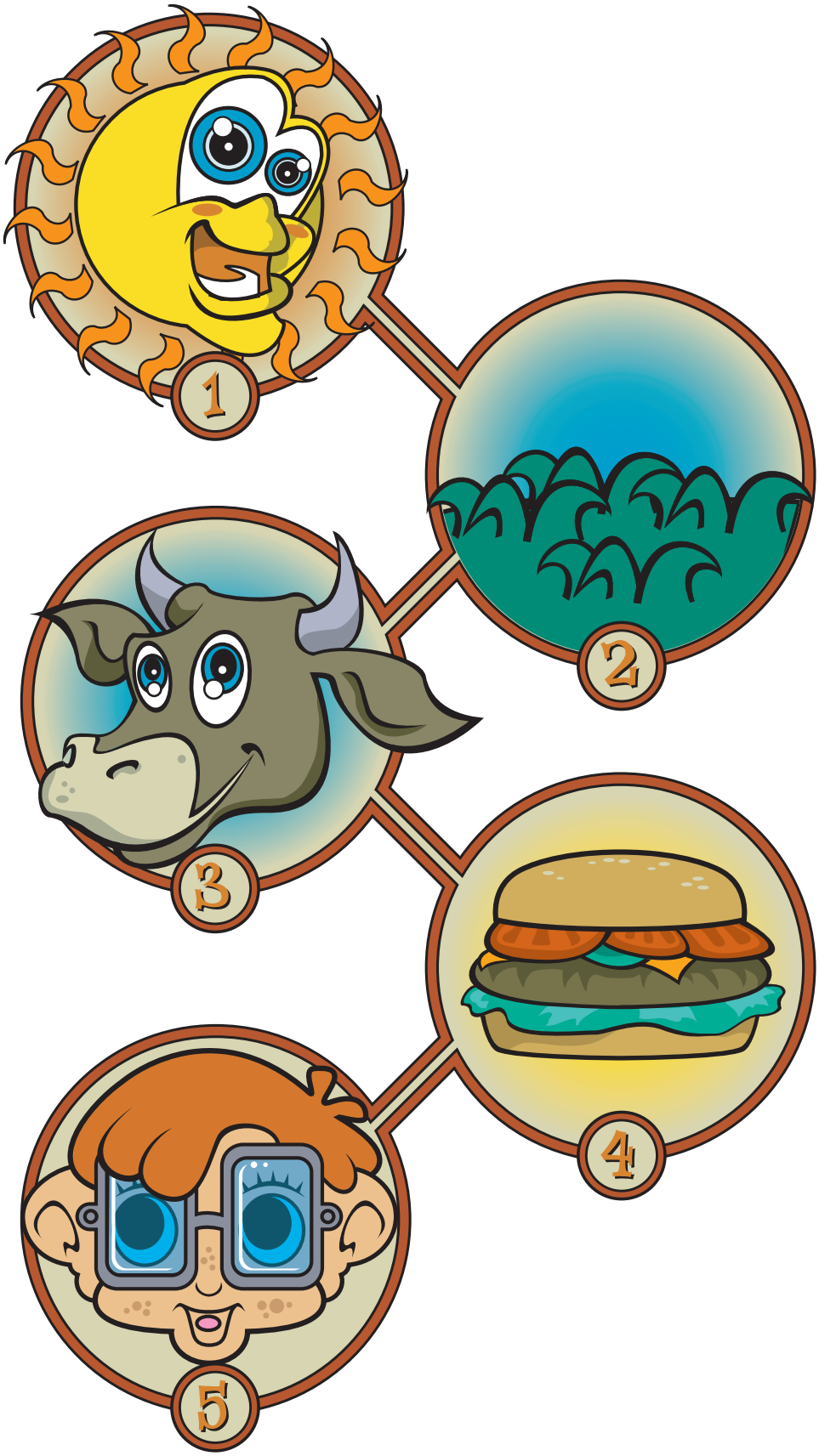
B. *As a writing assignment, some students may write a fairy tale about an evil being who takes away the sun one summer.*

Resources

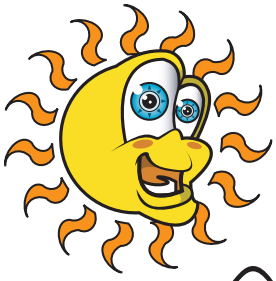
Marlinson, G. G., et. al. THE SILVER BURDETT ELEMENTARY SCIENCE PROGRAM *(pupils' books and teachers' editions, levels K-6)*. Morristown, NJ: Silver Burdett, 1984.

McDonald's Corporation. ECOLOGY AND ENERGY ACTION PACK. Oak Brook, IL: Author, 1977. *(Address: Director – Corporate Responsibility, McDonald's Corporation, One McDonald Plaza, Oak Brook, IL 60521.)*

Food Chain



Solar Sizzling!



SUBJECTS: Science

TIME: 50-100 minutes

MATERIALS: heavy cardboard box, black construction paper *(or flat black paint)*, tape, scissors, plastic wrap, small unwaxed paper cups, larger cups, apple slices, aluminum foil, newspaper, student sheets

Objectives *The student will do the following:*

1. Construct and use a simple solar cooker.
2. Learn practical uses of the sun's energy.
3. Learn the advantages and disadvantages of solar cooking.

Background Information

Exploring alternative sources of energy becomes more important as our other energy resources dwindle. The sun is the cleanest source of energy. Its light and heat are free as well as unlimited in supply. Of course, its availability varies from day to day and from place to place. It is also a diffuse energy source *(unlike fuels, which are highly concentrated)*.

Nevertheless, there are numerous ways to use this energy source. One use of solar energy is for cooking. Solar cooking is somewhat limited in that it can best be used only at mid-day and in fair weather. However, solar cooking is relatively simple and is important in some places in the world especially where firewood is in short supply.

Some day we may need the sun to provide most of our energy, so it is important to learn ways to harness this valuable resource. Solar cooking is but one avenue to be explored.

Procedure

I. *Setting the stage*

A. *Have the students think about the sun's importance.*

1. Read the following passage to the students:

   "Some say the sun is a golden earring, the earring of a beautiful girl. A white bird took it from her when she walked in the fields one day. But it caught on a spider web that stretches between the homes of men and the homes of the gods." FROM INDIA

2. Ask the students if they think this is a good description of the sun and why it is in the sky. Discuss why such stories were told *(to explain things in nature that people did not understand)*.

B. *Ask the students the following questions:*

1. What kinds of energy do we get from the sun? *(heat and light)*
2. What kind of energy is used for cooking? *(heat)* Ask them if they think the sun can be used for cooking. Why or why not? List their responses on the board.
3. Have they ever heard someone say that it is *"hot enough to fry an egg on the sidewalk?"* Discuss the saying, then share appropriate parts of the background information with the class.

II. *Activities*

A. *Tell the students that they will build a simple cooker to prove that we can use the sun's energy to cook food.*

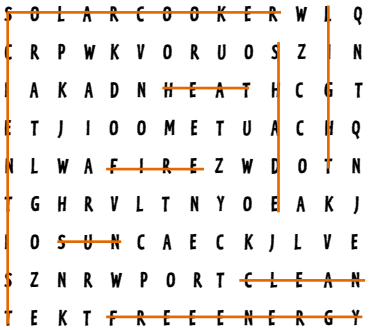
1. Let the students assist you in building the solar cooker(s), or build it ahead of time and explain how it was built. Use the following directions:
   a. Get a heavy corrugated carton from the grocery store.
   b. Fold in the open flaps and tape them down.
   c. Line the inside with black construction paper, or paint it flat black.
   d. The best foods to cook are simple ones. You might put hot dogs in an aluminum pan, fill a baking dish with baked beans or *(in summer)* put cookie dough on a cookie sheet.
   e. When you are ready to cook, put the dish of food inside the solar cooker and cover the box with a double layer of plastic wrap. Tape it down lightly.
   f. The cooker is to be placed outside in full sun. It may be flat on the ground or slightly tilted toward the south. It will receive the most sunshine from 11:00 a.m. to 2:00 p.m.; try to plan accordingly.
   g. Allow about 1.5 to 2 hours for the food to cook.
2. The next day, have a solar picnic. Cook some hot dogs in the solar cooker. Make "*sun tea*" also.
   a. Have the students record the cooking time, the time of day, weather conditions and the date for later discussion.
   b. Discuss with the students how the cooker might be improved.

B. *Use the sun's energy to bake apple slices.*

1. Prepare the materials for the students to construct their apple bakers. Spray painting the insides of the small cups flat black would simplify the assembly, as would obtaining sheets of foil-and-paper sandwich wrap *(like that used by fast-food restaurants)*.
2. Distribute copies of the student sheet *"Apple Baker" (page 41)*. Make the *"sun collector"* first; the baker is assembled outside. Choose a sunny day to cook the apples, and distribute to each student the materials he/she needs including an apple slice.
3. While the apple slices are baking, discuss the advantages and disadvantages of solar cooking with the students.

III. *Follow-up*

A. *Have the students do the word search puzzle on the student sheet "Solar Cooking Words."*



B. *Have the students answer the questions and draw a picture of the solar cooker on the student sheet "Cooking with the Sun."*

IV. *Extensions*

A. *Have the students conduct library research to find other recipes for solar-cooked foods.*
The recipes can be made into a solar cookbook, which may be shared with other classes or with the students' families.

B. *Have some students make acrostics using words about solar cooking.*
Posters could be made and hung in the classroom.

C. *Some students may write and illustrate limericks (funny five-line poems with the rhyme scheme aabba)*
The limerick should say something about the sun's energy and/or solar cooking.

D. *Interested students may plan menus using solar-cooked foods.*
The menus should include foods from all food groups. Posters showing these meals could be prepared for display.

E. *Some students may make their own word searches using the student sheet "Hidden Word Search."*
Have the students use the *"Hidden Word Search"* and the given words (*sun, solar cooker, scientist, free energy, clean, fire, light, heat, shade)* to make their own word search. The students can exchange papers and solve each others' puzzles. Sentences using each word in the puzzle should be written when the puzzles are solved.

Resources

Belting, N. M. THE SUN IS A GOLDEN EARRING.
New York: Holt, Rinehart, and Winston, 1962. *(pp. 2-5)*

Bonestell, C. THE SOLAR SYSTEM.
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"Building A Solar Oven." ORGANIC GARDENING.
August 1980.

Butti, K. and J. Periin. A GOLDEN THREAD: 2500 YEARS OF SOLAR ARCHITECTURE AND TECHNOLOGY.
New York:Van Nostrand Reinhold, 1980.

Halacy, B. and D. Halacy. THE SOLAR COOKERY BOOK.
Lakewood, CO: N.p., 1978.

Jackson, H. C. and I.L. Foilman. LIGHT, UNIVERSE, PLANTS, ENERGY.
St. Louis, MO: Milliken, 1979. *(p. 23)*

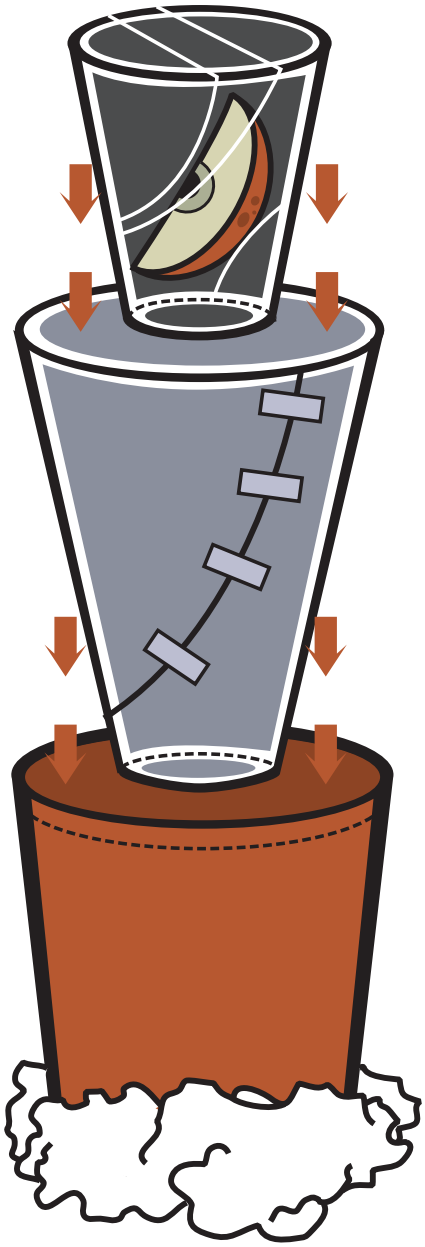
Kaplan, S. SOLAR ENERGY.
Milwaukee, WI: Raintree Publishers, 1983. *(pp. 39-43)*

Natural Sciences Industries. "SOLAR OVEN LAB" *(pamphlet)*.
Far Rockaway, NY: Author, 1976.

Oak Ridge Associated Universities *(assisted by Lawrence Hall of Science)*. "SOLAR ENERGY" *(pamphlet)*.
N.p.: Author, 1977.

Apple Baker

Materials: small *(unwaxed)* paper cup, black paper *(or spray paint)*, tape, white paper, aluminum foil, plastic food wrap, scissors, newspaper, large cup, apple slice



1. Line the inside of a paper cup with black paper *(or spray paint before-hand)*. Put a slice of apple in the cup. Cover the cup tightly with plastic wrap.

2. Make a large cone from white paper. Line the cone with aluminum foil. Put the apple cup down inside the cone.

3. Put the cone down inside a bigger cup. Crumple newspaper around the bottom of the outside cup.

4. Set up your apple baker outside in full sun. Aim the cone at the sun. Write down the time you start cooking. Check on the apple slice every 10 minutes or so. When the apple looks cooked, check the time again. How long did it take? _____ minutes.

5. How does the apple slice look? How has it changed?

   _____

   _____

   _____

   _____

6. You probably won't want to eat the apple slice, but birds and other animals might! Leave it outdoors for them, and dispose of the apple baker as your teacher instructs you.

Solar Cooking Words

Find the following terms hidden in the puzzle. Circle each term. Then write a sentence about solar cooking or solar energy using each of the words.

FREE ENERGY SOLAR COOKER SCIENTIST SUN CLEAN SHADE LIGHT HEAT FIRE

S	O	L	A	R	C	O	O	K	E	R	W	L	Q
C	R	P	W	K	V	O	R	U	O	S	Z	I	N
I	A	K	A	D	N	H	E	A	T	H	C	G	T
E	T	J	I	O	O	M	E	T	U	A	C	H	Q
N	L	W	A	F	I	R	E	Z	W	D	O	T	N
T	G	H	R	V	L	T	N	Y	O	E	A	K	J
I	O	S	U	N	C	A	E	C	K	J	L	V	E
S	Z	N	R	W	P	O	R	T	C	L	E	A	N
T	E	K	T	F	R	E	E	E	N	E	R	G	Y

Cooking with the Sun

Describe one advantage and one disadvantage of solar cooking.

Advantage:_____

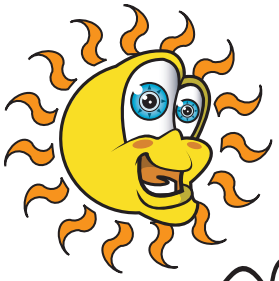
Disadvantage:_____

Draw a picture of the solar cooker that we used and show where the box should be placed for the best results.

Hidden Word Search

Make your own hidden word search using these words – sun, solar cooker, scientist, free energy, clean, fire, light, heat, and shade. When the puzzle is solved, write sentences using each word.

SOLAR GREENHOUSES



SUBJECTS: Science

TIME: 220 minutes

MATERIALS: *(for each group)* cardboard box, 2 coffee cans, spray paint *(various colors including black and white),* razor knife, tape, plastic wrap, thermometer, compass, wood chips, rocks, teacher sheet

Objectives *The student will do the following:*

1. Explain the advantages of solar greenhouses.
2. Explain the importance of the three major components of solar greenhouses – glazing, heat storage materials and insulation.
3. Build a solar greenhouse model.
4. Compare the effect of different colors on solar heat absorption.
5. Compare the effect of different materials on solar heat storage.

Background Information

Solar greenhouse development started in Canada in the early 1970s. Solar greenhouses are designed to maximize the usefulness of solar energy. There are thousands of solar greenhouses in the United States. Some of the advantages that may be enjoyed because of solar greenhouses are fresh fruits and vegetables year-round, foods free from chemicals and new hobby opportunities. Another important advantage of solar greenhouses is that they can be attached to houses providing substantial heat, a bright room and humidity to make the houses more comfortable.

A solar greenhouse must have glazing, heat storage materials and insulation. The glazing in a solar greenhouse is the transparent or translucent window-like material that allows sunlight to enter and keeps heat from escaping. Most of the glazing is on the south side of the greenhouse where it will collect more energy during the day than it loses at night. Double glazing reduces heat loss day and night. Materials that can be used for glazing include glass, acrylics and fiberglass.

Heat storage material in the greenhouse absorbs solar energy in the daytime and then releases the stored heat at night when the greenhouse cools off. Cement, earth, bricks, stone or large containers of water may be used as storage materials. Very dark colors are used because they absorb heat best. If heat storage materials are not used, the air temperature could reach up to 140 degrees (F) on a very hot, sunny day, and the night temperatures could get quite cold. This is, of course, not comfortable or desirable for people or plants. Massive heat storage materials tend to stabilize the temperature, improving both the comfort of the greenhouse for people and the productivity of plants.

Insulation is another key factor in the efficiency of solar greenhouses. They should be well-insulated to prevent as much heat loss as possible.

Terms

glazing: glass or other transparent material used to trap solar energy in a solar device or building.

heat storage materials: materials such as concrete, rocks or water that are capable of absorbing heat energy and slowly releasing it as the atmosphere cools down.

insulation: material that hinders the flow of heat energy.

Procedure

I. *Setting the stage*

A. *Ask the students the following questions:*

1. What forms of energy do we get from the sun? *(heat and light)*
2. What do plants need to grow? *(heat, light energy, water, nutrients from the soil)* Lead the students to deduce that plants need sunlight to grow.
3. Why don't we have gardens in the winter? *(the weather is too cold)*
4. How could we have gardens all year? *(Lead the students to answer "greenhouse.")* Explain to the students that some greenhouses use special light and heating to produce plants year-round.

B. *Show a transparency made from the provided teacher sheet "Solar Greenhouse."*

Share the background information with the students while showing the transparency *(page 52)*.

1. Discuss the advantages of solar greenhouses.
2. Explain the importance of glazing, heat storage materials and insulation in the workings of a solar greenhouse.
3. Explain that dark colors absorb more heat energy than light colors.
4. Relate insulation to the way we insulate our bodies. Ask the students why we wear coats, hats, gloves and so on in the winter. Hold up several articles of clothing *(for example a T-shirt, a windbreaker, gloves, sandals and a hat)*. Ask the students which they would wear if they were going to an outdoor ballgame when there is chance of snow. Ask the students why they would wear those items. Lead the students to answer that they trap and store body heat. Explain that the same principle applies to a solar greenhouse; it needs to be well-insulated to prevent heat loss.

II. *Activities*

A. *The day before the activities are to be done, ask the students to wear variously colored shirts* (*red, white, blue, yellow, black, brown and dark green*).

1. Take the class outside. You will need several compasses. Review briefly the information about the solar greenhouse.
2. As you stand outside in the sunshine, ask the students the following questions:
   a. Which one of you is absorbing more heat? Why? Who is absorbing less heat? Why?
   b. Ask the students to explain their different heat absorptions in terms of the colors of their shirts.
3. Take the students to your car. Ask the students, *"If my car was a solar greenhouse, what direction would I want it to face?" (south)*
   a. Have the students identify the instrument used to find geographical directions. *(compass)*
   b. Distribute several compasses. Have the students find south?
   c. Ask the students what the glazing would be if your car was a greenhouse. *(the windows)*
   d. Let some of the students take turns sitting in the car to feel the stored heat.

B. *Have the students do the following activity to show that dark colors absorb more heat*.

1. Divide the students into groups of four.
2. Have each group bring to class a cardboard box, two coffee cans, any color spray paint and plastic wrap. Provide tape and a thermometer for each group.
3. Have the students build and use a model greenhouse as instructed below.
   a. A window should be cut out of the front of the box using a razor knife. CAUTION – SUPERVISE CAREFULLY!
   b. Have the students spray paint their cans. For example, group #1 may have two black cans; group #2, white cans; and so on.
   c. Have each group cover the front of its box with a double layer of plastic wrap, taping it securely across the top of the box. Leave the bottom and sides of the plastic free.
   d. Take the students outside and give each group a compass so that the students may determine how to face their model solar greenhouses toward the south.

e. Return to the classroom and have each group make a chart that looks like this:

Time	Temperature
8:00 a.m.	
11:00 a.m.	
2:30 p.m.	

f. At the beginning of the following day, have each group take its model greenhouse, water-filled cans, tape, a thermometer, the data chart and a pencil to the experiment location previously chosen.

g. Have each group measure the temperature of the water and record it on the data chart.

h. Have each group place the cans of water in the model greenhouse and securely tape the free edges of the plastic to the box.

i. Have each group measure the water's temperature again at 11:00 a.m. and 2:30 p.m. *(When they re-measure, the tape will have to be pulled away. Remind the students to re-tape securely, so that the greenhouse will not lose heat.)*

4. Back in the classroom, compile the charts for each group's temperature readings. Put the compiled chart on the board or make a transparency. The compiled chart should look something like this:

Time	Black	Brown	Dk. Green	White	Yellow	Blue
8:00 a.m.						
11:00 a.m.						
2:30 p.m.						

5. Discuss the findings with the students. Ask the students what colors seemed to absorb more heat, why they think this is so, what colors absorbed less heat and why they think this is so.

6. If some data show the light colors absorbing more heat, ask what could have gone wrong. *(glazing was not secure, box had a hole in it [poor insulation], they read the thermometer incorrectly, and so on)*

C. *Have the students modify the experiment to investigate heat storage.*

1. Have the students test the heat storage capabilities of different materials using the solar greenhouse model in II. B.
   a. Provide three black and one white spray-painted cartons, coffee cans or other containers – one per group. The first group should obtain a black container of rocks; the second, a black container of wood chips; the third, a black container of water; the fourth, a white container of water.
   b. Have the students follow the directions given in II. B.
2. Back in the classroom, compile the charts for the temperatures of the different types of storage materials. Put the compiled chart on the board or on a transparency so the entire class may see it. The compiled chart should look something like this:

Time	Container with rocks	Container with wood chips	Black container with water	White container with water
8:00 a.m.				
11:00 a.m.				
2:30 p.m.				

3. Have the class discuss which material stored the most energy.
4. Ask the students the following questions:
   a. What heat storage materials would you use if you were building a solar greenhouse? Why?
   b. What would you not use? Why not?
   c. What would be the most practical? Why do you think so?

III. *Follow-up*

A. *Ask the students the following questions:*

1. What colors absorb the most heat? *(dark colors)*
2. What colors absorb the least heat? *(light colors)*
3. How can we relate this to solar greenhouses? *(They need dark-colored storage containers to absorb more heat.)*
4. Why do solar greenhouses need heat storage containers? *(The containers absorb the solar energy in the daytime to keep the greenhouse from getting too hot and release the heat at night to keep the greenhouse from getting too cool)*
5. What would happen in a solar greenhouse that did not have any heat storage containers? *(It would get too hot in the daytime and too cool at night. The plants would be harmed and it would be uncomfortable for people.)*

6. In the model solar greenhouse that you made, what material did you use for glazing? *(plastic)* What are some materials that real solar greenhouses use for glazing? *(glass, acrylics and fiberglass)* What is the purpose of glazing? *(It allows the sunlight to enter and keeps the heat from escaping.)*
7. Which direction does the front – the glazing – need to face? *(south)* Why? *(to get the most direct sunlight)*
8. How do we insulate our bodies? *(by wearing coats, gloves, hats, shoes and so on)* Why do we wear these things? *(to trap our body heat so we can stay warm)*
9. Why does a solar greenhouse need insulation? *(to keep it from losing heat energy at night or in cold weather)*
10. Summarize the findings of the experiments.

B. *Discuss with the students the following items:*

1. Have the students suggest some ideas for building efficient solar greenhouses. *(Ideas should be drawn from the class's solar greenhouse discussion and experiments. Accept reasonable answers. They should include the fact that the greenhouse should face south and should have glazing, heat storage materials and insulation.)*
2. Have the students list the advantages of solar greenhouses.
3. Have the students compare and contrast the different types of heat storage materials used in the experiment.

III. *Extensions*

A. *Some students may draw murals or make collages of some types of plants that might be found in a solar greenhouse.*

B. *Have the students write a newspaper advertisement for a greenhouse plant sale.*

C. *Have the students write poems about greenhouses.*

Brainstorm together with the students for words that rhyme with house.

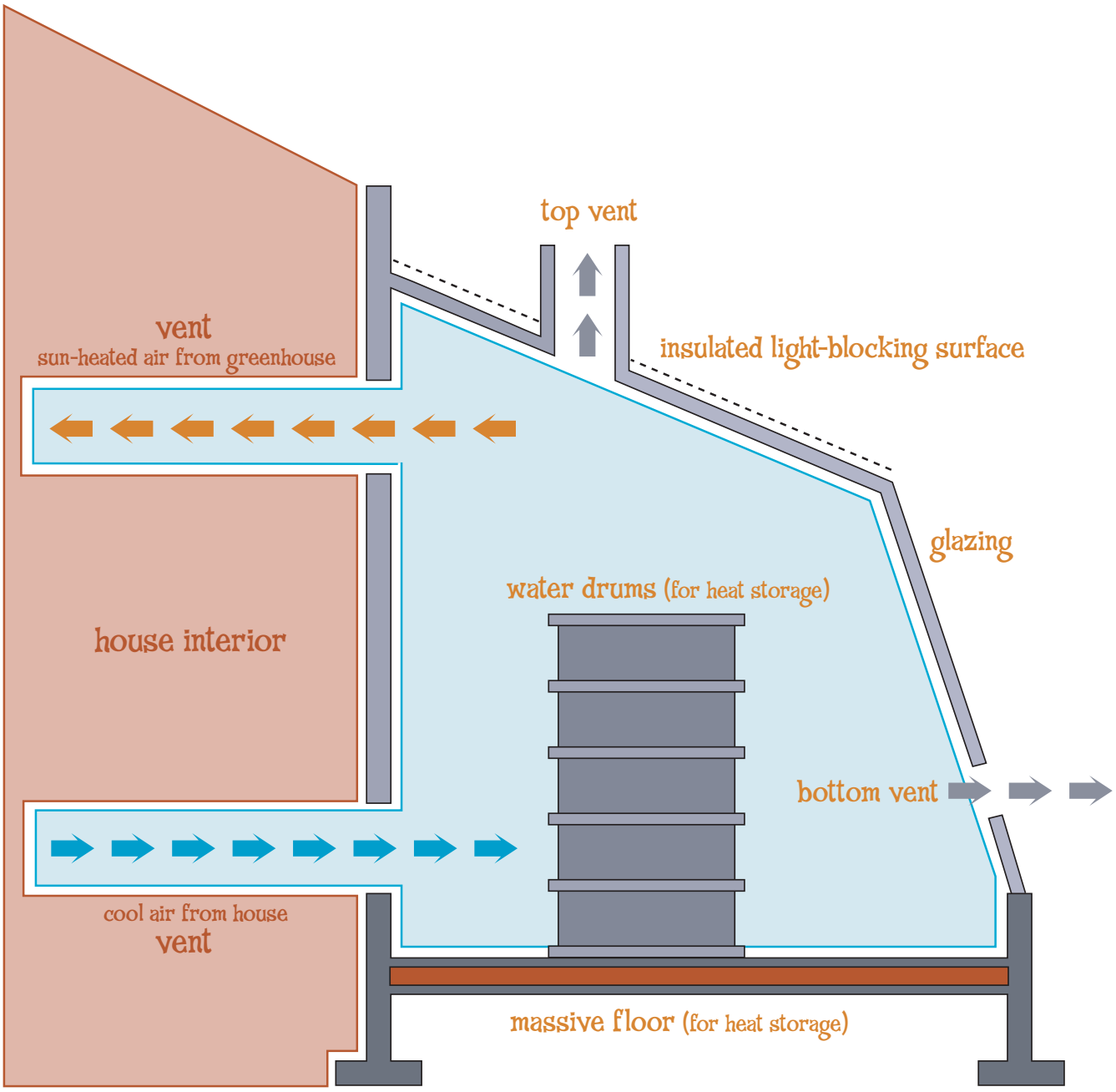
Resources

Alabama Solar Energy Center. BUILDING AND USING THE SOLAR GREENHOUSE. Huntsville, AL: Author, July 1984. *(Address: The University of Alabama in Huntsville, Research Institute, Box 212, Huntsville, AL 35889.)*

Fisher, R. and B. Yanda. THE FOOD AND HEAT PRODUCING GREENHOUSE – DESIGN, CONSTRUCTION, AND OPERATION. N.p: N.p, 1976.

National Appropriate Technology Assistance Service. BUILD A SOLAR GREENHOUSE. Butte, MT: Author, July 1980. *(Address: NATAS, P.O. Box 2525, Butte, MT 59702-2525. Telephone: 1-800-428-2525.)*

Solar Greenhouse



BE "SUN"-SIBLE ABOUT HEATING WATER

SUBJECTS: 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

Objectives *The student will do the following:*

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

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 system's 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*" *(page57)*.
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. *Activities*

A. *Have the students investigate color and heat.*

1. Have the students do the activity on the student sheet *"Which Color Holds Heat Longest?" (page 58)*.
   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"(page 59),* 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 Heater Model" (page 60)* to each group and hand out the materials needed.
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.
2. 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. *Extensions*

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 Factsheet/Solar Water Heaters."
Huntsville, AL: Author, n.d.

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

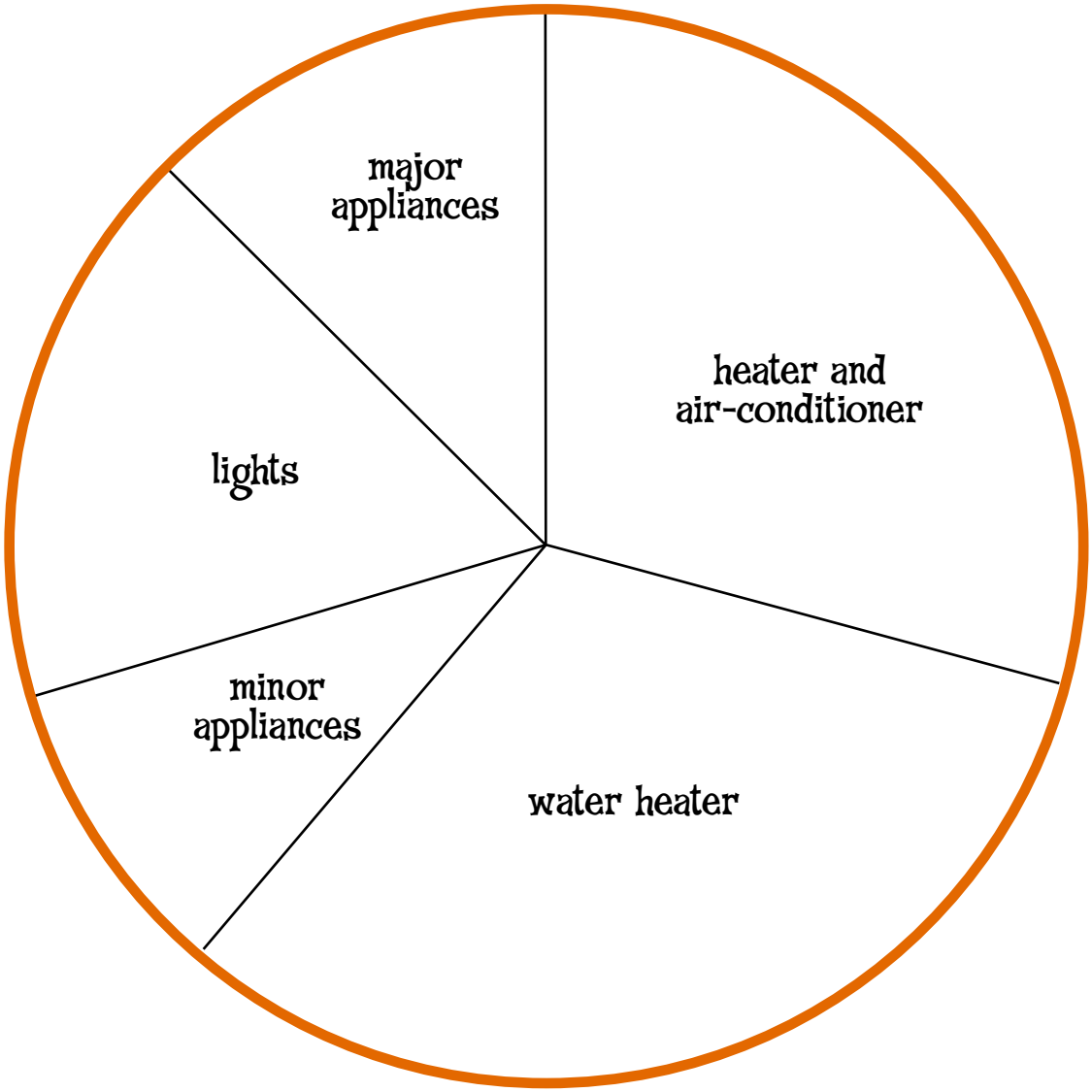
Barufaldi, J. P., G. T. Ladd, and A. J. Moses. Heath Science, Levels 3-5.
Lexington, MA: Heath, 1984.

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.

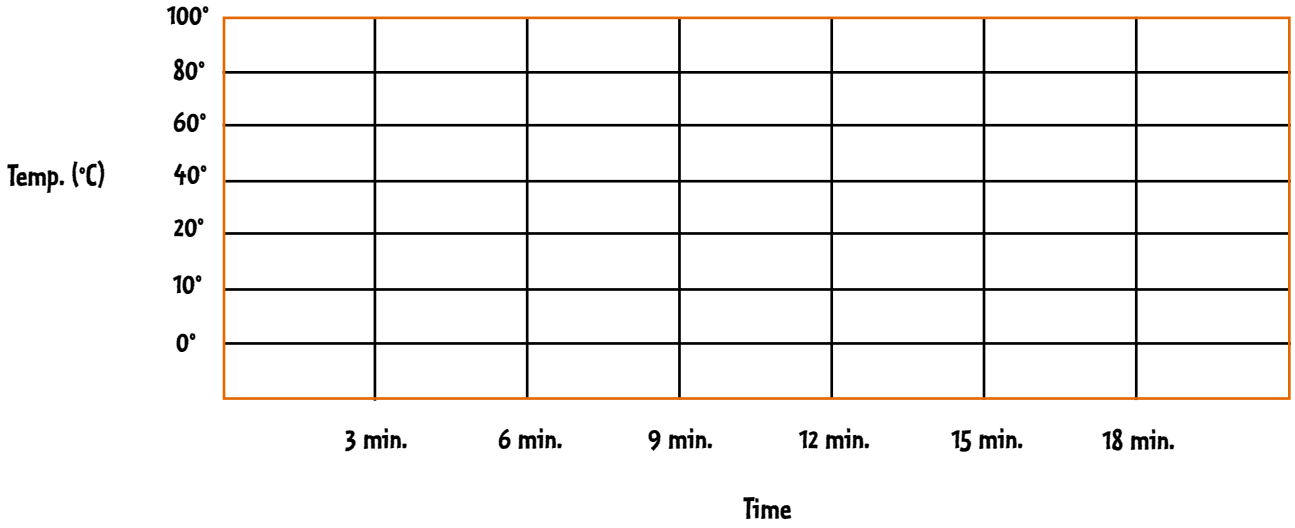
What are some ways the Jones family could decrease their electric bill?

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

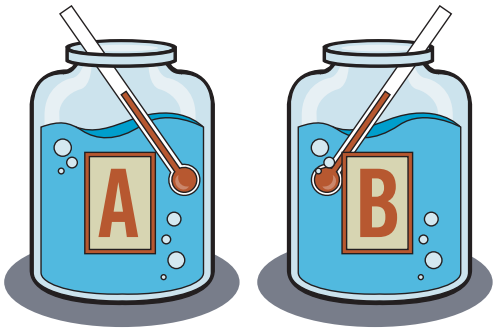
1. Paint each can a different color.
2. Fill each can with the same amount of hot water.
3. Add food coloring to the hot water; add drops of all the colors together to get black.
4. Put a thermometer in each can.
5. Read and record the temperature every three minutes until the water cools.
6. Make a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



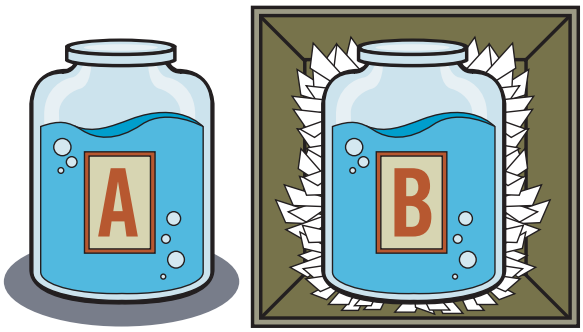
Which color held heat best?_____.

Insulation Really Works

Fill two 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.

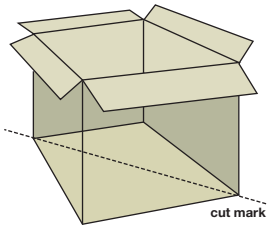


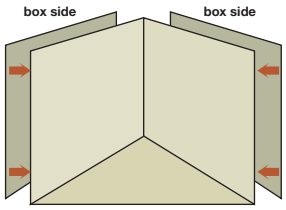
After one of the jars is "insulated," read and record the temperature of each jar every 10 minutes. After 30 minutes have passed, compare the results.

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

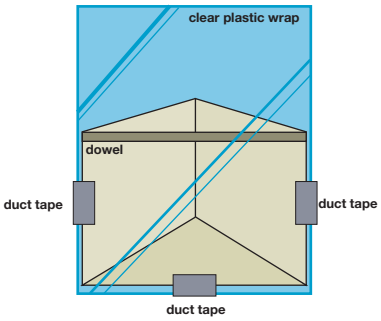
How to Make a Solar Water Heater Model

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 left-over 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)*.

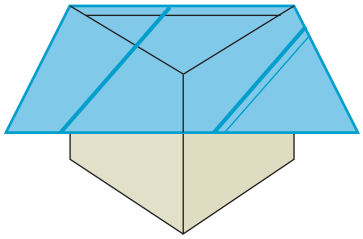




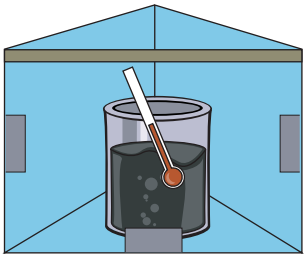
2. ***Glazing the box.***
   Tape a small stick of wood *(a dowel)* across the top corners of the heater box as a brace. Use silver duct tape. Tape clear plastic wrap to the bottom and sides of the box as shown. Make sure it is long enough to have some left over to fold over the top. The fold-over flap 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 cart 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.



fact sheet

ENERGY

Energy Defined

Most of us have some intuitive idea of what "*energy*" means. Although we might not be able to formulate a definition of the word, we use it often and in various contexts. The definition of energy used most often in physical science is *"the ability to do work."* What does *'work"* mean? Work can perhaps most easily be defined as a change in the position, speed, state or form of matter. Therefore, energy is the capacity for changing matter.

Perhaps it is easier to think in terms of what energy does than what it is. How do we detect energy; that is, how is it displayed? When heat or light is given off, energy is displayed. When objects move, energy is displayed. When sound is produced, energy is displayed. There are many ways in which we detect that energy is changing matter.

Law of Conservation of Energy

Obviously, energy is a rather abstract concept. In fact, the importance of the concept of energy was not really understood by scientists until the mid-1800s. Up until that time, scientists dealt with all the different known kinds and manifestations of energy as separate entities. The idea of energy as a universal concept – one thing that can take many forms and change from form to form – was then conceived. With this realization came the development of the principle of energy conservation *("scientific" conservation – not "utility bill" conservation)*. The Law of Conservation of Energy states that the total amount of energy in a system *(even the universe)* remains constant *("is conserved")* although energy can be changed from one form to another or transferred from one object to another. The concept of energy conservation is one of the fundamental concepts of modern science.

The energy conservation principle means that energy is conserved – still exists in some form – even though we may no longer be able to detect it or harness it for our purposes. For example, energy changes forms many times in the process of generating electricity in a fuel-burning power plant and then using the electricity to toast a piece of bread. Along the way, much energy escapes, primarily as waste heat. Just think of all the heat that escapes from the toaster alone. It is not put to use toasting the bread at all. In fact, it merely warms the air and the surface on which the toaster sits. Eventually the heat is so scattered that we can no longer detect it, but it still exists. The amount of energy in the universe is constant although the energy itself changes. This sequence of changes may be thought of as energy flow. Energy flows throughout the universe, constantly changing but remaining constant in total amount.

Forms of Energy

What are some of the forms in which energy can be found? Energy may be classified as either kinetic or potential energy. The easiest way to think of these is to generalize the terms. *"Kinetic"* refers to motion, so matter that is moving or displaying phenomena related to motion *(such as heat, light, sound and so on)* has kinetic energy. Matter that has the capacity of doing this – but is not doing it – has potential energy. There are two ways in which matter may have potential energy. Some matter has stored energy by virtue of its composition. *(examples include fuels.)* Some matter has energy by virtue of its position; for example, an arrow held in a drawn bow.

Heat, light, sound and motion are forms of energy familiar to us in our everyday lives. There are five energy forms from which we often obtain these and these are also familiar to us. Mechanical energy is the energy found in machines. It in turn comes from whatever powers the machines including electricity, flowing air *(or water or steam)* or human and animal muscle power. Of course each of these can be traced back through a chain of energy transformations also. Chemical energy is the energy contained in the chemical makeup of fuels or batteries. Again, it is but one form in a chain of energy transformations. In order to see the effects of chemical energy, we must do something to release it. Solar energy is the energy that comes to earth from the sun. It is primarily heat and light. The solar energy supplied throughout the earth's history is the source of almost all the energy on the earth. Nuclear energy is one of the only energy forms that cannot be traced back to the sun. Its source is the incredible energy binding together the particles making up the nuclei of atoms; when nuclei are split apart or fused together, energy is released. Electrical energy is found in nature in lightning, a form unusable to us. The electricity on which we are so dependent today is produced from other energy forms using machines we invented. We use it to produce many forms of energy.

Energy Use and Resources

When we speak of "*energy,"* we are usually referring to energy resources and the ways we use them. Energy resources are the things we obtain from nature in order to use their energy. All fuels are obtained from nature; these include coal, oil, gas, wood, crops for alternative fuel production *(such as alcohol from grain)* and uranium for nuclear power. Energy from the sun is the earth's primary energy resource. The energy we get from wind and water depend on the sun. Heat from deep inside the earth *(geothermal energy)*, the energy of rising and falling tides and the energy available from ocean temperature differences *(even that from seawater itself)* are resources we may be able to use more in the future.

Our demand for energy and our consumption of energy resources has increased at a much greater rate than the growth of human population. This is due to the fact that we have invented ever-increasing numbers of devices that consume energy resources. These devices replace human and animal labor and make our lives much easier than those of our ancestors *(or people in less-developed areas of the world)*. We pay a price, however, in that we are, very dependent upon the energy resources we consume.

fact sheet

RENEWABLE and NONRENEWABLE RESOURCES

Definition

Resources are the supplies of useful or valuable things from which we make or obtain things we need or want. Everything must come from something else; resources are those things with which we begin. Many of our resources are materials from nature. The sources of energy we use are also resources. Some of them are materials and some are not. For example, energy from the sun is a vital resource to life on earth. In addition and our industrialized society depends on the energy we get from coal, a fuel extracted from the earth.

Resources may be classified as either renewable or nonrenewable resources. Renewable resources are those that are replenishable or restorable. Nonrenewable resources are those that cannot be replenished, restored or that require extremely long periods of time to be replenished.

Renewable Resources

Some of the energy resources we use are renewable resources. Solar energy is a virtually inexhaustible resource. The sun's energy also powers two other renewable sources of usable energy – the water cycle and the wind. It is the sun's heat energy that evaporates water from the earth's surface so that it may fall again in some form of precipitation. Humans have used the energy of water flowing in streams, rivers and oceans for many centuries. Water wheels once powered many mills for grinding grain, pressing oil from olives, and manufacturing textiles and metal products. Today, hydroelectricity – electricity generated using falling water's energy – is an important renewable resource around the world. The sun also powers the wind which results when different air masses absorb different amounts of solar heat and therefore move about in the atmosphere. People used windmills and other wind-powered devices in many of the ways in which water wheels were employed. Before rural electricifation, windmills were common across America's farmlands; they provided the mechanical energy to perform tasks like pumping water. Today, modified windmills can be used in locations where the winds are both strong and constant enough to generate electricity. Both water and wind are inexhaustible resources.

A more indirect source of solar energy is plant matter. Plants store solar energy in the chemical compounds they assemble using the energy of sunlight. Examples of using plants as energy resources include firewood and liquid fuels produced from plant material *(e.g., alcohol fuels made from grain crop wastes)*. Plant materials are renewable resources because more plants can be grown. While farming and reforestation both require careful management of the land and crops, not to mention the time required, energy resources from plant materials can nevertheless be replenished.

Another energy resource that can be classified as a renewable resource is waste – anything that is discarded. Animals produce bodily waste. This waste material can be dried and burned as a fuel, as is common in some developing countries where firewood is in short supply. On a larger scale, such waste can be treated in devices called digesters; bacteria digest part of the waste matter, producing methane, which is similar to natural gas and may be used as a high-quality fuel. Some of the wastes we discard each day – primarily paper *(and some plastics)* can be burned or chemically converted into another type of fuel to be burned. This energy may be used directly as heat or may be used to run a steam-powered generator.

Resources that are raw materials may also be classified as renewable or nonrenewable. Examples of renewable resources that are used for the products we need and want are primarily plant and animal products, such as foods and fibers.

Nonrenewable Resources

About ninety percent of the total amount of energy we use in this country comes from nonrenewable resources, chiefly the fossil fuels – coal, oil and natural gas. These are called fossil fuels because they were formed over tremendously long periods of time from buried, partially decayed, ancient plants and animals. The energy stored in these fuels is actually traceable back to the sunlight that fell to earth in the lifetimes of the organisms. Although the kinds of processes that formed fossil fuels are ongoing in the world even today, fossil fuels are not renewable resources; their formation is far too slow for us to be able to look forward to renewed supplies of them in the foreseeable future.

Another nonrenewable energy resource is the uranium we must have for nuclear fission processes – the only way we currently can use nuclear energy to produce electricity in power plants. Uranium is not a very common element in the earth and less than one percent of it is usable in nuclear fission, but the amounts of energy available from it are incredibly large.

Nonrenewable resources we use as raw materials are primarily mineral resources such as metals and rocks. There are no more minerals being formed, so when we extract them from the earth, we are using irreplaceable resources. Soil, which is made from rocks, is another nonrenewable resource. The processes which weather rocks and produce soil are ongoing, but very long periods of time are required to make even a small amount of soil. We therefore consider soil to be a nonrenewable resource; once it is lost from a given area by erosion, the area suffers. *(Of course, soil is not destroyed. It is simply moved around, often to where it is not useful and may be harmful; for example, eroded soil often clogs streams.)*

Two of the fossil fuels are very important as raw materials. Coal and oil are used to make many of the products we use each day; they are important chemical resources. The most noteworthy use of these is the use of oil to make plastics. Most plastic products are designed to be used once, or for a short period of time, and then discarded. Each time we do so, we are discarding a very valuable nonrenewable resource. It has been suggested that someday our descendants may be amazed that we actually used these valuable chemical resources – fossil fuels – as fuels to be burned.

Implications for the Future

It is clear that we must be mindful of how we utilize resources, especially nonrenewable resources. In order to preserve supplies of nonrenewable resources, we must use more renewable resources and use nonrenewable resources as wisely and efficiently as possible. This is the essence of resource conservation. Supplies of nonrenewable resources will someday be small enough that we can no longer afford to obtain them and use them. We must begin to use more renewable resources, especially energy resources, and we must begin to recycle and reuse more materials.

fact sheet ENERGY CONSERVATION

Definition

Energy conservation can be defined as the wise and efficient use of energy. The wise use of energy involves judgments about energy use *(i.e., use of energy resources)*. It may mean changing wasteful habits and making energy use choices based on an awareness of the need for energy conservation.

Another aspect of energy conservation is the efficient use of energy. When we say we *"use"* energy, we mean we change it or harness it to do work. We can change *(or convert)* energy from one form to another, but energy can neither be created nor destroyed. Each time energy is changed from one form to another, however, some energy is *"lost"* as waste heat or some other form that does not contribute to the task for which the energy is being used. When a conversion process wastes a lot of energy, it is said to be *"inefficient."* The inefficient conversion and use of energy costs money and wastes resources. We are finding ways to save energy by efficiently converting and using it. The wise and efficient use of energy means that the energy we use is used for the best purposes in the best way.

While energy conservation itself cannot be considered an energy resource, it can extend the length of time that the energy resources we presently use remain available for our use. This is especially important in light of the fact that we currently get over ninety percent of our total energy from nonrenewable *(not replenishable)* fossil fuels like coal, oil and natural gas. These resources will someday be exhausted; the less of them we use now, the more of them will remain for use in the future. Conserving our energy resources now buys time as we search for new energy sources and improve how we use present energy supplies.

Exactly how many and which conservation techniques are to be adopted varies from one location or climate to another and with the preference of individual energy users. Many energy experts point out that great reductions in energy consumption are possible without lowering our present standards of living. While some think this is too optimistic, it is true that many western Europeans, for example, enjoy comforts comparable to ours but use only about half the energy.

The Energy Crisis

Although the United States has only 6 percent of the world's population, we use about 35 percent of the energy used in the world each year. Our energy consumption has increased dramatically during the 20th century. Between 1940 and 1970, the Nation's demand for electric power doubled almost every 10 years. Our consumption of oil almost doubled in the same period. Our dependence on foreign energy suppliers increased, but we gave it little thought because energy was still apparently plentiful and relatively cheap.

Then the Organization of Petroleum Exporting Countries *(OPEC)* stopped its oil exports for several months in 1973. The huge increase in oil prices that accompanied the embargo forced us to look more closely at our energy consumption. We began to speak of an "*energy crisis*."

Suddenly we were asked to change our lifestyles. We were urged to walk or carpool instead of driving; to reduce or eliminate electric lighting; to turn thermostats down in the winter and up in the summer; and to adopt a number of other energy-saving strategies. In short, we had to think about our energy consumption and take actions to lessen it.

Our Nation set a goal of independence from foreign energy producers. Although this goal was never realized, a national emphasis on energy conservation resulted. Conserving energy became a priority across the Nation. In the TN Valley, where electricity was abundant and cheap and therefore heavily used, conservation of electrical energy was made a special priority.

Conserving Energy

There are many things we can do to make energy usage more efficient which cost no money. Some examples are carpooling, driving less, making sure thermostats are set correctly, and turning off lights and appliances that are not being used. Not only do these things cost no money, but they actually save us money.

There are also things we can do or purchases we can make to conserve energy that require financial investments. The investments are then returned as savings on our energy bills. Home insulation is one good example of this. Insufficient amounts and/or unsuitable types of insulation are the leading causes of energy waste in most homes. By installing the correct amounts and types of insulation, consumers save significant amounts of energy in heating their homes in winter and cooling them in summer, not only saving money but also increasing their comfort.

Other measures that require expenditures in order to save energy *(and money)* include weather-stripping and caulking, automatic clock thermostats, and storm windows and doors. Appliance ***Energy Guide*** labels show the yearly energy cost of operating appliances and allow consumers to compare the energy costs of competing brands and models of similar size and with similar features. Many energy-efficient appliances cost less to operate over the long run even though their initial costs may be higher.

Purchasing nondurable goods with an eye toward the energy used in their production, use, and disposal is another way to conserve energy. Overly packaged one-use products represent a lot of wasted energy. Reusable and recyclable products conserve energy. Major purchases should also be made after consideration of energy consumption. For example, the energy efficiency of houses and automobiles should be a factor in our purchases.

Conserving energy should be practiced at every level of our society. Businesses, industries, governments and communities should practice and promote energy conservation. This is unlikely, however, unless individual citizens and consumers are committed to conserving energy. The measures we take individually may be simple, but the cumulative result of many people taking such action is undeniably effective.

Conservation Success

It is estimated that electricity conservation programs in the Valley have saved over three billion kilowatt-hours of electricity. This amount of savings affects more than present utility bills; it also represents a savings of almost 1400 megawatts of generating capacity. Conservation efforts in the 1970s and 1980s will help power customers in the future because expensive new generating facilities have not been required to be built; financing power plant construction adds to utility bills for years to come. These savings also demonstrate that when energy is conserved, everyone is a *"winner."* Our personal pocketbooks benefit; the Nation benefits; and the environment benefits.

Despite the success of energy conservation efforts, our rate of increase in energy consumption is rising again. We have become complacent about conservation. The success of electrical energy conservation efforts in the Valley should provide an example to the Nation of what can be done when conservation is made a priority.

fact sheets ENERGY and SOLID WASTE

Definitions

Anything that is discarded, useless or unwanted is called waste. Wastes includes trash, tailings from mining and milling, unwanted parts of crop plants, building and manufacturing debris and many other materials. Most of the waste we dispose of is solid waste *(as opposed to liquid or airborne wastes)*.

Waste Reduction, Reuse, and Recycling

We live in throw-away society. Americans buy, use and discard an amazing array of products, many of which are for one-time use and almost all of which are packaged in several materials. Every phase of manufacturing, transporting and merchandising these goods involves the use of energy. When used goods and/or their packaging are discarded, collected and disposed of, more energy is used.

Reducing the amount of waste we generate is one way to conserve energy. The most obvious way to reduce waste is for consumers to purchase fewer throw-away goods. One way manufacturers could conserve energy would be to cut back on unnecessary packaging. This is particularly important since so much packaging is plastic, which is made from oil. Closely related to waste reduction is reusing waste. Many products that we customarily use once and discard could be used again: some could be used many times. This too reduces energy *(and materials)* consumption.

Recycling is another way to conserve energy and materials. Recycling a waste material means separating it from other wastes and processing it so that it can be used again. Some materials can be recycled an indefinite number of times, while others can only be recycled a limited number of times before their properties are altered too much for them to be used again for similar products. For example, aluminum cans and glass bottles can be recycled again and again, but paper is often recycled into lower grades of paper. Recycling saves vast amounts of energy. Recycling paper saves 30 to 55 percent of the energy required to produce paper from trees, and recycling aluminum cans saves about 95 percent of the energy required to produce them from the raw ore.

Using Waste as an Energy Resource

Energy may also be gained directly from waste materials. The most obvious way to do so is to burn it. Waste incineration is a carefully controlled process performed in a specially designed system; burning is efficient and clean. Most of the household wastes we discard each day are combustible – particularly paper and plastic. Anything that burns releases heat energy. This heat can be used to heat buildings or to generate electricity. Concerns about air quality and the high cost of waste incineration facilities have limited their use in the United States. Two waste incineration facilities in the Valley *(both in Middle Tennessee)* have been providing energy from waste for several years.

Waste materials can also be chemically changed to produce fuels which can then be burned. For example, pyrolysis is the heating of waste materials to very high temperatures in an oxygen-free environment;
depending upon the wastes and/or the process, a gas – or oil-like fuel is produced. Methane, similar to natural gas, is produced when bacteria digest certain wastes under oxygen-free conditions.

There are two main advantages to using waste as an energy resource. The first is that it is a readily available, *"renewable"* resource that can help extend our supplies of conventional, nonrenewable resources. The second is that it helps alleviate our growing waste disposal problems. Of course there are also disadvantages to using energy from waste *(such as air quality, economic and organizational concerns)*, but we should continue to develop this energy option.

fact sheet

SOLAR ENERGY

Importance of the Sun's Energy

The sun is the earth's primary energy source. Without heat energy from the sun, the earth would not be habitable; its temperature would be approximately -450°F. Without light energy from the sun, photosynthesis could not take place; there would be no green plants and, therefore, no animals and no people.

The warmth and heat of sunshine are not the only forms in which solar energy is important to us. The heating of the earth's surface and atmosphere generates wind, waves, rainfall, and ocean temperature differences. All these phenomena of nature are considered to be indirect forms of solar energy and can be used to generate electricity. Hydroelectricity is commonly used now. Wind-powered generators have limited use at this time. Waves and ocean temperature differences have potential as future large-scale generators of electricity.

Even the energy from most of our fuels can be traced back to solar energy. The sunshine of millions of years ago supplied the energy that is stored in the fossil fuels that are our chief energy resources in the twentieth century. For most of human history, wood was the primary fuel. It remains an important energy resource today. Trees and other plants store the sun's energy through the process of photosynthesis. We release this energy when we burn them or when we burn other fuels made from them; for example, liquid fuels can be made from many agricultural crops.

As we have developed more and more energy-using technologies, our demands for energy have soared. We are using our resources, especially fossil fuels, at an alarming rate. It has become clear that we must develop new energy resources and technologies. Because the sun's energy is inexhaustible, free and nonpolluting, it is a particularly attractive energy option. We are re-examining old ways of using solar energy as well as developing new ways.

Ancient Uses of Solar Energy

Use of the sun's energy is not new. People have always used the sun for light and for heat to dry clothing and food and to warm their dwellings. Cities in ancient Greece and in Asia were designed so that their streets ran in north-south and east-west directions, giving homes along these routes a southern exposure and making the most use of the sun's warmth. Courts of the Roman Empire passed laws to guarantee homeowners the right to unobstructed sunlight. In North America, long before European colonization, Southwestern Indians constructed entire communities that made use of solar heating.

Solar Energy Systems

Though there are many variations, there are only two basic types of technology for using the direct rays of the sun – active and passive solar energy systems. Active systems rely on mechanical devices such as fans, pumps or motors to collect and distribute solar-gained heat. Passive solar systems, unlike active systems, use few or no moving parts. Instead, passive solar heating is accomplished by designing and orienting buildings in such a way as to allow them to benefit most from direct sunlight.

Active systems are used for heating water or inside air. Active systems use solar collector panels made of metal, glass, or plastic that are installed on the roof of a building or elsewhere outside it. These panels capture the sun's heat in air or water which is transported to various points of usage. Active solar technologies include solar water heaters, solar heat pumps for heating and cooling, and several other types of systems that use solar energy to power cooling equipment. Larger-scale active systems that use the sun's heat to produce steam with which to generate electricity are also being developed. These are expensive, however, and are practical only in desert areas.

Passive solar technologies tend to be simpler and less expensive than active systems. Many are simply improvements on very old ideas. Large windows are placed on the south side of buildings, and window space is minimized on the north. Interior walls or floors are specially designed to retain heat. Buildings designed for maximum solar heat gain in winter also include simple design elements which help cool them in summer. For example, overhangs and shade plants block out the summer sun's rays, preventing unwanted solar heat gain in summer.

Passive solar technologies are more easily used by individual homeowners or builders than are active systems. For example, people constructing new buildings or remodeling old ones can incorporate passive solar design elements into their plans. Existing buildings can be retrofitted – modified or added to – in order to take advantage of solar energy.

Electricity From the Sun

The solar or photovoltaic cell is an example of a different kind of solar technology. These cells convert light directly to electricity. Solar cells are frequently found in hand-held calculators. They are also used to supply power to satellites and other space vehicles. Large-scale use of solar-generated electricity is not practical at the present time. For instance, it would take a 20- to 30-foot panel of such cells atop a residence and many storage batteries inside to provide ample electricity for an average household. At present, the cost of such systems is extremely high. There are, however, uses for this technology; for example, solar cells can power communication devices where there is no other source of electricity such as in remote areas and less developed countries. More use may be made of solar electricity in the future as the technology is improved.

Challenges to Solar Power

The major challenges to using more solar power include the lack of satisfactory means of energy storage and concerns about flexibility and economics. Because no power can be produced when the sun is not shining, scientists must develop cost-effective methods of storing solar power in order to supply energy whenever it is needed. The development of effective and efficient storage systems will be one key to the future of our use of direct forms of solar energy. As technologies improve, the use of solar energy will increase, and its cost will become more reasonable.

Advantages of Solar Energy

Using energy from the sun is attractive for a variety of reasons. The environmental and safety hazards associated with fossil fuels and nuclear energy do not apply to solar energy. Solar energy is clean, free and abundant. Technologies and methods of using solar energy can be as simple as the proper use of window shades or blinds or as complicated as a building designed with active solar energy systems. Every person can make better use of the sun's energy. In so doing, we can reduce our energy costs, use fewer nonrenewable energy resources and increase our energy independence.

GLOSSARY

coal: a major fuel resource formed from the remains of ancient plants.

food chain: a path by which energy and materials pass from one living thing to another in the form of food.

gale: a very strong wind.

generator: a machine that changes mechanical energy into electrical energy.

glazing: glass or other transparent material (*such as is used for windows*) used to trap solar energy in a solar device or building.

heat storage materials: materials such as concrete, rocks, or water, that are capable of absorbing heat energy and slowly releasing it as the atmosphere cools down.

hurricane: a storm with violent wind and (*usually*) heavy rain; forms over the ocean in tropical regions; term "*hurricane*" is used in the Western Hemisphere; term "*typhoon*" is used in the Eastern Hemisphere.

insulation: material that hinders the flow of heat energy.

nonrenewable: not able to be restored or replenished.

oil: a mixture of liquids formed from the remains of ancient living things; the source of many important fuels (*such as gasoline, diesel fuel and kerosene*) and other substances.

passive solar system: a device or structure that does not require mechanical parts to collect, store and make use of solar energy.

renewable: able to be restored or replenished.

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

solar energy: the energy we get directly from the sun's rays, especially the heat energy we can trap and use.

turbine: a device in which a bladed wheel is turned by the force of jets of water (*or steam*); connected by a shaft to a generator.

wind vane: a device used to indicate the direction of the wind.