RENEWABLE ENERGY RESOURCES

for elementary, middle & high school

includes: lesson plans, demonstrations, hands-on activities, enrichment activities, science fair projects, reference materials and websites


contents

Note to Educators

The Renewable Energy Sources educational curriculum is a classroom resource developed by TVA's Public Power Institute. The purpose of this resource is to engage children in the science and ecology of renewable energy.

Learning about renewable energy resources is appropriate for any grade level. The material has been divided into 3 levels: elementary (grades 3-5), middle (grades 6-8) and high school (grades 9-12). A list of activities, black line masters and answer sheets are provided for each level. Use this resource for lesson plans, demonstrations, hand's-on activities, enrichment activities, science fair projects and as a reference manual.

Renewable Energy: An Overview of TVA's Green Power Switch Program

Green Power Switch℠

Renewable Energy

Green Power Switch is a renewable energy initiative that offers consumers in the Tennessee Valley a choice in the type of power they buy. TVA and local public power companies, working with input from the environmental community, have created a program called Green Power Switch to produce electricity from cleaner, greener sources and adds to the Tennessee Valley's power mix.

What makes green power green?

RENEWABILITY.

Resources like wind, solar power, and landfill gas produce energy for today and renew themselves for tomorrow – like a growing plant.

How much electricity will Green Power Switch produce?

Approximately eight megawatts of green power will be generated initially. Physical laws determine where electricity is ultimately used, so power from these cleaner sources will go into TVA's electric system as part of the Valley's total power mix, rather than to individual homes or businesses. There will be times when green power resources aren't operating. For example, when wind speeds are too low to generate energy, TVA's other resources will continue to supply reliable electricity.

How many consumers will Green Power Switch serve?

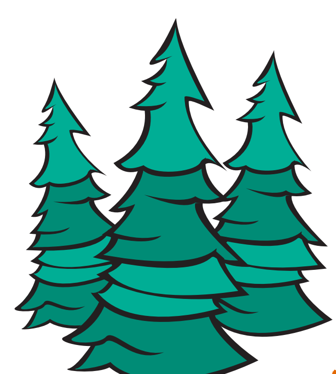
Green Power Switch can provide enough electricity to supply 150 kilowatt-hours a month for about 30,000 Tennessee Valley homes, plus an ample supply of energy for participating businesses and industries.

How does green power benefit the environment?

The environmental effects of traditional energy sources like coal, natural gas, oil and nuclear power can be significant. Although no source of energy is impact-free, renewable resources create less waste and pollution. This can lead to a reduction in the greenhouse effect or global warming.

Why does green power cost more?

Although renewable sources like sunlight and wind are free, the technology used to capture this energy is still more expensive than traditional power generation methods. Increased demand may lead to expanded power production capacity and eventually to lower costs.



Where are Green Power Switch's generation sites located?
WIND: TVA built the first commercial wind-powered turbines in the southeastern U.S. on Buffalo Mountain in Anderson County, Tennessee.

SOLAR: Solar generation sites are located in the service areas of participating public power companies across the Tennessee Valley.

LANDFILL GAS: A plant has been built in Middle Tennessee. As Green Power Switch gets under way, electricity from landfill gas will provide the largest proportion of green power. That amount will decrease over time as wind and solar energy grows.

Wind Turbine Energy Power

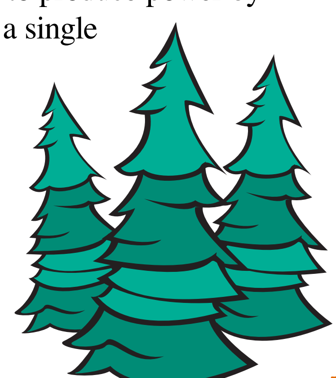
Properly placed wind turbines can generate electric power anywhere the wind blows steady and strong. Wind turbines use the momentum of moving air to quietly turn large blades that are attached to the shaft of an efficient electric generator. TVA has constructed a wind power-generating site on Buffalo Mountain near Oak Ridge, Tennessee. Initially, wind power will add about two megawatts of capacity to the TVA power system, but plans are for its share of total green power generation to increase over time.

What is the role of wind energy in Green Power Switch?
The production of wind energy creates no air pollution and, if the turbines are sited properly, has minimal environmental impact. By including wind generation in Green Power Switch, TVA and the public power distributors of TVA electricity are introducing this clean technology to the Tennessee Valley. TVA built three wind-powered generators on a two-acre site on Buffalo Mountain in Anderson County, Tennessee, about six miles northwest of Oak Ridge. This is the first commercial-scale use of wind power to generate electricity in the Southeastern United States.

How much electricity is produced, and will there be more?
The turbines on Buffalo Mountain provide about two megawatts of capacity, but TVA plans to increase wind power's share of the total Green Power Switch energy generation over time. Each of the wind turbines has a generating capacity of 660 kilowatts. Together the three turbines are expected to produce some six million kilowatt-hours per year, enough to serve more than 400 typical Tennessee Valley households.

How is wind energy generated?
In a modern wind machine, a turbine and switchgear are mounted at the top of a tower in a casing called a nacelle and blades are attached to the turbine. Generally, the higher the tower, the better the access to the wind. TVA's three wind generators sit atop towers that are 213 feet tall, and each generator drives three rotor blades. The blades are about 75 feet long, making the diameter of the rotors' span 150 feet. Each assembly is 290 feet from the ground to the tip of an upright rotor. The turbines use moving air to produce power by transferring the wind's momentum to the rotor blades and localizing that energy in a single rotating shaft. The resulting power can be used in many ways; modern turbines convert it into electricity.

Do wind turbines produce electricity all the time?
No. When the wind turbines aren't operating, other resources will continue to supply power as reliably as ever. Wind speed varies according to the time of day, season, height above ground and terrain. The proper placement of a wind turbine in a breezy location away from large obstructions will enhance its performance.



How are wind sites selected?

The turbines must be situated where the wind is relatively steady and strong. Windy sites in environmentally sensitive areas will be excluded. For cost-control reasons, it's helpful to have access to transmission or distribution lines nearby and access by road is needed for construction and maintenance. TVA's Buffalo Mountain Wind Park is located on a reclaimed strip mine owned by Coal Creek Mining and Manufacturing of Knoxville, Tennessee. TVA is using the land through a long-term lease for the life of the project which is expected to be two to three decades.

Will the turning rotor blades harm birds?

TVA has studied potential wind sites to make sure that they aren't located on bird migration routes and that endangered species don't inhabit or frequently visit them. Careful site selection will ensure that there is no significant hazard to birds.

Are the wind turbines noisy?

Large modern turbines are very quiet. The swishing sound of the rotor blades is usually completely masked at distances of 650 feet or more by wind noise in the leaves of trees or shrubs. The turbine sites will be far enough from neighbors so that people won't hear any sound at all unless they're standing close to the towers.

Will the turbines interfere with radio and TV signals?

No. In fact, some turbines even double as communications towers for cellular phone transmitters, among other things. The turbine blades are made not of metal but of glass-reinforced epoxy *(a material similar to fiberglass)*. The turbines are equipped with asynchronous *(brushless)* generators that don't create any electrical disturbance. Therefore, the turbines used in the Green Power Program will cause no electromagnetic interference and will not disrupt radio or television signals.

Solar Energy

Solar power frying eggs from 93 million miles away. Now that's power!

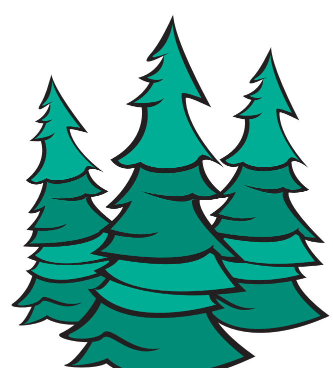
The sun is an incredibly powerful source of energy. Each day enough solar energy falls to the Earth to supply the world's energy needs for more than 27 years. There are several types of solar energy: photovoltaics or solar cell systems, solar systems that produce heat, passive solar systems, solar hot water heaters and solar lighting systems. TVA is using the photovoltaic system to generate solar power. In this case, sunshine strikes the photovotaic (solar) panels giving the electrons inside more energy and creating an electric current.

How much power are we generating?

The amount of energy derived from solar power will be small at first, but TVA plans to expand Green Power Switch's solar component.

What is the role of solar energy in Green Power Switch?

Solar energy constitutes a small but important part of Green Power Switch's energy resources. Its capacity will be 225 to 250 kilowatts – an amount that demonstrates TVA's leadership among Southeastern utilities in its commitment to solar energy.



How is solar energy generated?

Solar energy is generated by photovoltaic (*PV*) systems. The word photo equals light and voltaic equals voltage producing. PV systems use semiconductor cells or modules that convert sunlight directly into electricity. When the sunlight strikes the module, a portion of the light is absorbed by the semiconductor material. The light energizes the electrons in the semiconductors thus allowing them to flow between the semiconductors in the modules. This flow of electrons creates an electrical current. Once used almost exclusively in space, PV cells and modules are now used more on Earth. The solar systems also contain additional equipment like inverters, which change direct current *(DC)* to alternating current *(AC, the type that we use in our homes*). The PV cells are connected in the form of flat panels that can be mounted on rooftops or integrated into roofing shingles and other building materials.

How much electricity does a PV system produce?

Production ranges from 10 to 100 kilowatts. On average, a 10-kilowatt PV system located in the Tennessee Valley will generate approximately 13,200 kilowatt-hours per year. This is a little less than needed to supply a typical home.

How are the solar sites selected?

TVA has asked the power companies participating to help identify sites that offer high visibility and good opportunities for public education. These include high-traffic facilities like visitor centers, museums and schools. Of course, the sites must also meet the necessary physical criteria: a southern orientation, good exposure to the sun and the appropriate amount of structural support and space for placement of the PV panels.

Does a PV system produce electricity all the time?

No. Depending on the season, it will ordinarily generate power from 8 a.m. to 6 p.m., reaching its maximum output between noon and 1 p.m. Since solar energy will not be a primary element of the power mix for Green Power Switch, batteries or collection-and-storage systems won't be used. When the PV systems aren't producing power, TVA's other resources will continue to supply reliable electricity.

Can PV systems produce power on cloudy days?

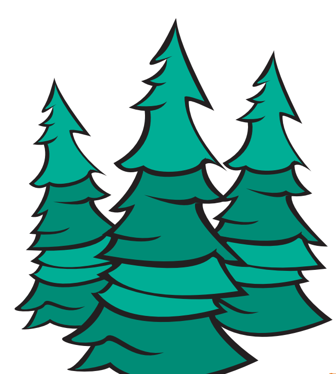
Yes. PV modules generate electricity when the weather is cloudy, although their output is diminished. On a dark, overcast day a PV system might receive only 5 percent to 10 percent of the usual amount of sunlight, so the power output would decrease proportionately.

Do PV systems work well in the cold?

PV modules actually generate more power at lower temperatures. Like most other electronic devices, they operate more efficiently when it's cooler. PV systems generate less energy in the winter than in the summer, but that's due to the combination of fewer daylight hours and lower sun angles, not to cooler temperatures.

What about breakage? Don't most modules contain glass?

The modules are two pieces of glass with the semiconductor material between the glass. However, PV modules are designed to withstand all the potential rigors of the environment including arctic cold, desert heat, tropical humidity, winds of more than 125 miles per hour and one-inch hail at terminal velocity. Even with this very durable construction the glass can still break under an extremely strong impact.



Landfill Gas

There is treasure in your trash. In the start-up stage of Green Power Switch, methane gas from landfills will provide the largest source of cleaner energy. If released directly into the atmosphere, the methane that landfills emit becomes a potent greenhouse gas. But using landfill gas to power an electric generator transforms the problem into a renewable energy solution that actually helps reduce air pollution.

What is landfill gas, and how is electricity generated from it?

Landfill gas, which consists mainly of methane and carbon dioxide, is produced when organic wastes in landfill sites decay. At landfills over a certain size, the gas must be burned *(or flared)* to reduce the hazard arising from gas buildup. Although landfill gas is primarily a pollutant that needs to be controlled, the methane it contains makes it valuable as a fuel for powering an electric generator. Landfill gas was first used as a fuel in the U.S. during the late 1970s. Since then the technology required for its collection and use has developed steadily. This method of producing renewable energy is now regarded as one of the most mature and successful in the field of green power.

Does burning landfill gas have other benefits?

Methane released directly into the atmosphere is a potent greenhouse gas. In fact, its global-warming potential is 21 times greater than that of carbon dioxide. As mentioned above, landfill gas can be flared *(the simplest option)*, but using it to generate energy encourages more efficient collection and thereby reduces emissions into the atmosphere. For this reason, energy recovery from landfill methane, where economically viable, is of considerable benefit to the environment. Besides reducing global warming, it lessens the use of conventional fuels and reduces regional and local pollution.

How much electricity can a landfill produce?

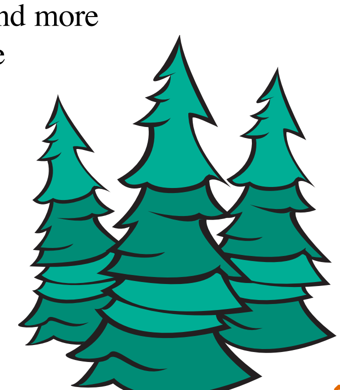
It depends on the size and age of the landfill, but production tends to range from three to eight megawatts. Generators at landfill-gas sites are very reliable and operate almost year-round with little downtime. So a five-megawatt plant would produce approximately 42 million kilowatt-hours per year, enough to supply about 3,200 homes.

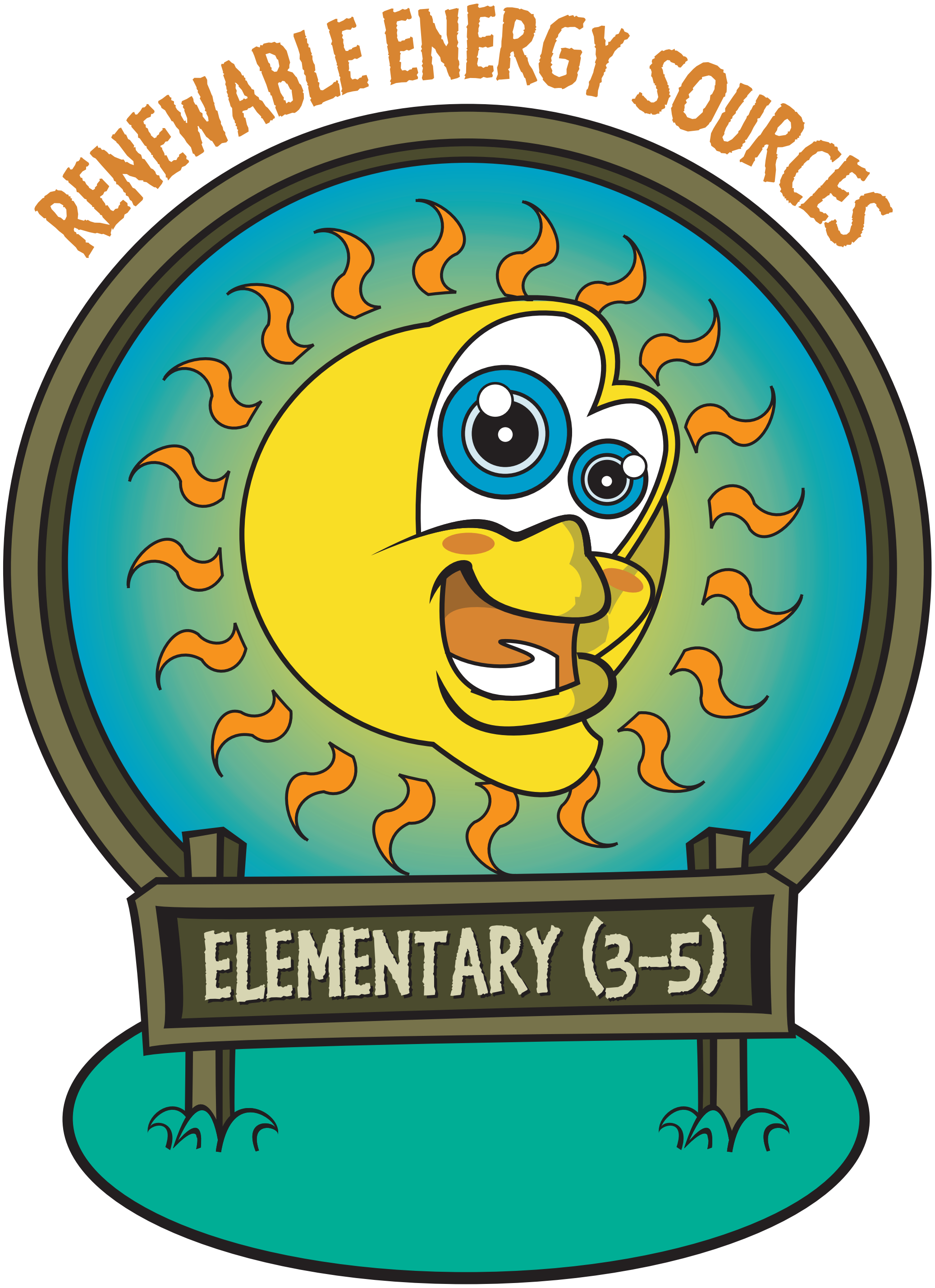
How long will a landfill continue to produce gas?

The answer depends on the landfill's age and size. Although gas is produced once anaerobic conditions are established within the landfill, it may be several years before there is enough gas to fuel an electric generator. Later, as the site ages, gas production *(as well as the quality of the gas)* declines to the point at which power generation is no longer economical. In the case of a typical well-engineered and well-operated landfill, gas may be produced for as long as 50 to 100 years, but production may be economically feasible for only 10 to 15 years.

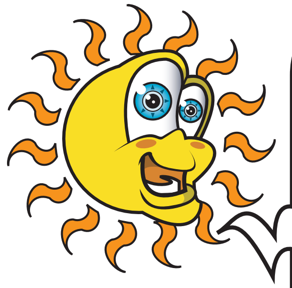
Does using landfill gas to produce electricity encourage a throwaway society?

The part landfill gas plays in energy generation will decline over time as more and more waste is reduced, reused or recycled instead of being added to landfills. As waste pretreatment becomes more widespread, the biodegradable content of landfill wastes will also drop. Such changes in waste management, combined with environmental pressures to reduce reliance on landfilling as a disposal method, will eventually lead to a decrease in the use of landfill gas as an energy source.




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

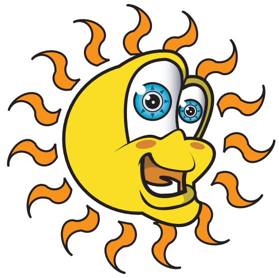
Throughout human history, the development of new energy sources has been linked to human progress. Fire and bodily strength were all primitive people had to use. Harnessing new sources of energy and building new machines to use them changed our lifestyles dramatically. The study of our energy past reveals 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.*

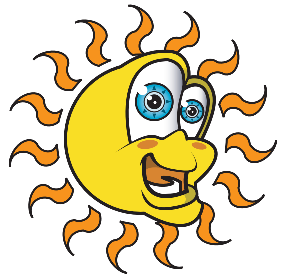
1. Ask the students the following questions:
    a. What is energy? *(the ability to do work)*
    b. How do you think early people got their work done; that is, what energy forms did they use? *(bodily strength, fire, animal power and so on)*
    c. Have the students give a definition for fuel. *(something 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.*

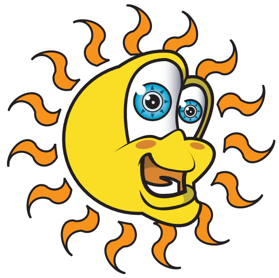
Nuclear energy is fundamentally different from all the major fuels. We use it to produce electricity and, although the process requires uranium as *"fuel,"* there is no fire involved. Read this Isaac Asimov statement concerning nuclear power to the students.

> *"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.

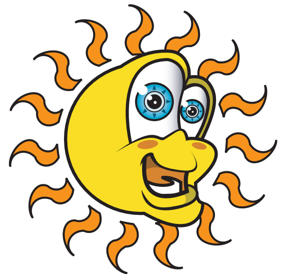
III. *Follow-up*

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

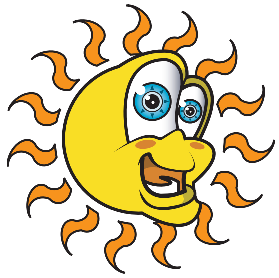
Abruscato, J. HOLT SCIENCE SKILLBOOK.
New York: Holt, Rinehart, & Winston, 1984.

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.

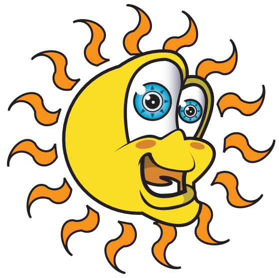
6. In 1900, one-room schoolhouses were often heated by___________________.

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___________________.

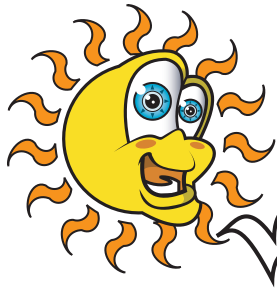


What Makes it Go?

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

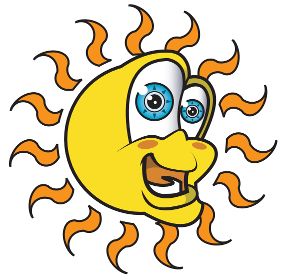
I. *Setting the stage*

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.

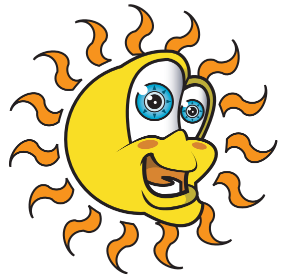
III. *Follow-up*

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).*

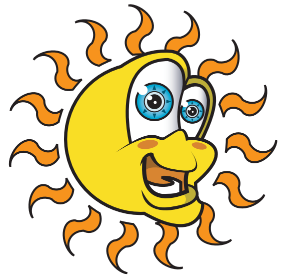
E. *Some students may research wind power and write reports about the advantages and disadvantages of using wind power.*

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.

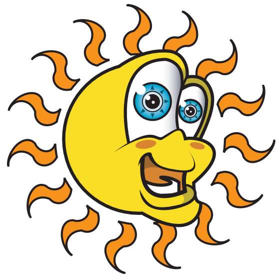


Resources

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.

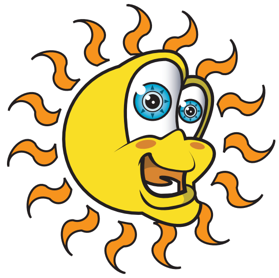
American Museum of Science and Energy. "Where Is the Windiest Spot on Your School Ground?" Science Activities in Energy. Oak Ridge, TN: Oak Ridge Associated Universities, n.d.

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.



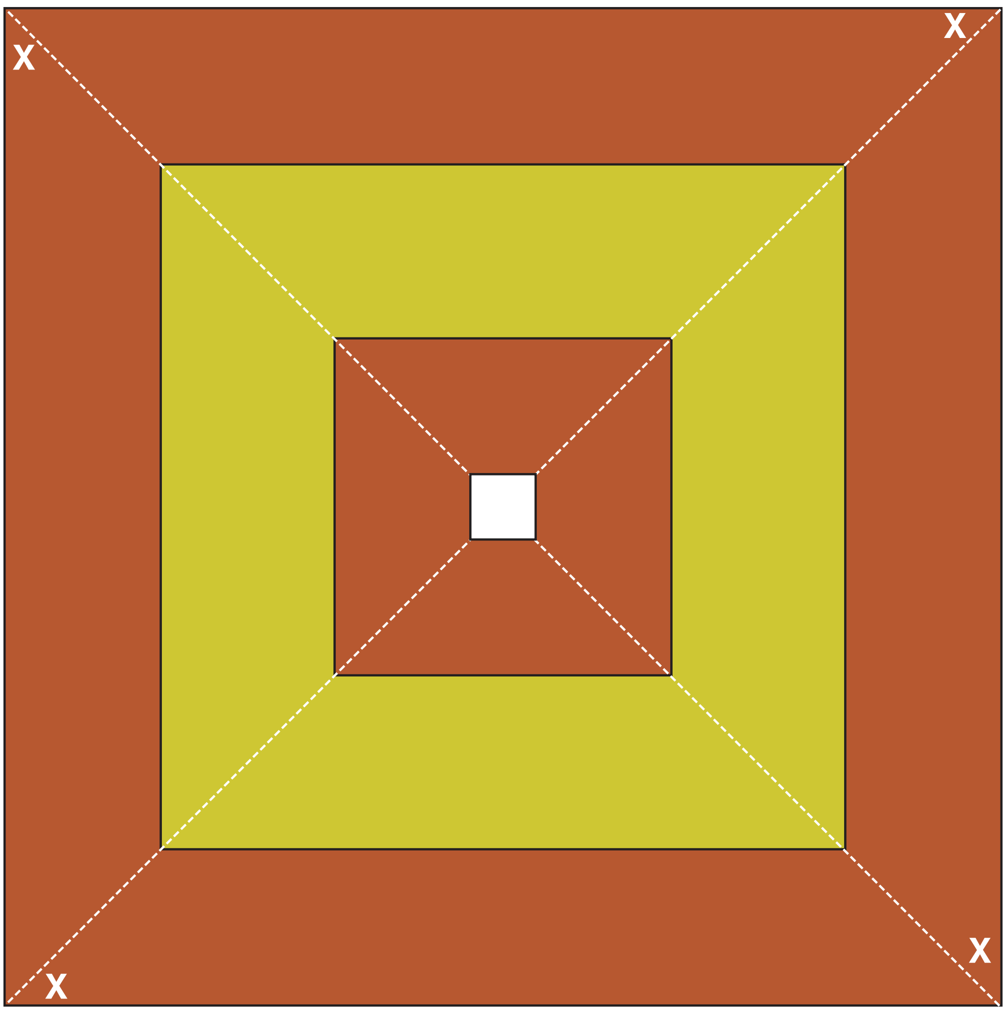
Estimating Wind Speed

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.					

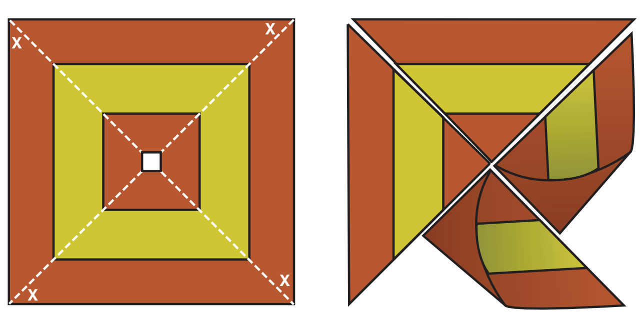
How to Make a Windmill

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.

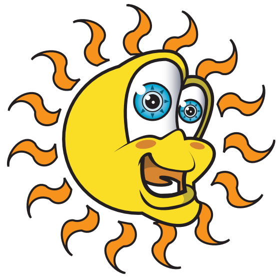


Does the pinwheel move faster when you blow harder? Why?

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.

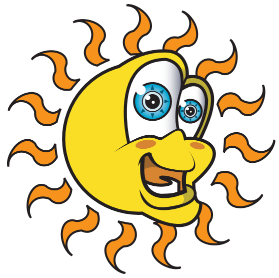
Effectively collecting the sun's warmth means that the device or building trapping the solar energy must be positioned so that it receives the maximum amount of energy in the winter – when our Northern Hemisphere is tilted away from the sun, making its warmth less intense. The collector or structure 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.*

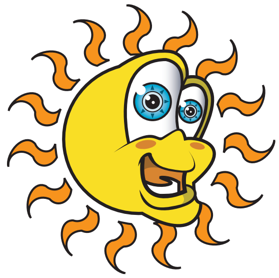
1. Use a globe and a flashlight to help them understand how the tilt of the earth on its axis causes seasons. In winter, the sun appears lower in the sky because the Northern Hemisphere is tilted away from the sun. The heat of the sun is more spread out – is less intense – than it is in the summer. The 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.		



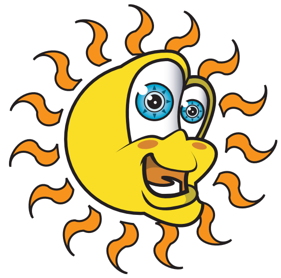
c. Each group is to place a thermometer in the glass jar and screw on the lid. Each jar is to be placed in direct sunlight and a second thermometer placed next to the jar.
d. The students are to read both thermometers and record the beginning temperatures at 0 minutes. They are to read and record the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

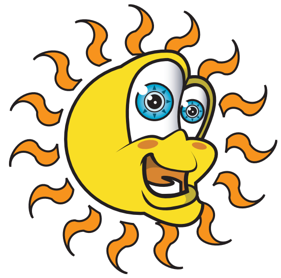
1. Share the following information on solar heating: Huge amounts of energy come from the sun. We can make use of this energy by changing it into heat for our homes. Some houses have boxes on their roofs. These boxes, called solar collectors, have glass tops and are black inside. Water flows through 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)

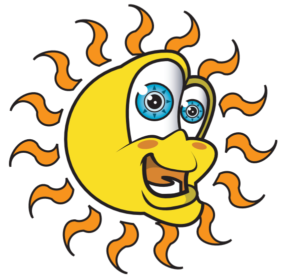
III. *Extensions*

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

Fogel, B. Energy Choices for the Future.
Franklin Watts, NY: Impact, 1985. *(pp. 57-62)*

Mallinson, Mallinson, Valentino, and Smallwood. Science – Grade 4.
Morristown, NJ: Silver Burdett, 1984. *(p. 146)*

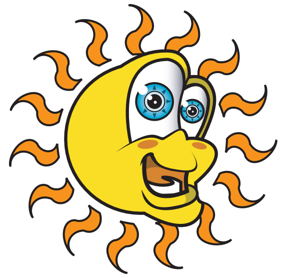
Mason, J. Power Station Sun.
East Grinsted, Sussex, England: BLA, 1987. *(p. 7)*

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

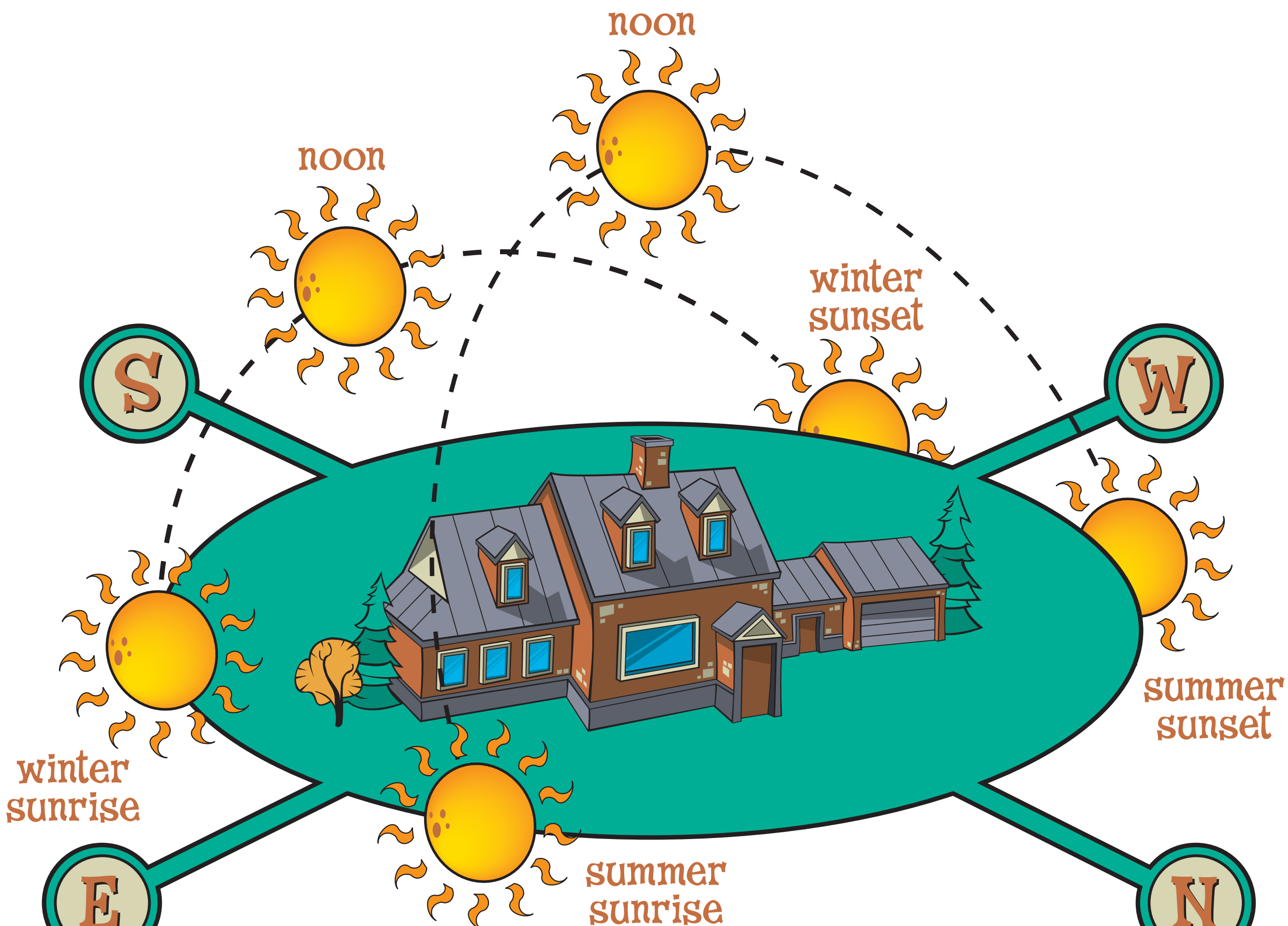
"Science Scene, Solar Fun." The Mailbox.
October 1987.

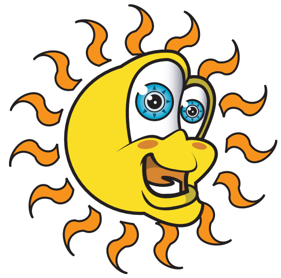
Spetgang, Tilly, Wells, and Malcolm. The Children's Solar Energy Book.
New York: Sterling, 1982. *(pp. 65, 89)*

Thompson, Hancock, Witte, and Associates. Passive Retrofit Handbook.
Atlanta: Southern Solar Energy Center and U.S. Department of Energy, 1980.



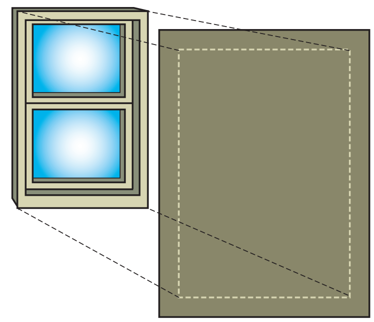
The Sun's Daily Path





Build a Solar Air Heater

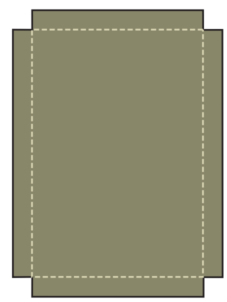
I. *Prepare to build a solar air heater.*



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.

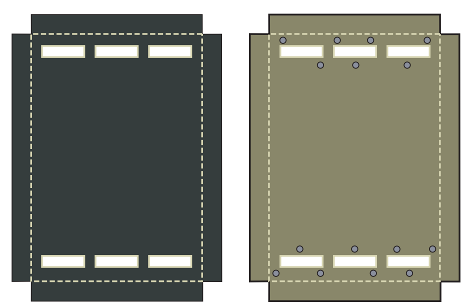
C. Mark off the exact size of the window on the cardboard. Add 5 inches all the way around the window size and cut out the heater as shown in the diagram.



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.

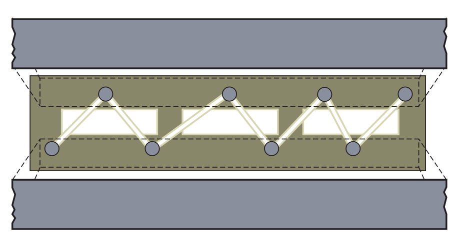
II. *Make the vent holes in the heater.*



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)*.

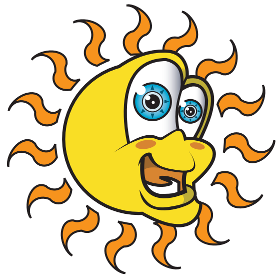
C. Weave some thin string around the thumbtacks, crossing the vent holes.



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.*

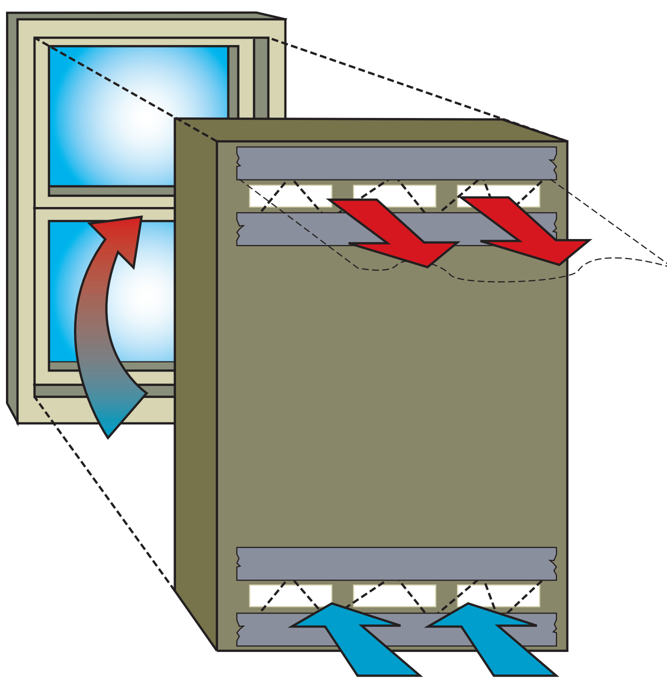
A. Place the heater – black side facing the window, top vents up *(so that the plastic flaps hang down over the vent holes)* – inside the window frame. Then tape it to the window frame with masking tape.

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

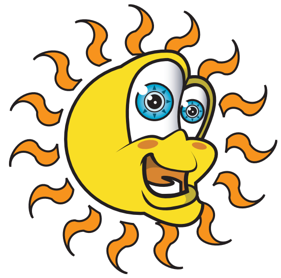
I. *Setting the stage*

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.*

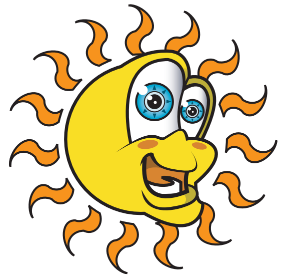
Ask what food they chose and where we get this food. How does this animal or plant grow?

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.*

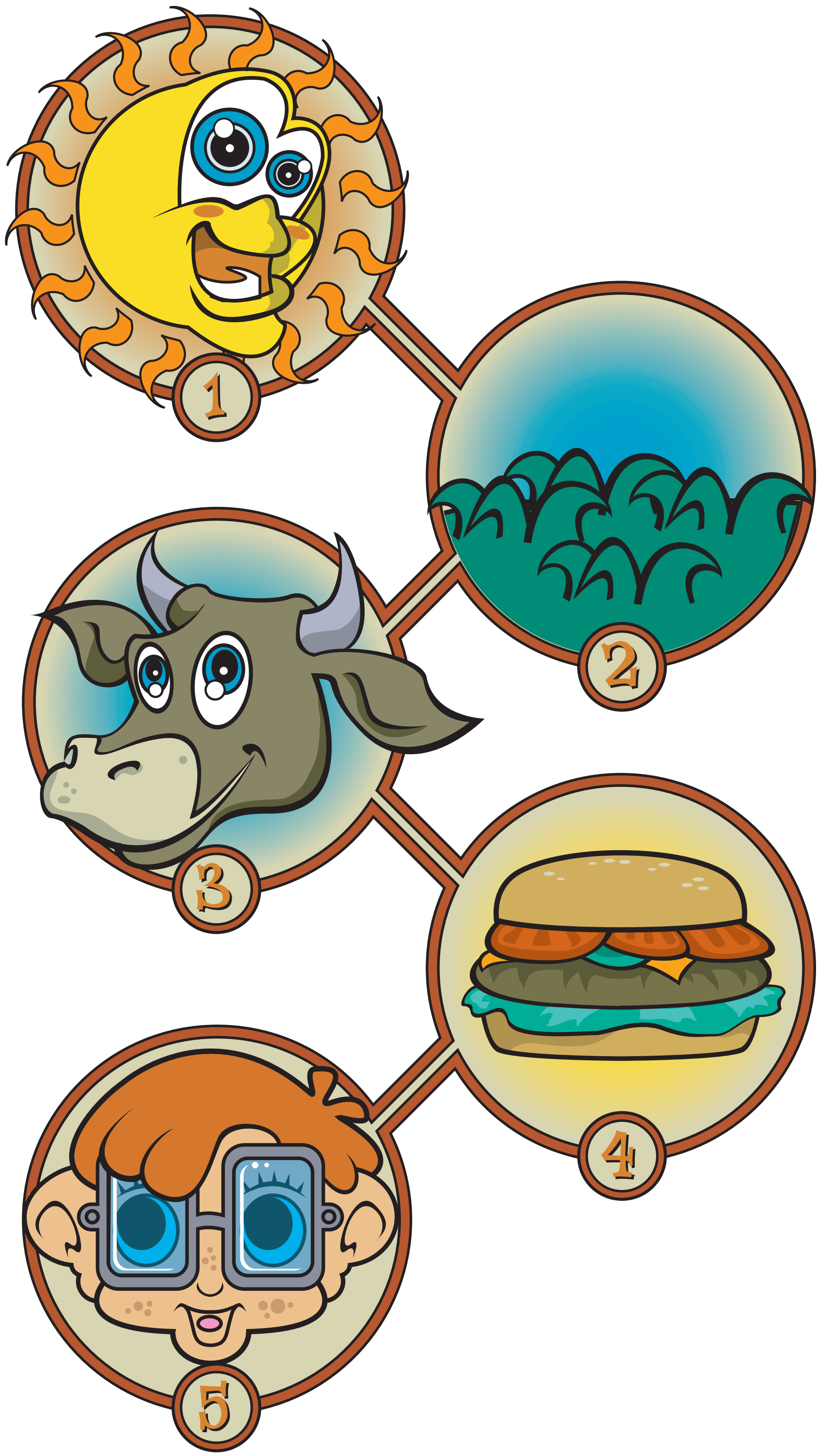


Resources

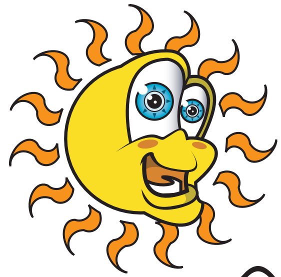
Marlinson, G. G., et. al. The Silver Burdett Elementary Science Program *(pupils' books and teachers' editions, levels K-6)*. Morristown, NJ: Silver Burdett, 1984.

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

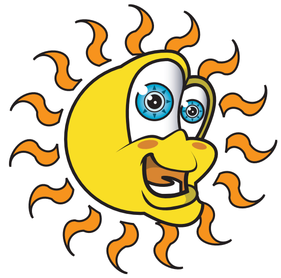
I. *Setting the stage*

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.

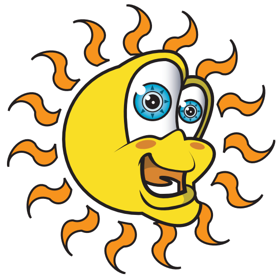
II. *Activities*

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."*

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

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)*

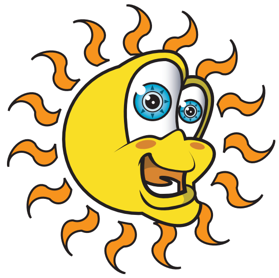
The limerick should say something about the sun's energy and/or solar cooking.

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.
N.p: Childrens Press, 1981. *(p. 22)*

"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.

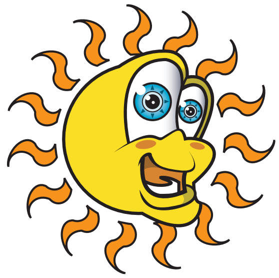
Halacy, B. and D. Halacy. The Solar Cookery Book.
Lakewood, CO: N.p., 1978.

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)*

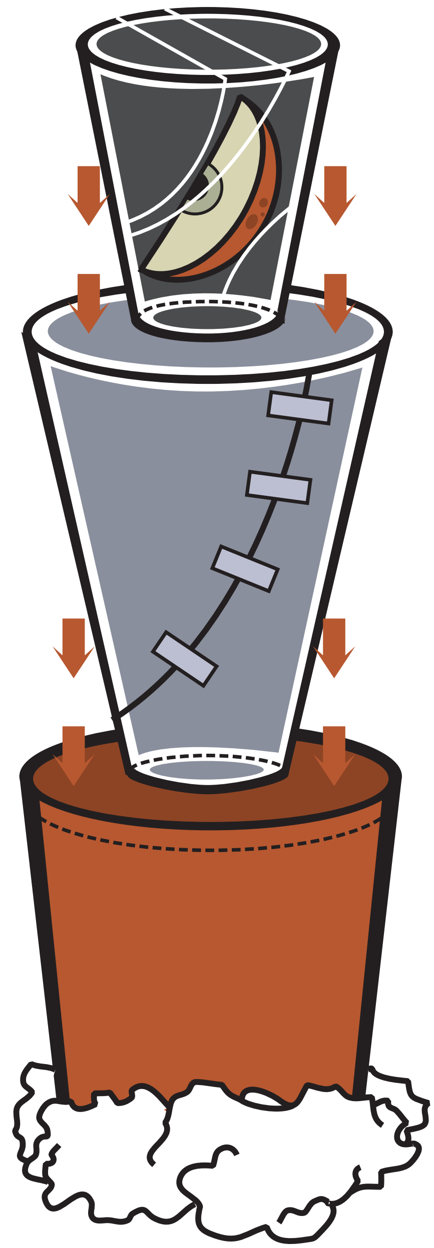
Natural Sciences Industries. "Solar Oven Lab" *(pamphlet)*.
Far Rockaway, NY: Author, 1976.

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?

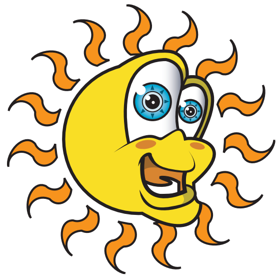
   ____

   ____

   ____

   ____

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

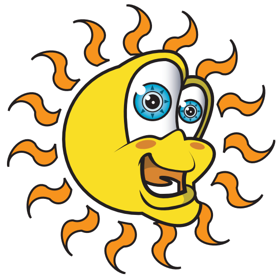
Cooking with the Sun

Describe one advantage and one disadvantage of solar cooking.

Advantage: ____

Disadvantage: ____

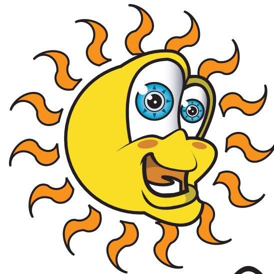
Draw a picture of the solar cooker that we used and show where the box should be placed for the best results.



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.

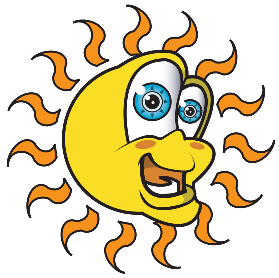
Background Information

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*

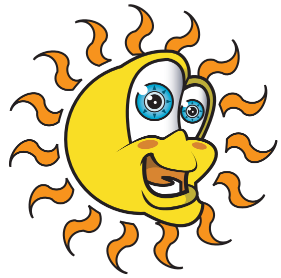
A. *Ask the students the following questions:*

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.



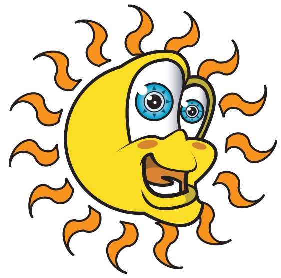
II. *Activities*

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.

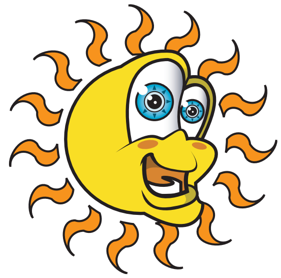
i. Have each group measure the water's temperature again at 11:00 a.m. and 2:30 p.m. *(When they re-measure, the tape will have to be pulled away. Remind the students to re-tape securely, so that the greenhouse will not lose heat.)*

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:

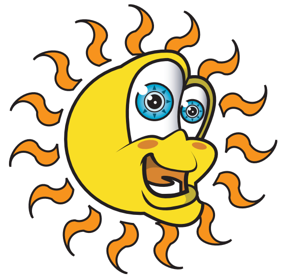
Time	Container with rocks	Container with wood chips	Black container with water	White container with water
8:00 a.m.				
11:00 a.m.				
2:30 p.m.				

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.

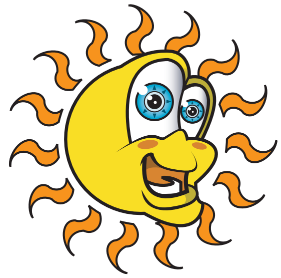
III. *Extensions*

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.



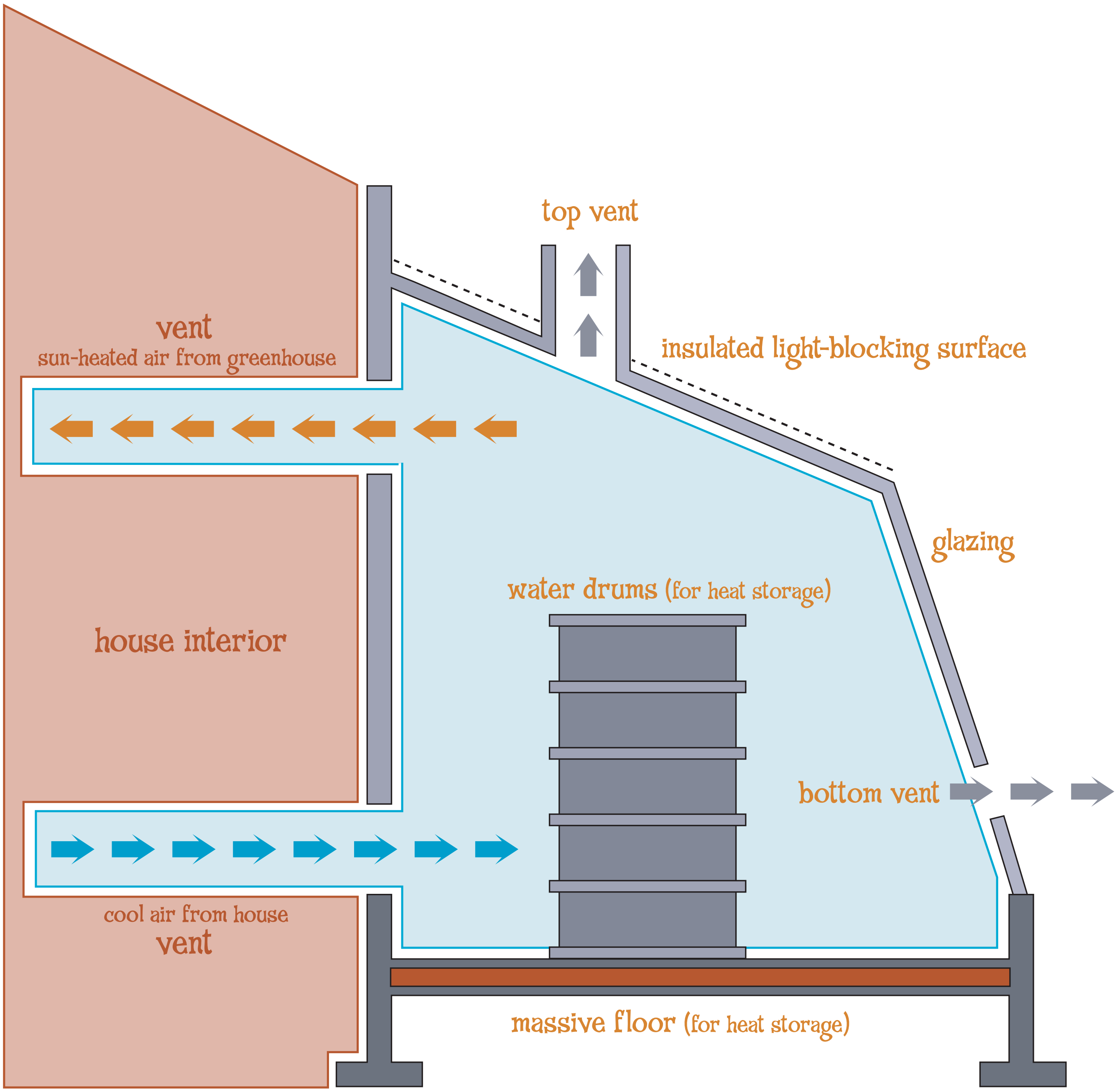
Resources

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.)*

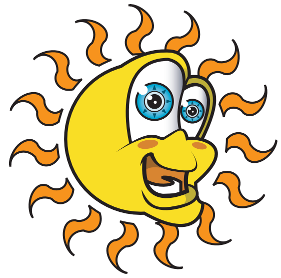
Fisher, R. and B. Yanda. The Food and Heat Producing Greenhouse – Design, Construction, and Operation. N.p: N.p, 1976.

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

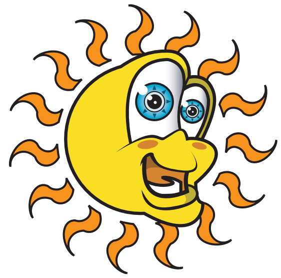
Heating water for use in the home is a major contributor to the home energy bill. One way to reduce energy use by the heater is to turn its thermostat back; settings of 120 to 140 degrees will save energy and still provide water hot enough for all the various purposes for which it is used. Another way 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.*

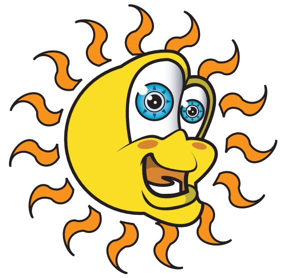
1. Have the students do the activity on the student sheet *"Which Color Holds Heat Longest?" (page 58)*.
   a. Help the students make graphs and record data as they follow the instructions on the student sheet.
   b. Discuss the results with the students.
2. Have the students investigate color and the 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.)*

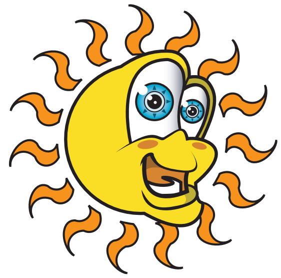
IV. *Extensions*

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.

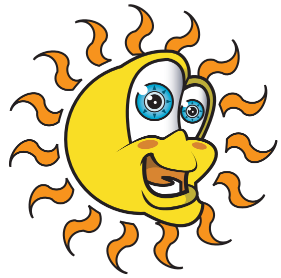
Alabama Solar Energy Center. "Solar Homes for Alabama."
Huntsville, AL: Author, n.d. *(p. 2-3)*

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

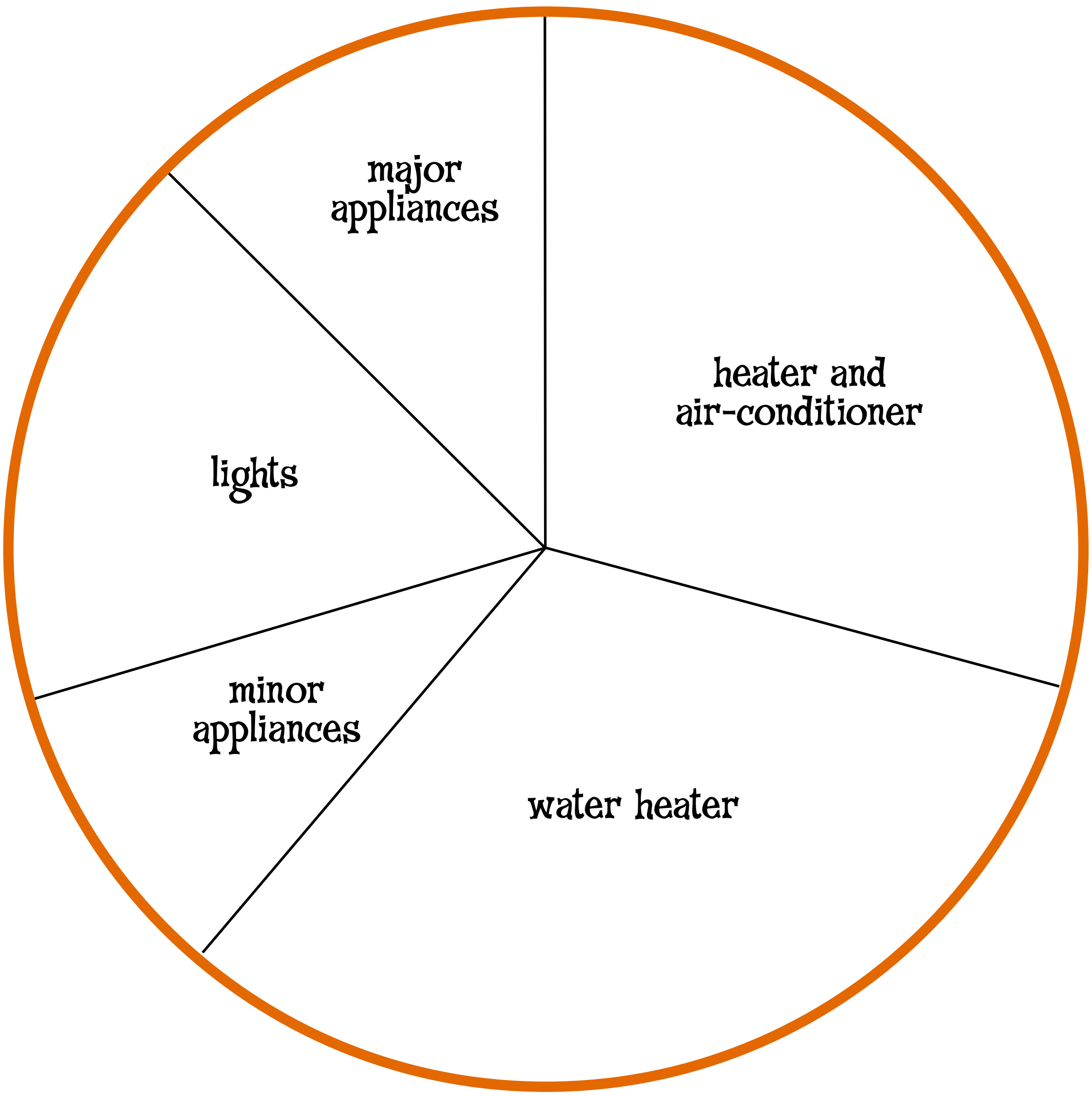
National Appropriate Technology Assistance Service. "How to Make a Solar Water Heater."
Connections. A Curriculum in Appropriate Technology for 5th and 6th Grades. N.p.: U.S. Department of Energy, 1986. *(Address: NATAS, P.O. Box 2525, Butte, MT 59702-2525. Telephone: 1-800-428-2525.)*

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.



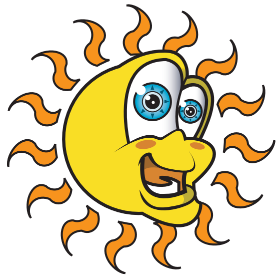
Jones Family Electricity Use



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.

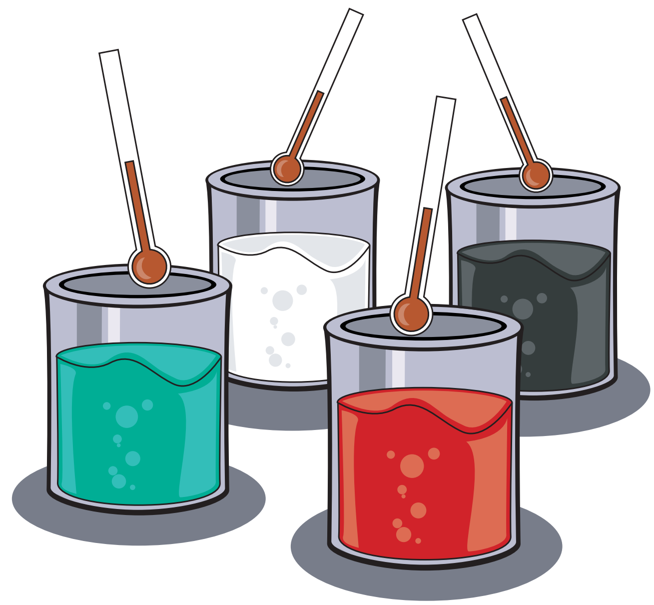
What are some ways the Jones family could decrease their electric bill?

Is there an alternative method for heating water?

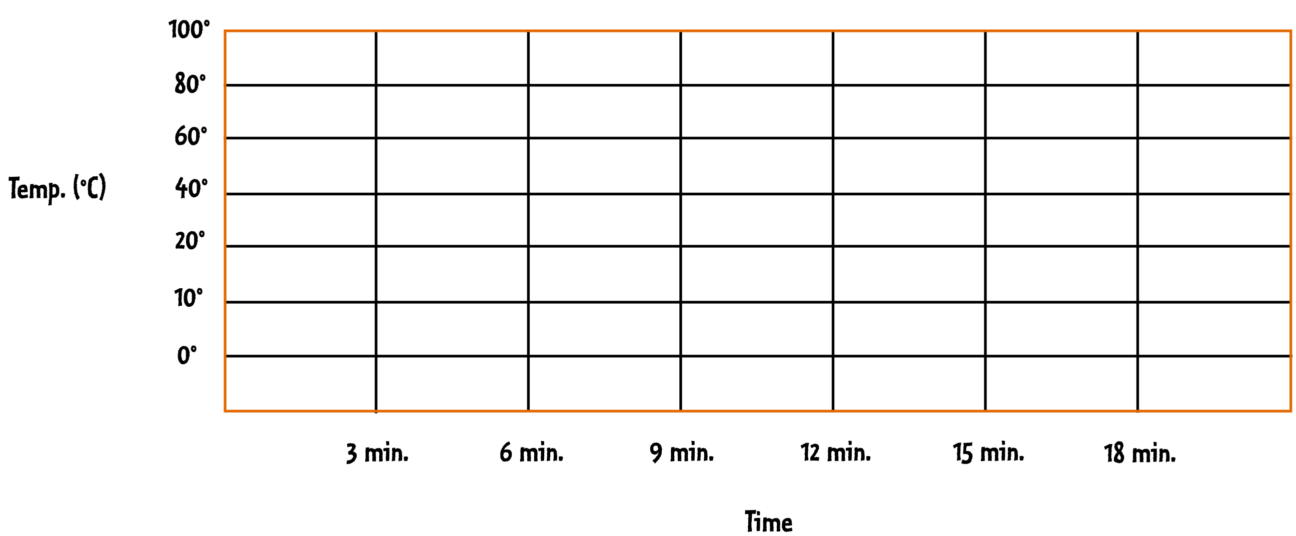


Which Color Holds Heat Longest?

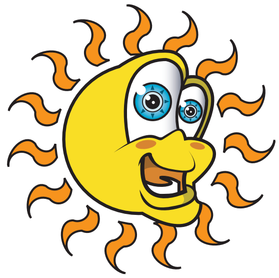
Materials: 4 juice cans, 4 colors of paint *(white, black, green, and red)*, very hot water *(close to boiling)*, 4 thermometers, food colors



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.

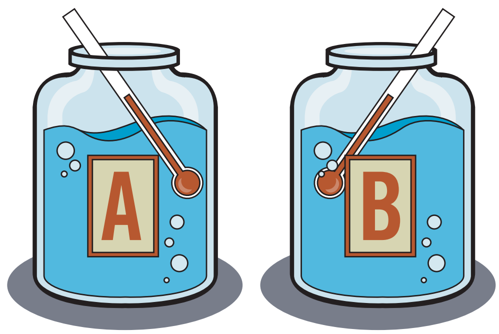


Which color held heat best?________________________________.

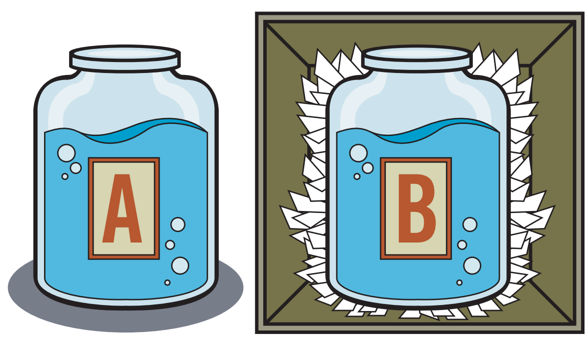


Insulation Really Works

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

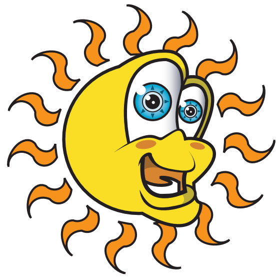


Record the starting temperature on the chart below. Next, place one of the jars in a cardboard box. Cover it and surround it with shredded newspapers. The other jar remains as is.



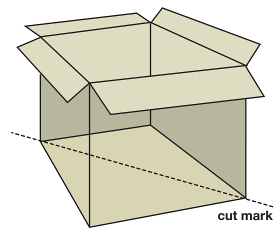
After one of the jars is "insulated," read and record the temperature of each jar every 10 minutes. After 30 minutes have passed, compare the results.

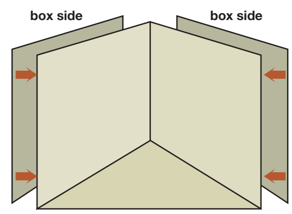
	Jar A	Jar B
Starting temperature		
After 10 minutes		
After 20 minutes		
After 30 minutes		



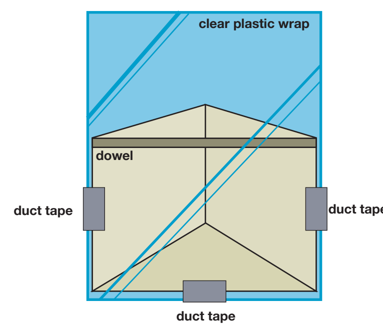
How to Make a Solar Water Heater Model

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)*.

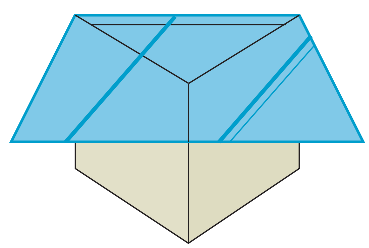




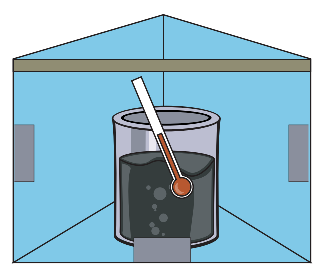
2. *Glazing the box.*
Tape a small stick of wood *(a dowel)* across the top corners of the heater box as a brace. Use silver duct tape. Tape clear plastic wrap to the bottom and sides of the box as shown. Make sure it is long enough to have some left over to fold over the top. The fold-over flap can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

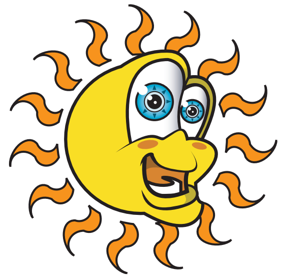


4. *Set up the water heater.*
Open the top of the heater box. Fill the water can, cover the top of it with clear plastic wrap and put a rubber band around the top of the cart to seal it. Place the filled can on the bottom of the heater box and close the top flap. Be sure it is well-sealed. Face the front 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

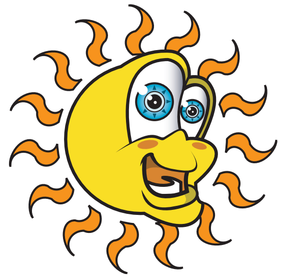
Most of us have some intuitive idea of what "*energy*" means. Although we might not be able to formulate a definition of the word, we use it often and in various contexts. The definition of energy used most often in physical science is *"the ability to do work."* What does *'work"* mean? Work can perhaps 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.

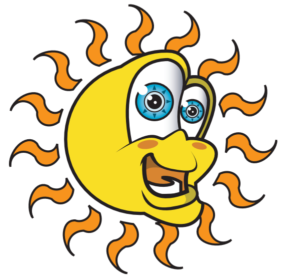
Energy Use and Resources

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

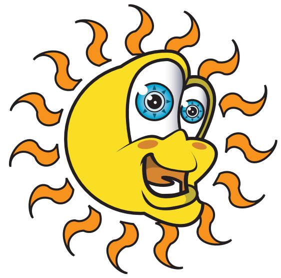
Resources are the supplies of useful or valuable things from which we make or obtain things we need or want. Everything must come from something else; resources are those things with which we begin. Many of our resources are materials from nature. The sources of energy we use are also resources. Some 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 electricification, 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.

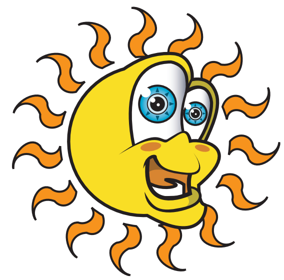
Resources that are raw materials may also be classified as renewable or nonrenewable. Examples of renewable resources that are used for the products we need and want are primarily plant and animal products, such as foods and fibers.

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.)*

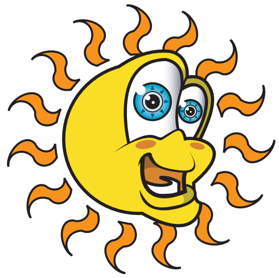


Two of the fossil fuels are very important as raw materials. Coal and oil are used to make many of the products we use each day; they are important chemical resources. The most noteworthy use of these is the use of oil to make plastics. Most plastic products are designed to be used once, or for a short 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.

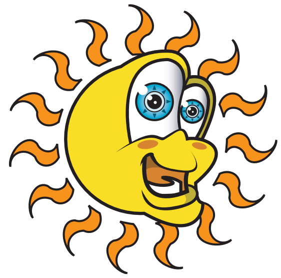
Another aspect of energy conservation is the efficient use of energy. When we say we *"use"* energy, we mean we change it or harness it to do work. We can change *(or convert)* energy from one form to another, but energy can neither be created nor destroyed. Each time energy is changed from one form 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.

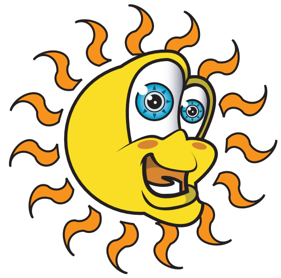
Conserving Energy

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.

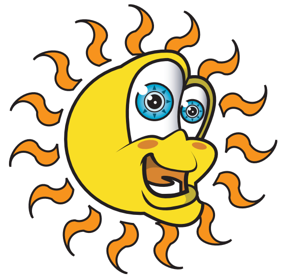


Conserving energy should be practiced at every level of our society. Businesses, industries, governments and communities should practice and promote energy conservation. This is unlikely, however, unless individual citizens and consumers are committed to conserving energy. The measures we take individually 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.



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

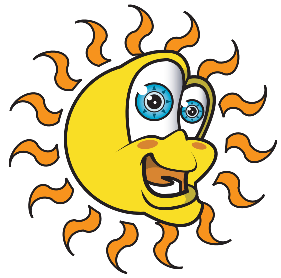
We live in throw-away society. Americans buy, use and discard an amazing array of products, many of which are for one-time use and almost all of which are packaged in several materials. Every phase of manufacturing, transporting and merchandising these goods involves the use of energy. When used goods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

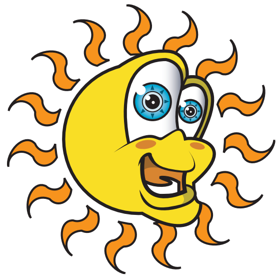


Waste materials can also be chemically changed to produce fuels which can then be burned. For example, pyrolysis is the heating of waste materials to very high temperatures in an oxygen-free environment;
depending upon the wastes and/or the process, a gas – or oil-like fuel is produced. Methane, similar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

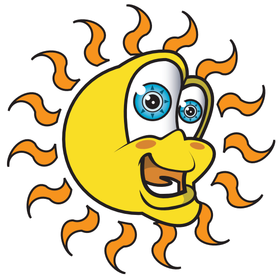
As we have developed more and more energy-using technologies, our demands for energy have soared. We are using our resources, especially fossil fuels, at an alarming rate. It has become clear that we must develop new energy resources and technologies. Because the sun's energy is inexhaustible, free and 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.

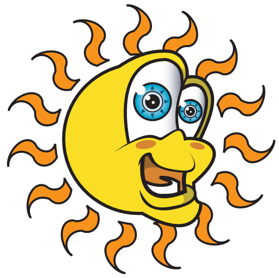
Passive solar technologies are more easily used by individual homeowners or builders than are active systems. For example, people constructing new buildings or remodeling old ones can incorporate passive solar design elements into their plans. Existing buildings can be retrofitted – modified or added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

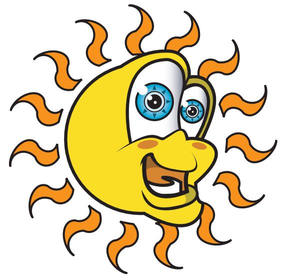
The major challenges to using more solar power include the lack of satisfactory means of energy storage and concerns about flexibility and economics. Because no power can be produced when the sun is not shining, scientists must develop cost-effective methods of storing solar power in order to supply 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.

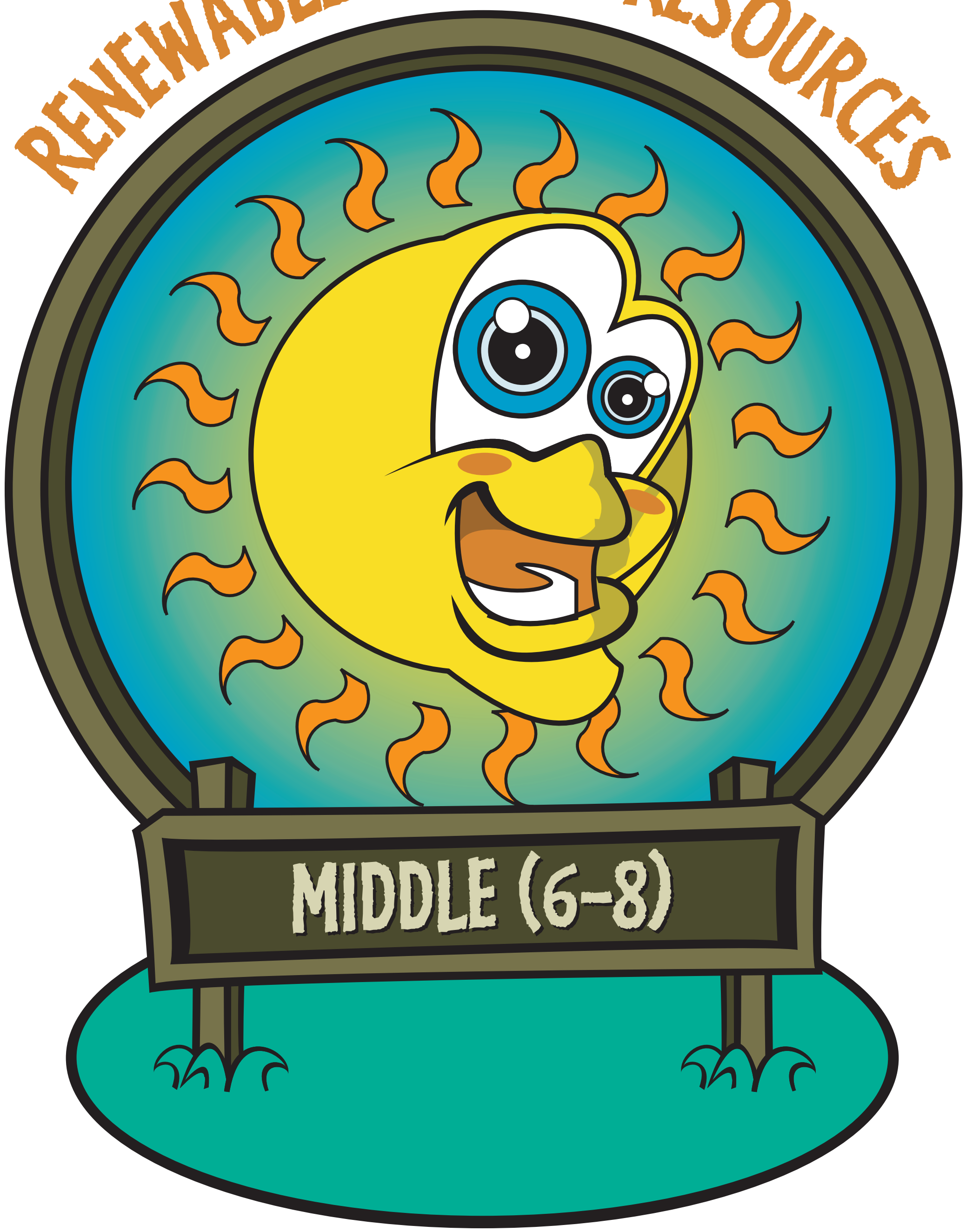
solar collector: any device used to trap the sun's energy and change it into heat energy.

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

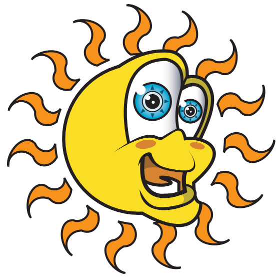
turbine: a device in which a bladed wheel is turned by the force of jets of water (*or steam*); connected by a shaft to a generator.

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

RENEWABLE ENERGY RESOURCES



BRAVE NEW WORLD



SUBJECTS: Life Science, Earth Science, General Science

TIME: 3 class periods

MATERIALS: 1 roll 6-mil plastic *(20' wide x 100' long)*, 1-2 rolls good duct tape, scissors, window fan, small balloons, large balloons, hot plate, water, measuring tape *(or string and ruler)*, water squeeze bottles, box of books, roller skates, 2 chairs with rollers, ball, muddy water, coffee filter, jar, teacher sheets, student sheets

Objectives *The student will do the following:*

1. Identify the requirements for sustaining human life and how these requirements are met on earth.
2. Identify the problems of creating a human habitat in space.
3. Identify waste products and how they can be recycled into usable resources.
4. Simulate some of the conditions of living in space.

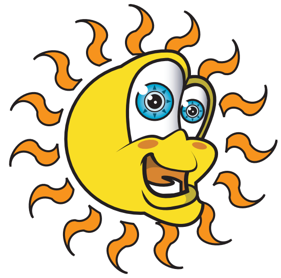
Background Information

The earth's habitat supports life for millions of organisms that are, as far as we know, unique to this planet. The critical external influence on the earth's habitat is the sun. Solar energy, in the form of light and heat, is the "*engine*" that sustains the habitat on earth. The earth must have a constant input of energy from the sun to function as a living habitat. The earth's habitat has an incredibly complex, interrelated web of cycles by which water, minerals and organic materials are naturally recycled, providing a continuous supply of the essential requirements for life. The earth's habitat, with all its complex interactions and its living organisms, is called the earth ecosystem.

Every organism on earth has requirements which must be met if it is to grow and reproduce. Heat energy, gravity, small quantities of many minerals, oxygen, and water are essential to all living organisms *(although some do live without oxygen)*. Plants must also have light and carbon dioxide for use in photosynthesis, a biochemical reaction which results in the formation of energy-storing simple sugars. Animals must have a source of food and so ultimately depend entirely on the presence of plants.

As human activity increases, the ecological balance of the earth is affected by our increasing use of nonrenewable resources and by our production of tremendous amounts of un-recycled wastes and toxic pollutants. The challenge for humans is to use and reuse the earth's resources much more wisely and to greatly decrease the negative effects of wastes on the delicate systems on which we depend. Although the earth seems a huge place to us, it still is a closed system *(with the exception of solar energy)*. As far as we know, no other planets offer us a suitable habitat.

Space exploration has given us opportunities to solve smaller-scale problems about how to live in a closed system. The insights gained from creating a self-sustaining habitat designed for prolonged human use in space are important in our understanding of the problems of the earth's habitat. In this activity, students will examine what is essential to human life in our habitat. Using this information, the students will investigate the problem of designing a self-sustaining human habitat, such as must be accomplished if we are to live in space for extended periods of time.



Terms

closed system: a system that requires nothing from outside itself to sustain itself and that releases nothing to the outside.

ecosystem: a self-regulating community of living organisms interacting with each other and with their environment.

environment: all the physical and organic factors that surround and affect living organisms.

gravity: the force which attracts anything that has mass toward the center of the earth.

habitat: the place where a plant or animal lives, grows, and reproduces.

photosynthesis: the biochemical process in which green plants use energy from the sun to combine carbon dioxide and water into simple sugars; these simple sugars are the basis for all food on the earth.

recycling: reusing waste products.

waste: materials generated as the result of an activity and discarded as no longer wanted or needed.

Procedure

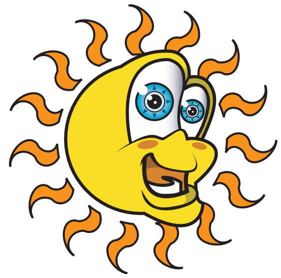
I. *Setting the stage*

A. *Discuss the uniqueness of our planet with the students.*

If you have a space photograph of the earth *(such as a poster)*, show it to the students. Use the following terms as you talk with them about our planet: habitat, environment, ecosystem, cycles. **NOTE:** You might want to illustrate cycles with a simple diagram of the water cycle or the carbon cycle, waste, solar energy and photosynthesis.

B. *Discuss with the students the concept of the earth as a habitat.*

1. Ask the students to describe the habitat of one particular species of plant or animal *(for example: squirrel, otter, palm tree, whale)*.
2. Discuss the interaction and overlap of habitats and the slightly different requirements of different species of organisms. Ask the students to think of their town and the country around it. How many different kinds of plants and animals live there? Point out that most of them have interacting habitats.
3. Make the point to the students that to list the characteristics of the earth's habitat means listing characteristics which are broad enough to cover all the different, smaller habitats and all the requirements for the different forms of life found on earth.



II. *Activities*

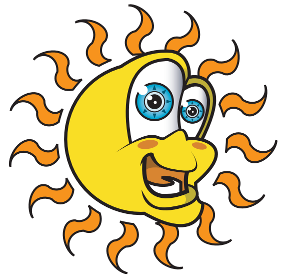
A. *Have the students list the essential requirements of life on earth.*

1. Divide the class into discussion groups of five to-seven students each. Have each group make a list of the essential requirements for life on earth and explain why each is essential. Remind them that they must consider plants as well as animals.
2. Using the background information and the discussion group lists, lead a class discussion on the essential requirements. Asking the students to identify *(in general)* how the requirements are met. *(Heat energy, gravity, small quantities of many minerals, and water are essential to all living organisms. Almost all organisms require oxygen. In addition, light and carbon dioxide are essential for plants and, indirectly, for food for animals. All living things need a place to live and for many animals that includes shelter.)*

B. *Have the students focus on the essential requirements of human life.*

In the process of developing a closed system for long-distance space travel, the first consideration is providing the basic needs of humans for sustaining healthy human life. This exercise will help the students focus specifically on human requirements *(although the same requirements would serve for many other organisms)*.

1. Have the students list the basic requirements for human life in the earth habitat. Then discuss why each one is needed and how it is provided.
   NOTE: You may choose to do this as a group activity first, then a class discussion.
   These requirements, and the *"how"* and *"why"* concerning them, follow.
   a. Food:
      Why Needed? Provides energy for basic body functions and activities; required to build and maintain the structure of the body *(bones, muscles, organs, etc.)*.
      How Provided? Directly or indirectly from plants. Photosynthesis uses the energy from sunlight to produce simple sugars *(food)*.
   b. Oxygen:
      Why? Essential for the chemical reactions *(respiration)* that enable the body to utilize the energy contained in the chemical bonds of food.
      How? From the atmospheric oxygen released by plants. Light energy, carbon dioxide and water are combined during photosynthesis to produce simple sugars *(food)*; oxygen is a waste product which is released into the atmosphere.
   c. Water:
      Why? Medium in which chemical reactions in the body take place; also dissolves harmful waste products so they can be eliminated.
      How? By the earth ecosystem's water cycle.



d. Heat from the environment:
Why? The chemical reactions within the human body occur only within a narrow range of temperatures. The body has regulatory mechanisms *(producing heat from food or sweating to reduce heat),* but these are limited to a small range of environmental temperatures.
How? By the heat energy of the sun. Solar heat energy, combined with the rotation of the earth, creates the overall climates of different areas of the earth, as well as seasonal and daily weather.

e. Air Pressure:
Why? Essential to keep oxygen dissolved in the blood and for the inflation of the lungs.
How? The atmospheric layers around the earth result from the gravitational pull of the earth on gas molecules. Gravity decreases as the distance from the center of the earth increases. This causes the gas molecules in the atmosphere to move further from each other as the altitude increases. In general, air pressure is highest at sea level and decreases as the altitude increases. Natural air pressure is caused by gravity. One example of artificially maintained air pressure is the air in an airplane during flight.
NOTE: Nitrogen constitutes about 78 percent of the atmospheric gases, while oxygen is about 21 percent. Carbon dioxide constitutes 0.03 percent, and a variety of other gases and water vapor make up the rest.

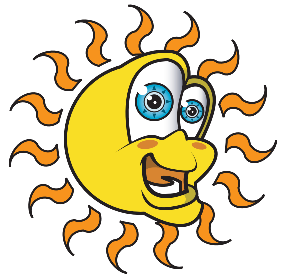
f. Light:
Why? Indirectly, as the source of energy in all food *(captured by photosynthesis).*
How? By the sun.

g. **NOTE:** Although a place to live and shelter are needs for living things, for the purposes of this exercise, we will assume that the provision of this need is a given. When we apply this information to the problem of creating a habitat in space, the space vehicle will serve as our shelter.

2. Give each student a copy of each of the student sheets *"Basic Needs for Human Life" (page 83)*, and *"Sources for Basic Human Needs" (page 84)*. Have the students complete them.
   a. The answers for *"Basic Human Needs"* are as follows: 1) food; 2) food, oxygen; 3) air pressure; 4) oxygen; 5) water; 6) light; 7) heat.
   b. The answers for *"Sources for Basic Human Needs"* are as follows: Food – animals, plants; oxygen – atmosphere *(and, indirectly, plants)*; water – streams, lakes, wells; heat – sun; air pressure – atmosphere; light – sun.

C. *Remind the students that we have discussed human needs, including the things we must take in, but that human waste products are part of the habitat too.*

1. Discuss with the students the different kinds of materials included in the category *"human waste."* Ask the students to name general categories of human waste. *(Body wastes; household wastes; industrial wastes)* Have the students list examples of each type of waste. Categories and examples are:



a. Body wastes – solid *(feces)*, liquid *(urine and perspiration)*, gas *(carbon dioxide)*
b. Household wastes – paper, aluminum, steel, glass, plastic, food scraps and other vegetable materials
c. Industrial wastes – toxic chemicals, gases, carbon dioxide, excess heat, materials as listed for household wastes
d. Fossil fuel and nuclear wastes – toxic gases *(including NO_x and SO_x)*, excess CO_2, radioactive waste, ash from fossil fuels

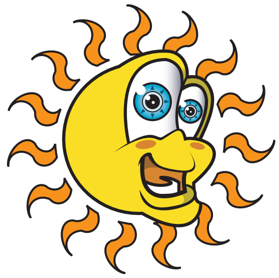
2. It has been said that wastes are simply resources out of place. Discuss with the students the concept that nature recycles wastes. All organisms generate waste. For example, plants release oxygen and water vapor to the atmosphere. Additionally, when organisms die, they become organic waste. All these wastes are part of the natural recycling that operates in the earth's ecosystem. However, human activities are much more extensive than those of other organisms, and the wastes we generate are not extensively recycled. Ask the students to give examples of how human wastes in each category above are recycled or could be recycled.
   a. Solid and liquid body waste, and dead organisms – food for other organisms; nitrogen for plant growth; minerals returned to the ecosystem.
   b. Gaseous body waste – CO_2 from animals is essential for plants; O_2 given off by plants is essential for both plants and animals.
   c. Household wastes – many materials can be treated and reprocessed into similar products.
   d. Industrial wastes – many may be useful in other industrial processes.
   e. Fossil fuel and nuclear wastes – We may someday find ways to use more of these, but are not thus far using any of these wastes except fossil fuel ash *(e.g., as a raw material for road building)*.
3. Give each student a copy of the student sheet *"Human Waste Management" (page 85)* and have them complete the questions. The answers are as follows: 1) carbon dioxide, urine, feces; 2) paper, yes; 3) metal, glass, plastic, yes; 4) heat, carbon dioxide and other gases.

D. *Build a school yard "space bubble" using the instructions on the teacher sheet "Build a Space Bubble" (page 86).*

Use it to conduct the activities below. *(Other activities, in cooperation with other teachers, may include physical education, creative writing, and astronomy activities.)*

E. *Have the students consider some of the problems of developing a human habitat in space.*

1. Ask the students how size will affect the problems of designing a space habitat that has all the requirements for healthy human life. How do size/space limitations relate to the essentials? Here are some examples:



a. We must provide oxygen *(and other inert atmospheric gases)* because there is no atmosphere and not enough room to grow enough plants to provide oxygen.
b. There is limited space for growing/storing food and storing waste.
c. We must store water, but space is limited.

2. Ask the students what physical requirements have to be met for life in space.
   a. We must carefully control temperature.
   b. We must provide light inside. We cannot rely on direct solar energy through the windows because it provides too much heat along with light.
   c. The effects of lack of gravity must be counteracted.
      1. Air has to be pressurized.
      2. People must exercise to prevent muscle deterioration.
      3. Problems in eating, bathing, and using the toilet must be solved.
3. Have the students think about the problems and requirements they have listed and answer the following questions:
   a. In a small space station, what could be recycled? *(water, heat from bodies, lights, and equipment)*
   b. How would things change if the space station were much larger *(multi-roomed)*? *(Answers will vary.)*
   c. What in the space station will require the use of energy? *(pressurization, temperature control, lights, equipment, some of the recycling)*
4. Conduct the activities suggested on the teacher sheet *"Space Habitat Problems"* in the space bubble. Discuss the questions with the students as they complete the activities.

III. *Follow-Up*

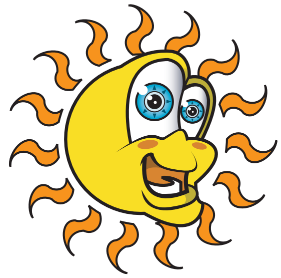
A. *Have the students name five of the six needs examined in these exercises and write a short explanation of how these needs are met in both earthbound and space habitats.*

B. *Have each student write a one- to two-page short story about life aboard a space station.*

IV. *Extensions*

A. *Simulate the work and living area of the space shuttles in your classroom.*

B. *Have the students write a report on the habitat needs and waste management aspects of a fish bowl.*



C. ***Have the students write a report on the habitat differences they would have to consider if they were making a terrarium for desert plants and another for tropical plants.***

D. ***Have the students research the benefits we have received from space exploration and the preparations for it.*** *(See who makes the longest list.)*
NOTE: A list of resources for information about space exploration appears on the teacher sheet *"Nasa Centers"*.

E. ***Have the students write reports on their choice of the following topics:***
1. The use of robotics in space
2. Plumbing in space
3. Artificial gravity
4. Storing, preparing, and eating food in space
5. Solar energy in a space vehicle

Resources

Alabama Department of Economic and Community Affairs. "Environmental Control for Spacecraft" [LS07], Alabama Energy Education Idea Book for High Schools. Montgomery: ADECA, 1987.

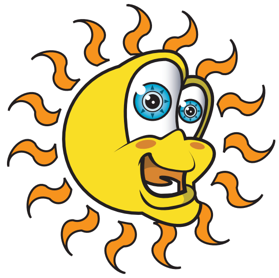
Lujan, B.F., and R. J. White. Human Physiology in Space: A Program for America. Washington, DC: NASA, 1990.

NASA. "Living and Working on the New Frontier." NASA Information Summary. PMS 017-A(KSC).

NASA. "NASA Space Link" *(An Electronic Information System for Educators)*. MSFC 1E988.

NASA. Teacher In Space Teacher's Guide. N.p.: NASA, n.d.

Sharpe, M.R. "Living in Space," Double Science Series. Garden City, NY: Doubleday,1969.



Basic Needs for Human Life

Fill in the blanks below by choosing from the listed words:
food, oxygen, water, heat, air pressure and light.

1. Plants make their own, but we must take in ___________________.

2. Which of the essentials must our bodies take in to supply us with energy?

___________________ and ___________________.

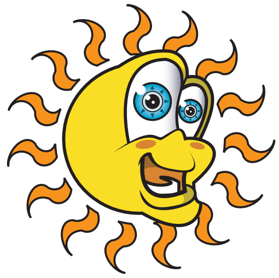
3. Our lungs require ___________________*(two words)* to function.

4. The air we take into our lungs must contain ___________________.

5. All activity of the human body is based on chemical reactions. These reactions require a certain amount of ___________________ to dissolve the chemicals.

6. While some animals rely mainly on their sense of smell to find food, human beings rely mainly on sight. Therefore, for most of us, finding food and water requires ___________________.

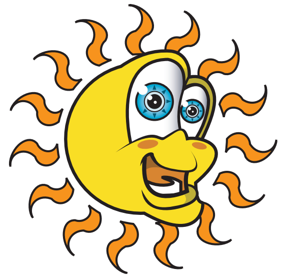
7. It is essential that our bodies maintain temperatures at which normal functions take place. Some of this is provided by burning food *(our fuel)*, but we must also have ___________________ from our environment.



Sources for Basic Human Needs

Match the essentials for human survival with the sources from which we get them. Some needs have more than one source. Some sources provide more than one need.

Needs	Sources
food	animals
oxygen	plants
water	sun
heat	atmosphere
air pressure	streams, lakes, wells
light	



Human Waste Management

Fill in the blanks below by choosing from the listed words:

carbon dioxide, feces, heat, paper, urine, carbon dioxide and other gases, glass, metal, and plastic.

1. Waste products from the human body are: _________________________ *(a gas)*,

_________________________ *(a liquid)* and _________________________ *(a solid)*.

2. When you read a magazine and throw it in the trash, you generate waste in the form of

_________________________. Can it be recycled? ___________ yes ___________no.

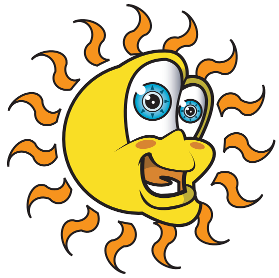
3. Empty soft drink cans are _________________________ waste products, while bottles are either

_________________________ or _________________________ waste products.

Can it be recycled? ___________ yes ___________no.

4. Automobiles generate excess ____ as well as

____ *(several words)*.



Build a Space Bubble

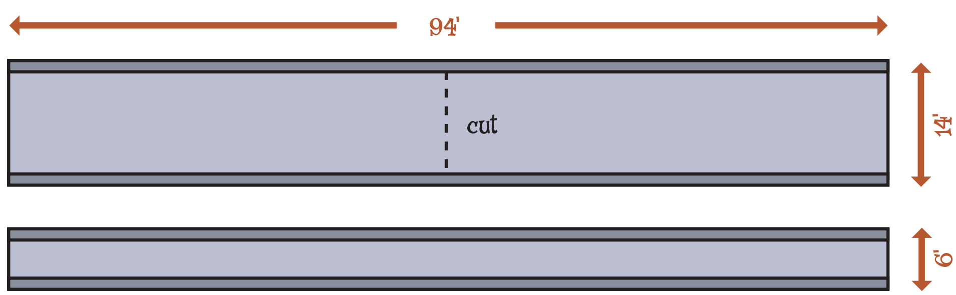
The "bubble" is an envelope-like room, constructed from plastic sheeting, and inflated with a household window fan. It is easy to construct, fairly inexpensive, and provides a wide variety of uses for the classroom teacher or outdoor educator.

Materials: 1 roll of 6-ml polyethylene *(20' wide and 100' long)* – Check with garden centers or large hardware stores, 1-2 rolls of good duct tape, scissors, measuring tape *(or ruler and string)* window fan, a large area for construction.

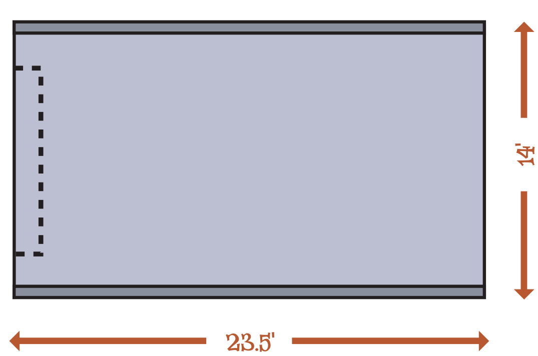
Instructions:

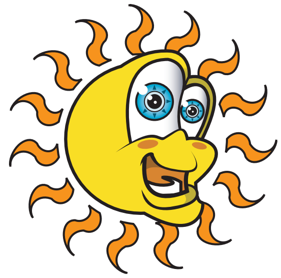
1. Unroll and cut about 6 feet off the roll. You will use this to attach a fan to the bubble. *(Piece will be 6 x 20 feet.)*

2. Unroll the remaining plastic. Cut a strip 6-8 feet wide along the entire length; this can be used for a water slide! Then cut the big piece in half crosswise.



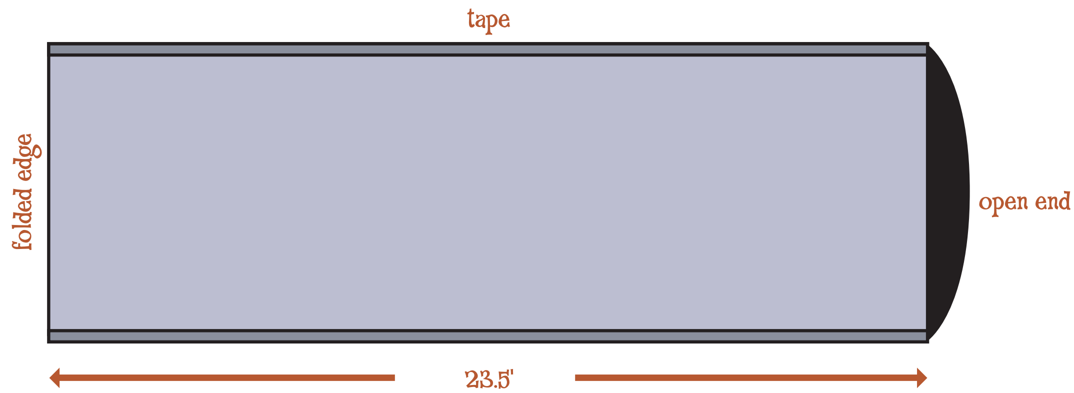
3. Spread out one of the two halves and then fold it in half.





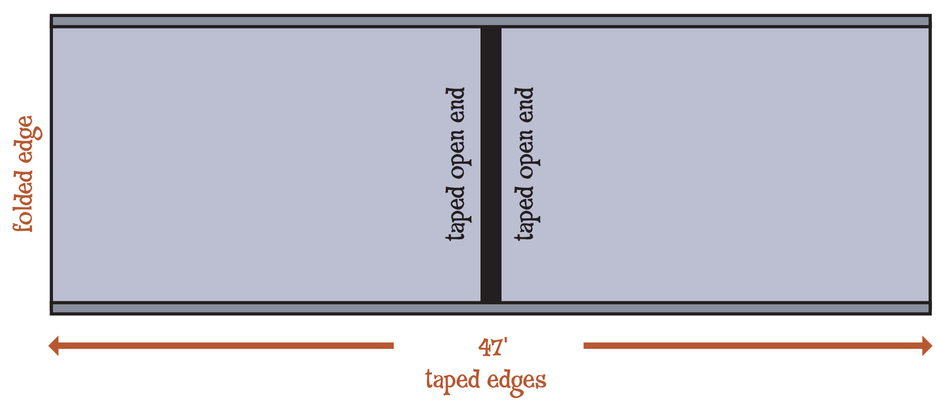
Build a Space Bubble continued

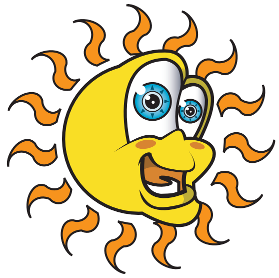
4. Tape along the two long sides, creating a long, narrow envelope. *(When taping, lay the edges next to each other or even overlapped a little, and press firmly so that there are no gaps. It helps to have a hard surface to tape on.)*



5. Repeat steps 3 and 4 *(above)* with the other half of the plastic.

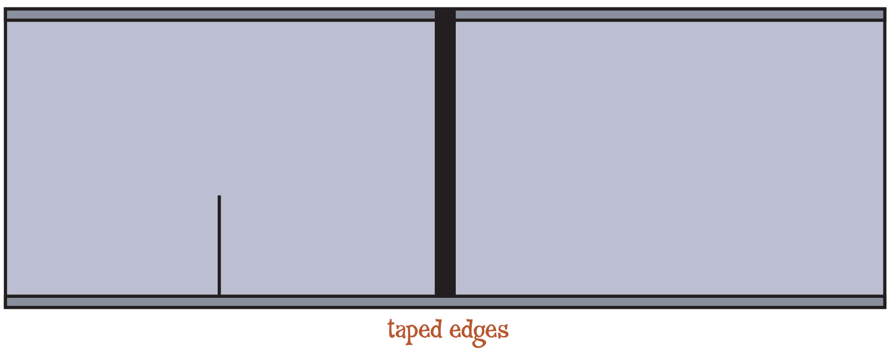
6. Tape the two envelopes together, first on one side and then the other.





Build a Space Bubble continued

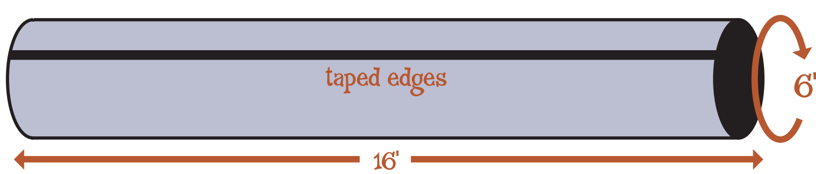
7. For an entrance, start at one of the taped side seams, and cut a slit in one side inward from the side seam about 4 feet. Make the slit about halfway between the corner and the midseam.



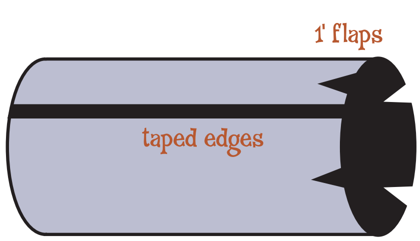
8. Reinforce the edges of the entrance with duct tape.

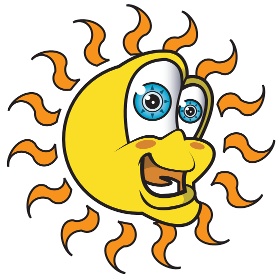
9. Cut about 4 feet off the piece that you cut for the fan attachment. You will have a piece 4 x 6 feet and one 16 x 6 feet.

10. Make a long tube by taking the longer piece and taping the edges together.



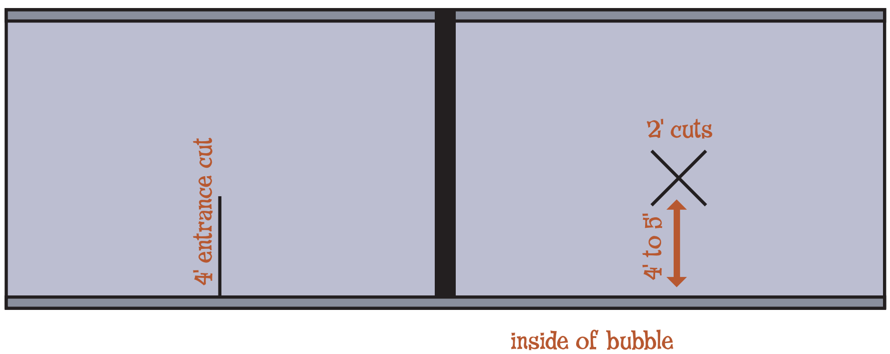
11. Cut one of the ends of the tube so that it has 4 flaps, each about a foot long.



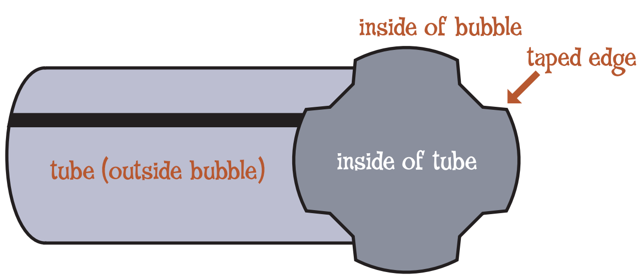


Build a Space Bubble continued

12. On the same side of the bubble as the entrance, cut an X with two 2-foot cuts. Make the cut about 4-5 feet in from the side seam and about halfway between the corner and the midseam.



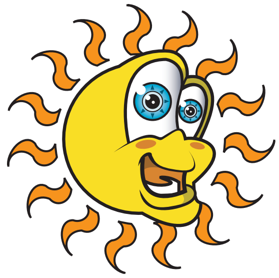
13. Insert the end of the tube with the flaps on it into the X and then tape it from both sides: Pull out the flaps from the X and tape them to the sides of the tube. Tape the tube flaps to the inside wall of the bubble.



14. Turn the bubble so that the entrance and the tube are on the underside. Tape a fan to the tube, making sure that there is an airtight seal around the fan. *(Make sure that the plastic does not cover the fan's air intake.)* To start blowing up the bubble, you may have to lift the corner of the bubble so that the tube is not constricted for the first few minutes. With a good fan, the bubble should be blown up in 45 minutes to an hour.

15. To stop air from escaping from the entrance, tape the 4 x 6-foot left-over piece on the inside, wall so that it hangs over the slit.

16. If you are using the bubble outside, it is a good idea to stake it down by tying rope around a tennis ball in each corner and then staking the rope on the outside. You will have to cut a slit in the tape to put the rope through. Don't use the bubble outside if it is very windy.



Space Habitat Problems

Materials: small and large balloons, hot plate, water squeeze bottles, box of books, roller skates, 2 chairs with rollers, ball, measuring tape *(or string and ruler),* muddy water *(optional)*, coffee filter, jar.

Instructions:

Discuss these questions with the students. Have the students complete the demonstrations as you work through the questions.

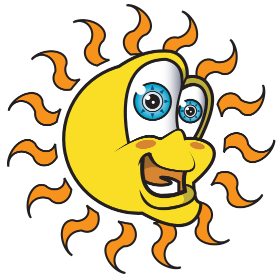
1. ***Problem: Pressurized air for the space habitat***
   a. What gases should be used to fill the space bubble? Why?
   b. What can affect air pressure in an enclosed space? To help get an answer, do this demonstration.
      1. Blow up a small balloon, but not too tightly. Feel how easily it *"gives"* when you press it. This is an indication of the amount of air pressure inside the balloon.
      2. Blow in more air. What happens to the air pressure in the balloon? Why?
      3. Heat the balloon carefully over a hot plate. *(If the balloon bursts, try again with another one.)* What happens to the air pressure in the balloon? Why?
      4. Carefully transfer all the air in the small balloon to a large balloon. How does the air pressure in the large balloon compare with the air pressure caused by the same amount of air in the small balloon?

         Explanation: The actual pressure of the gas inside a closed space *(such as a space vehicle or a balloon)* is directly affected by the quantity of gases and the temperature of the gas *(the more gas and/or the higher the temperature, the higher the air pressure)*, and by the volume of the container *(the greater the volume, the lower the air pressure)*.

2. ***Problem: Recycle the water***
   a. What steps will have to be taken to recycle water in the space habitat?
   b. What would have to be taken out of the water before it could be used for drinking?
   c. Why can't water be filtered in space the same way it is done on earth? *(If desired, pour some muddy water through a coffee filter to demonstrate filtration.)*
   d. What would you have to do to filter water in space?

3. ***Problem: No gravity***
   a. Effects of zero gravity

      This demonstration gives an indication of what happens in zero gravity. Have one student lie flat on the floor with both legs raised vertically. Use a measuring tape to measure the circumference of each ankle. Measure again every 5 minutes for 15 minutes. Discuss the results.



Space Habitat Problems continued

b. Exercise and gravity

Muscles in our bodies retain and increase their strength by working against the force of gravity on earth. In a space habitat, there is no gravity.

1. How can humans prevent loss of muscle tone in space?
2. Would a jump rope be an appropriate piece of equipment for exercise in a space habitat? What would alternatives be?

c. Practical problems

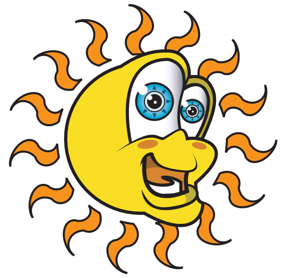
1. Eating in zero gravity
   What would happen in the space habitat if you spilled a glass of water or a spoonful of peas? Eating and drinking must be done from very confining containers. Try drinking from a squeeze bottle while it is standing upright. Your food might be served in tubes like toothpaste tubes so it could be squeezed into your mouth.
2. Moving in zero gravity
   Demonstrate some of the difficulties of zero gravity in the following ways: Have a student try to push a big, heavy box of books *(or a table)* while wearing roller skates. Have two students seated on chairs with rollers throw a ball back and forth while keeping their feet off the floor.

4. ***Problem: Psychological effects of too little space***

a. Ask the students to think of situations when they are crowded with too many people around them. What reactions do they have when they are in a crowd of people for a long time?

b. Discuss with the students the following questions.
What do they think would bother them the most about living with the same people for several months with no other place to go? What could be done to prevent this from becoming a serious problem?

c. Ask the students to think about their own bedrooms at home, and draw the following room arrangements. If they share with someone, how do they divide it so that each person has private space? How would they change it if they could? If they do not share a room, have them imagine how they would arrange the room if they could use only half of it for personal space.



NASA Centers

NASA Headquarters
Washington, DC 20546

Ames Research Center
National Aeronautics and Space Administration
Moffet Field, California 94035
Technology Utilization Officer: Laurence A. Milor
Telephone: (415) 694-4044

Goddard Space Flight Center
National Aeronautics and Space Administration
Greenbelt, Maryland 20771
Technology Utilization Officer: Donald S. Friedman
Telephone: (301) 286-6242

Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91109
Technology Utilization Manager: Norman L. Chaffin
Telephone: (818) 354-2240

Lyndon B. Johnson Space Flight Center
National Aeronautics and Space Administration
Houston, Texas 77058
Technology Utilization Officer: Dean C. Glenn
Telephone: (713) 483-3809

John F. Kennedy Space Center
National Aeronautics and Space Administration
Kennedy Space Center, Florida 32899
Technology Utilization Officer: Thomas M. Hammond
Telephone: (407) 867-3017

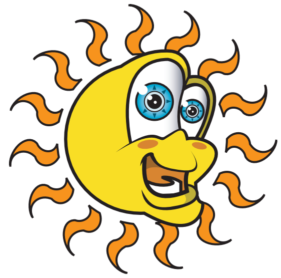
Langley Research Center
National Aeronautics and Space Administration
Hampton, Virginia 23665
Technology Utilization Officer: John Samos
Telephone: (804) 864-2484

Lewis Research Center
National Aeronautics and Space Administration
21000 Brook Park Road
Cleveland, Ohio 44135
Technology Utilization Officer: Harvey Schwartz
Telephone: (216) 433-5567

George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Marshall Space Flight Center
Huntsville, Alabama, 35812
Director Technology Utilization Office: Ismail Akbay
Telephone: (205) 544-2223

John C. Stennis Space Center
Bay St. Louis, Mississippi 39529
Technology Utilization Officer: Robert M. Barlow
Telephone: (601) 688-1929

THAR' SHE BLOWS!



SUBJECTS: General Science, Earth Science

TIME: 2 class periods

MATERIALS: record player, paper, pinwheel, 2- or 3-speed electric fan, metric rulers, wire coat hangers, corks, wire cutters, sheets of paper, marker pens, small map tacks, thread spools, small saws or hobby knives, drill or small nails and hammer, scissors, wood dowels or pencils, bathroom cups, large square nuts, pencils with erasers, 3/8" thick balsa, 1/8" thick balsa, wood glue, large map tacks or straight pins, tape, wood or ceramic beads, student sheets

Objectives *The student will do the following:*

1. Demonstrate how the earth's rotation results in global wind patterns.
2. Build and demonstrate the use of wind machine models.
3. Trace the flow of energy from solar heat to mechanical energy in wind machines.

Background Information

Wind is air moving across the earth's surface. Uneven heating of the atmosphere creates the movement of air masses. As the sun heats the surface of the earth, hot air expands and rises, and air from cooler areas flows in to take the place of the heated air. The earth's rotation causes the rising air to move in a certain direction *(called a Coriolis force)*. This effect produces the earth's major wind patterns.

As long as 5,000 years ago, people used wind as a source of energy. Ancient people sailed, using wind energy to move their boats. They also used wind to turn windmills for grinding grain. In the 14th and 15th centuries, wind machines were used for pumping water as well as for grinding grain. Although we still use wind energy today for recreational sailing and for pumping water in some areas, its use has declined as the world has increasingly relied on fossil fuels for energy. However, fossil fuels are nonrenewable resources and their use produces undesirable environmental effects. Wind is one possible alternative – a nonpolluting, inexhaustible energy source.

Terms

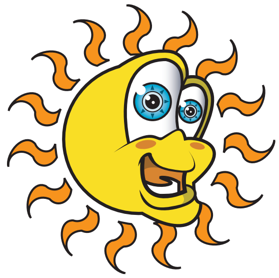
blade: a flat or concave projection from a rotor shaft; a rotor shaft plus its blades make up a propeller.

convection: the natural movement within a fluid caused by unequal heating; warm air rises and cool air sinks.

Coriolis force: rotational force of the earth which affects global wind patterns.

rotor: the rotating part of an electrical or mechanical device; transfers mechanical energy from its source *(such as wind or flowing water or steam)* to the device.

wind: moving air masses; especially, natural air movement parallel to the surface of the earth.



Procedure

I. *Setting the stage*

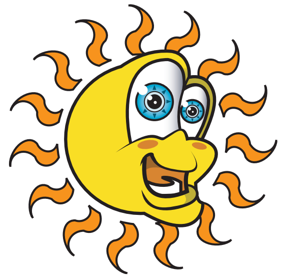
A. ***Have your students brainstorm a list of ways that we capture and use wind energy.*** *(Answers might include windmills, sails, gliders, kites and balloons.)*

B. ***Remind the students of convection.*** Ask them to give examples of convection they have observed at home or school. *(Good examples include a room being warmer near the ceiling; breezes created by opening a window at both top and bottom to cool a room; and rooms on the lower floor of a building being cooler than those on upper floors.)* How does convection relate to the uses of wind the students listed above?

II. *Activities*

A. ***Have the students conduct a simple demonstration to aid their understanding of convective air currents and Coriolis forces.***

1. Share with the students the following introductory information:
   When the sun heats the atmosphere, the gas molecules in the air gain energy, move faster, spread out, and rise higher. As a mass of warmed air rises, it is replaced by cooler, heavier air. A beach on a hot summer day heats much more quickly than the water in the ocean. As a result the breeze will blow from the sea toward the beach during the day. However, at night the sand cools off much more quickly than the water so the breeze blows from the beach toward the sea at night. Unequal heating also causes global winds. The hot air at the equator rises and is replaced by cooler air from the poles. Because of this convective movement of air, we would expect most winds to be northerly and southerly. However, most global winds, travel east or west. The rotation of the earth on its axis explains this.
2. Have the students use a turntable to illustrate the effect of the earth's rotation on its winds.
   - a. Have the students cut a square of paper to cover the top of a turntable. Instruct them to make a hole in the center of the paper and fit the paper onto the turntable, mark the circumference, remove the paper, and cut it to the size of the turntable.
   - b. Have the students do the following:
     1. Measure one-third the distance from the edge of the paper to the hole in the center, and place an "*X*" there. Label it 60°N.
     2. Measure one-third the remaining distance to the hole, and make another "*X*". Label it 30°N.
     3. Use a compass and a colored marker to draw circles at 60° and 30°.
     4. Put the paper back on the turntable.



c. Instruct the first student to brace his/her wrist with one hand and hold a marker on the 30°N latitude line of the paper on the turntable. Have the second student slowly and steadily rotate the turntable counterclockwise at least one full rotation. Have the students do the same thing again, this time holding the pencil at the 60°N latitude line.
   NOTE: The student will have to adjust the pressure of the marker on the paper so that he/she does not stop the motion of the turntable.

d. Now instruct the student with the marker to try to move it on the paper in a straight line from the center to the 60° line while the second student continues to turn the turntable slowly counterclockwise. Have several pairs of students try this.

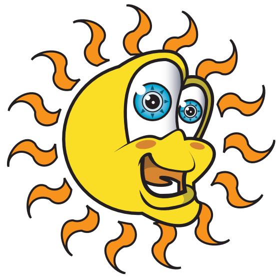
e. Since the surface air currents move over the earth toward the poles from 30°N to 60°N, have several pairs of students try moving the marker point on the paper in a straight line from 30°N latitude to 60°N latitude while the turntable moves counterclockwise.

B. *Have the students build models of wind machines.*

1. Show the students a pinwheel. Have several students blow on it to rotate it. Relate this to wind machines. Point out the blades and the rotating structure to which they are attached. These are analogous to the propeller of a wind machine.
2. Divide the students into three groups. The students in different groups will build models of different kinds of simple wind machines. Give each group copies of a different student sheet: *"Making a Helix Rotor" (page 97), "Making a Savonius Rotor" (page 98),* or *"Making a Conventional Wind Machine" (page 99).*
   NOTE: The conventional wind machine model is more complex and requires more time.
3. Provide the materials listed on the student sheets. Have the groups construct the wind machine models according to the instructions on the student sheets.
4. When the wind machine models are constructed, have the students demonstrate the use of each machine. Use a large room fan with slow and fast speeds to provide the *"wind." (You can take the students outside for the demonstration if there is a steady wind blowing.)*
5. Have the students count the number of times each machine turns at a slow fan speed in a given amount of time *(10, 15, or 30 seconds)*. Discuss how to tell which wind machine did the best job of harnessing the wind.

C. *Have the students trace the energy conversions in the models.*

(For example, begin with solar heat – the energy that causes the development of convection currents – and trace it to the wind's kinetic energy and then to mechanical energy.) Use the models above to illustrate mechanical energy derived from the wind. Explain that we can produce electrical energy by using wind to turn turbines attached to electrical generators.



III. *Follow-Up*

A. ***Have the students write a paragraph explaining why winds occur.***

B. ***Have the students name four ways we can convert wind energy into usable energy.***
(grinding, pumping, producing electricity, sailing)

IV. *Extensions*

A. ***Have the students look at a climate map of the U.S. and suggest locations which might be appropriate for wind energy use.***
Have them research the average wind speeds and frequency in the areas they have selected. Ask them to find out the minimum average speed for economically feasible wind-powered generation of electricity. For detailed information on wind, contact the AMERICAN WIND ENERGY ASSOCIATION, 777 North Capitol Street, NE, Suite 805, Washington, DC 20002.

B. ***Have the students research power plants that use wind energy to produce electricity.***

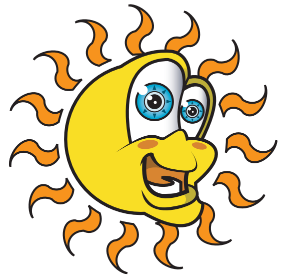
Resources

Clark, P. NATURAL ENEROV WORKBOOK. BERKELEY.
CA: Visual Purple, 1974.

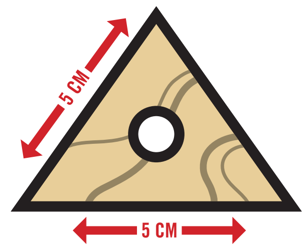
Eldridge, F. R. WIND MACHINES.
McLean, VA: The Mitre Corporation, 1975.

Konigsberg, J. THE MONTANA RENEWABLE ENERGY HANDBOOK.
Helena, MT: Department of Natural Resources and Conservation, 1981.

Oak Ridge Associated Universities. "WIND ENERGY."
Oak Ridge, TN: DOE, n.d. *(Address: Technical Information Center, DOE, P. O. Box 62, Oak Ridge, TN 37830.)*

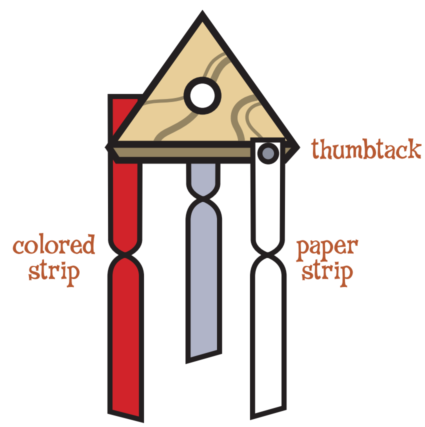


Making a Helix Rotor



Materials: piece of 3/8" thick balsa wood, sheet of paper, wire coat hanger, wire cutters, 2 corks, 6 small map tacks, 2 empty thread spools, marker pen, small saw or hobby knife, drill *(or small nail and hammer)*

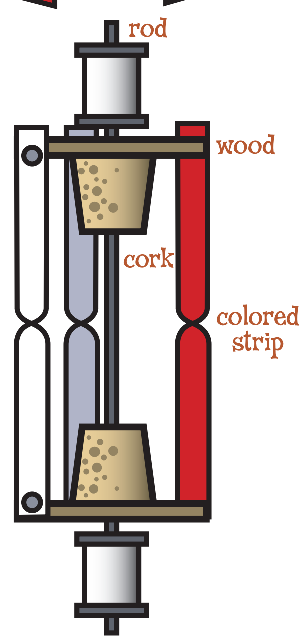
1. Cut 2 triangles, measuring 5 cm on each side, from the 3/8" balsa. Make a hole in the center of each triangle, as shown. Use a small nail and a hammer or use a drill. The hole should be slightly larger than the thickness of the wire coat hanger.



2. Cut a straight length of coat hanger to measure about 12".

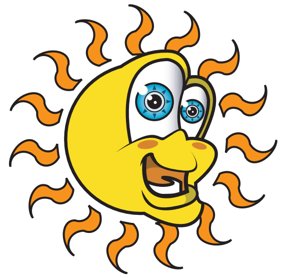
3. Force each cork onto an end of the wire, moving each to about 2" from the end of the wire.

4. Cut 3 paper strips *(1/2" wide)* from the top or bottom of a sheet of paper. The strips will be 8" x 1/2". Use a marker to color one of the paper strips. Then use small map tacks to attach the 3 paper strips to one of the triangles, as shown.



5. Put both balsa triangles on the wire, outside the corks. Position the corks to determine the proper gap between the triangles. Twist each paper strip once and tack each to the second triangle.

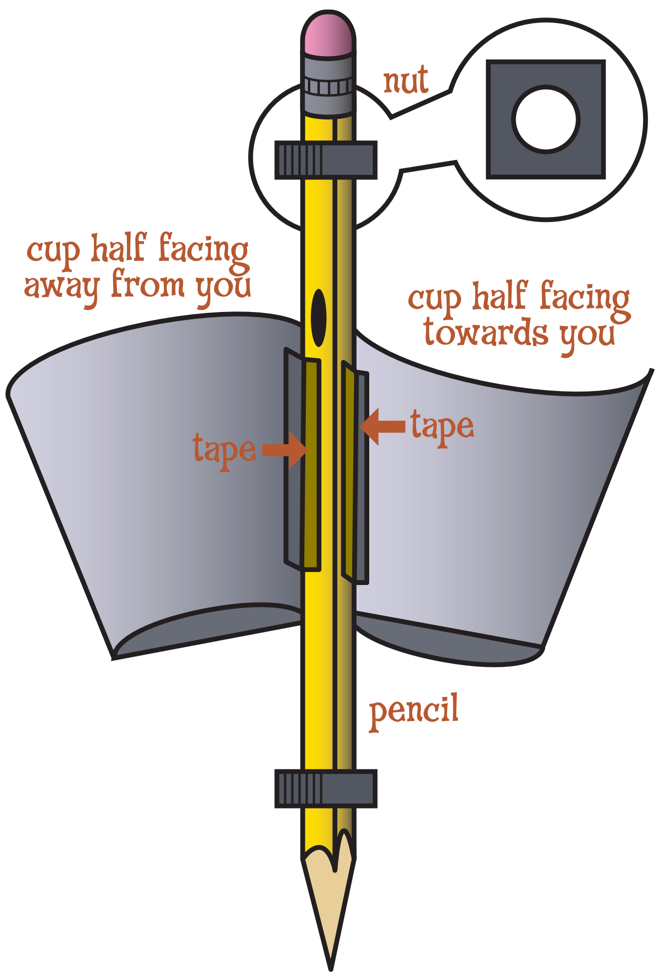
6. Put a thread spool on each end of the wire. When you hold the helix rotor in the wind, hold it by these spools so that the rotor can spin freely. Hold the rotor vertically in the wind.

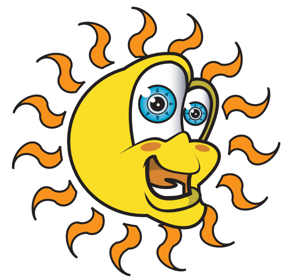


Making a Savonius Rotor

Materials: bathroom cup, wood dowel or pencil, marker pen, 2 large square nuts *(to fit dowel or pencil loosely)*, scissors, tape.

1. Cut a bathroom cup in half vertically and tape each half to the pencil or dowel, as shown.
2. Use a marker *(or a strip of tape)* to make a stripe down the outside of one of the cup halves.
3. Fit a large square nut over each end of the dowel or pencil.
4. Hold the nuts and position the rotor vertically in the wind.

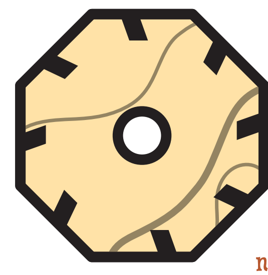




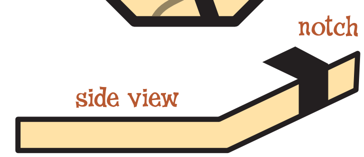
Making a Conventional Wind Machine

Materials: pencil with eraser, 5-cm square of 3/8" balsa, 12 cm x 15 cm piece of 1/8" balsa, hobby knife or small saw, metric ruler, tape, wood glue, large map tack or straight pin, marker pen, wood or ceramic bead.

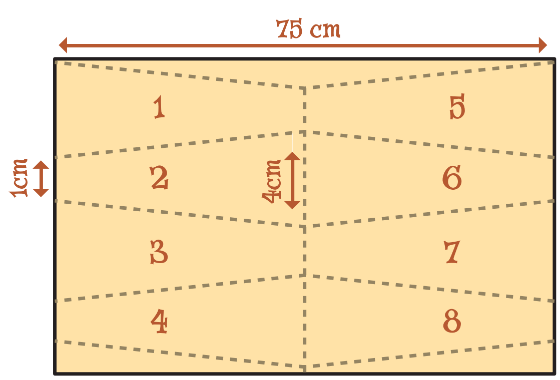
1. Cut the corners from the square of 3/8" balsa to make an octagon. This will be the hub of your wind machine's propeller.



2. Use the ruler to determine the center of the hub. Push the map tack or straight pin through the center. Turn the hub on the pin until it spins freely. Remove the pin until after you have finished building the propeller.

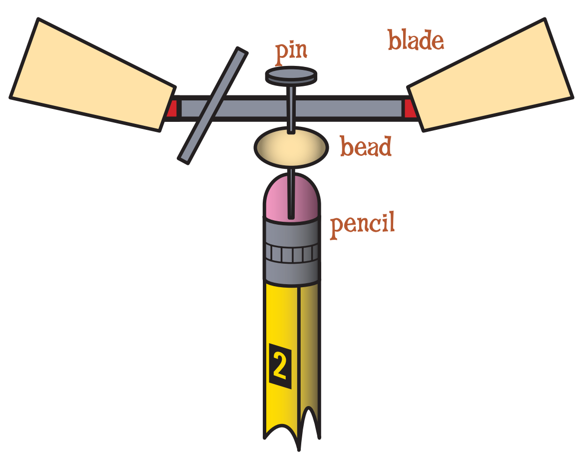


3. Use a hobby knife to cut grooves in each of the octagon's edges. The grooves are where you will insert the blades. Cut them at an angle, as shown. Make them 1/2 to 1 cm deep.



4. Divide the rectangle of 1/8" balsa in half. Use a pencil and a metric ruler; mark the wood so that you have 7.5 cm halves. Use the pencil and ruler to mark off 8 blades, each 1 cm wide on the narrow end and 4 cm wide on the other end, as shown. Use the hobby knife to cut out the blades.

5. Use a marker to color 1 propeller blade.

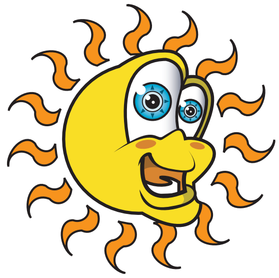


6. Insert and glue the propeller blades into the grooves you cut in the hub. Let the glue dry.

7. Reinsert the pin through the hub. Put a small wood or ceramic bead on the pin and push the pin down into the top of the eraser.

8. Hold the model by the pencil, so that the propeller is vertical, and allow the propeller to spin in the wind.

OLD MACDONALD MADE SOME FUEL



SUBJECTS: Life Science, General Science

TIME: 4 class periods
(including record keeping over 2 weeks)

MATERIALS: transparencies, overhead projector, one-quart canning jars *(or large beakers)*, dried baking yeast, sugar, hot water, paper towels, rubber bands, heavy duty plastic bags, shovel, fresh manure, large buckets *(preferably, with volume measurements)*, duct tape, grease pencils, water, thermometers, large cardboard box, study lamp with 40-W bulb, *(optional)* gas collection bottles, tapers, matches, student sheets

Objectives *The student will do the following:*

1. Define biomass and name at least 10 sources of biomass.
2. Describe fermentation and the production of ethanol.
3. Describe the production of methane.
4. List advantages and disadvantages of using biomass rather than fossil fuels.

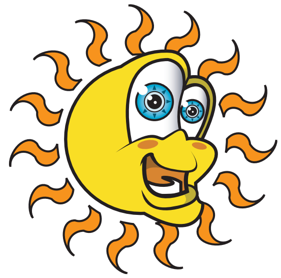
Background Information

The process of photosynthesis in plants stores 40 trillion watts of solar energy in organic matter each year. As the use of nonrenewable fossil fuels continues to result in environmental and supply concerns, organic matter may provide a significant energy alternative. Green plants continually convert solar energy to the chemical bonds in organic matter – a renewable energy resource. This energy source can be used in two basic ways: burned directly as a fuel *(as in specially adapted electric generating plants)* or used to produce transportable fuel, such as ethanol, methanol, and methane. Any solid material of animal or vegetable origin from which energy can be extracted is called biomass.

Plants with high concentrations of carbohydrates *(sugars or starches)* can be harvested for their total organic content rather than just for the vegetables or other limited products they provide. Carbohydrates from such plants can be broken down by enzymes into simple sugars. We can ferment simple sugars under anaerobic *(without oxygen)* conditions to produce ethanol and carbon dioxide. *(We already use some ethanol as fuel.)*

When organic wastes from both plants and animals are stored in anaerobic conditions, the decomposer bacteria use the organic matter as food and produce methane gas. If only half the one-and-a-half billion tons of organic waste produced by the United States *(U.S.)* each year were collected and processed, we could produce methane gas equivalent to half our current natural gas production. A few electric generating plants in the U.S. already use methane gas, piped in from extensive landfill areas, as a fuel to produce electricity.

There are three chief advantages of using biomass instead of fossil fuels for energy. First, biomass is renewable. Second, using organic wastes for energy makes use of something we would otherwise have to dispose of. Third, using biomass energy is often less environmentally damaging than obtaining fossil fuels and burning them. There are, however, drawbacks. Biomass is not renewable if the plant materials are not grown at a rate matching the rate of use. Biomass contains less energy per unit of weight or volume than fossil fuels *(in which energy is highly concentrated)*. Some forms of biomass energy have thus far been more expensive than conventional fossil fuels. Finally, some biofuels or ways of using biomass have environmental effects that are as undesirable as those of fossil fuels.



Terms

aerobic: describes organisms that must have free oxygen for respiration to live.

anaerobic: describes organisms that are able to live and gain energy without oxygen.

biomass: all solid material of animal or vegetable origin from which energy can be extracted.

ethanol: a form of alcohol derived from fermentation of sugar and grain crops and used as fuel; structural formula is CH_3CH_2OH.

fermentation: the breakdown of complex molecules by microbes into ethanol and carbon dioxide.

methane: a colorless, odorless gas formed by the anaerobic decomposition of biomass; formula is CH_4; can be burned as a fuel.

methanol: a form of alcohol produced from a variety of materials *(including wood)* and used as fuel; formula is CH_3OH.

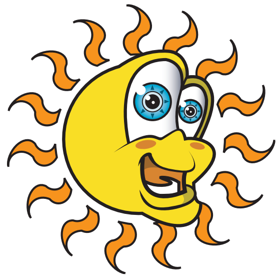
organic wastes: discarded or unwanted materials of living or once-living origin such as animal wastes, crop residues, agricultural product residues, and food scraps; composed of carbon-based substances.

Procedure

I. *Setting the stage*

A. *Ask the students how they would define "biomass."* *("Bio" indicates living or once-living.)* Make sure the students understand that the term *"biomass"* refers specifically to the use of materials from plant or animal sources as energy resources.

B. *Ask what normally happens to organic materials when they are no longer a part of the organism that produced them.*
(They decay or are eaten; their energy is transferred to the organisms which decay or eat them.)
NOTE: This may lead to a brief review of food chains. Make the point that solar energy, used in photosynthesis to make carbohydrates, is transferred from one organism to another. If humans use organic materials as biomass fuel, they are stepping into the food chain and using the energy for other purposes.



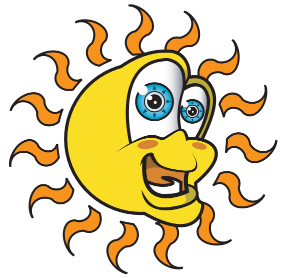
C. ***Have the students brainstorm a list of materials that could serve as biomass.***
Some materials such as firewood are very familiar to them. In some places in the world dried dung is a common fuel. Some students may be familiar with beeswax candles or lamps that burn whale or plant oils.

II. *Activities*

In these activities, the students will demonstrate the production of two fuels from solid organic wastes. Such fuels are sometimes called biofuels. First, the students will investigate the fermentation of sugar to produce ethanol. Second, they will demonstrate the production of methane from manure.

A. ***Have the students produce ethanol by the yeast fermentation of sugar.***

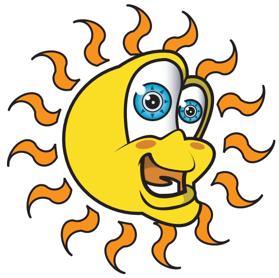
1. Introduce fermentation to the class.
   a. Share the following information:
   Fermentation is a biochemical process in which microorganisms convert simple sugars into ethanol and carbon dioxide. The microbes release carbon dioxide as a gas. Ethanol can be blended with gasoline *(to make "gasohol")* or used by itself as a fuel. For ethanol production, we can ferment sugar-rich crops such as corn, wheat, sugar cane, potatoes, and beets and/or organic by-products and wastes. Large carbohydrate molecules such as starches and cellulose are treated to break them down into simple sugars, which are then mixed in a warm, water-based mash. Yeasts then ferment the organic mixture.
   b. Show the students a transparency made from the teacher sheet *"Commercial Fermentation Process" (page 106)*. Discuss the information with the students.
   NOTE: Point out that none of the by-products are wasted.
2. Have the students complete the demonstration.
   a. Divide the students into groups of two to four students each. Dispense to each group a one-quart canning jar or large glass beaker. Then have the students combine *(in order):*
   2 cups water *(hand hot from the tap)*
   2 tablespoons white sugar
   1 teaspoon dried baking yeast.
   b. Have them loosely cover the jar and leave it in a dark place. *(You might provide paper towels and rubber bands for covering the jar.)*
   c. Have the students record the smell and appearance of the mixture every day for a week, including the end of the class period the first day.
   d. Discuss the results with the students. The mixture should smell like bread the first day. In following days, it should smell progressively more like beer or wine. It should get progressively cloudier as the yeasts multiply. The mixture should have a "*head*" of carbon dioxide bubbles on the top of the solution for the first day or two. At the end of the week, the solution may be relatively clear and the head on the top may be completely gone. The ethanol produced by the yeast during fermentation actually kills the yeast eventually when its concentration reaches lethal levels.



e. Show the students the transparency again and relate the classroom demonstration to the industrial processes in the diagram.
f. Ask the students to list some common food products produced by fermentation.

B. ***Have the students produce methane by the anaerobic decompositon of animal waste.***

1. Introduce the topic to the students. Show the students a transparency made from the teacher sheet *"Basic Steps from Biomass to Gas" (page 107).*
2. Have the students generate methane from manure.
   a. Prepare in advance for the production of methane.
   Obtain a supply of fresh *(green)* animal manure adequate to provide two cups for each group of students. It may contain small amounts of straw or hay without creating a problem. Remove any sticks or other things that could punch a hole in the plastic bag. The manure can be handled best by placing it in a container *(such as a garbage bag)* that can be securely closed, and then putting the bag in a large can or bucket. The manure should be high enough in water content so that it is highly viscous *(semi-liquid).* Add water to it if it is too dry. Local farms, stockyards and large animal treatment facilities are sources of manure. Cow manure is preferable; sheep, horse, hog, or chicken manure is a satisfactory alternative.
   NOTE: Check with the students to see if they have access to cow manure. You may be able to make arrangements with one of them for bringing it to the classroom.
   b. Divide the students into groups of about four students each. Give each group a copy of the student sheet *"Methane from Manure" (page 108).* Give each student a copy of the student sheet *"Data Sheet: Methane from Manure" (page 110).*
   c. Supply each group with the materials listed on the student sheet. Have them proceed according to the given instructions.
      1. Caution the students about the need for care in handling the material and in preparing the bags for gas collection. Methane will escape if there are holes in the bags or if they are not properly closed and secured. Use thick bags that will hold two to three gallons.
      2. Before the students put the wastes into the bags, they must label the bags and test them for air leaks by inflating them with air and submerging them in water.
      NOTE: Grease pencil-writing on duct tape makes a good label and is waterproof.
   Apply it before inflating and submerging the bag to check for air leaks.
      3. Have the students estimate the volume of material placed in the bags, following the directions on the student sheet. Provide a large bucket or other container *(preferably with volume measurements)* for each group. If necessary, provide each group with a container to catch the displaced water and a beaker or other graduated container to measure the volume of the displaced water.



d. Have the students incubate their biomass digesters for five to ten days.
   1. Have the students place the bags in various locations, recording the temperatures and locations on the data sheets. Some suggested locations are: incubators or warming chambers, under an inverted cardboard box with a lamp with a 40-watt bulb to supply heat, on a sunny window ledge, in a shaded part of the classroom, or in a portable cooler with a few ice cubes *(which should be replaced each day as the ice melts)*.
   2. Bags placed in the warmer environments may fill with gas in a few days and should be evaluated then. The others may be evaluated at the same time. Those in cooler environments will take much longer and may not generate methane at all if the temperature is sufficiently low. Have the students make daily observations for five to ten days and record them on the student sheet.

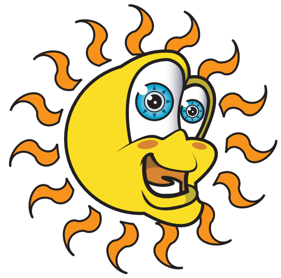
e. *(Optional)* Demonstrate collecting and testing the gas.
   1. With the help of a student, submerge a gas-filled bag in a sink or large tub filled with water and puncture a hole in the double plastic bags with a sharp instrument. Allow the gas to bubble into submerged, water-filled gas collection bottles. You may need to collect the gas from several bags.
   2. After filling several bottles, test a few of them by bringing a long taper near the mouths of the bottles. Have the students compare the flame to that produced by burning natural gas *(e.g., in a gas range)*. Compare the clean burning of methane and natural gas to the characteristics of kerosene or another lower-grade fuel.

III. *Follow-Up*

A. ***Have the students list 10 types of biomass.***

B. ***Have the students discuss the advantages and disadvantages of using biomass and biofuels instead of fossil fuels.*** *(Use the background information to guide the discussion.)*

C. ***Have the students write a paragraph and draw simple diagrams describing the use of biomass for ethanol and for methane production.***



IV. *Extensions*

A. *Have the students survey local gas stations to see how many sell gasohol.*

Have them write to their state government *(and those of other states)* to find out how widely gasohol is used.

B. *Have the students report on other types of biomass energy now being used such as wood.*

C. *Have them debate the use of crops for biomass when there are people in the world who need crops for food.*

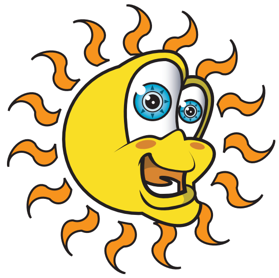
Divide the students into two groups.

Resources

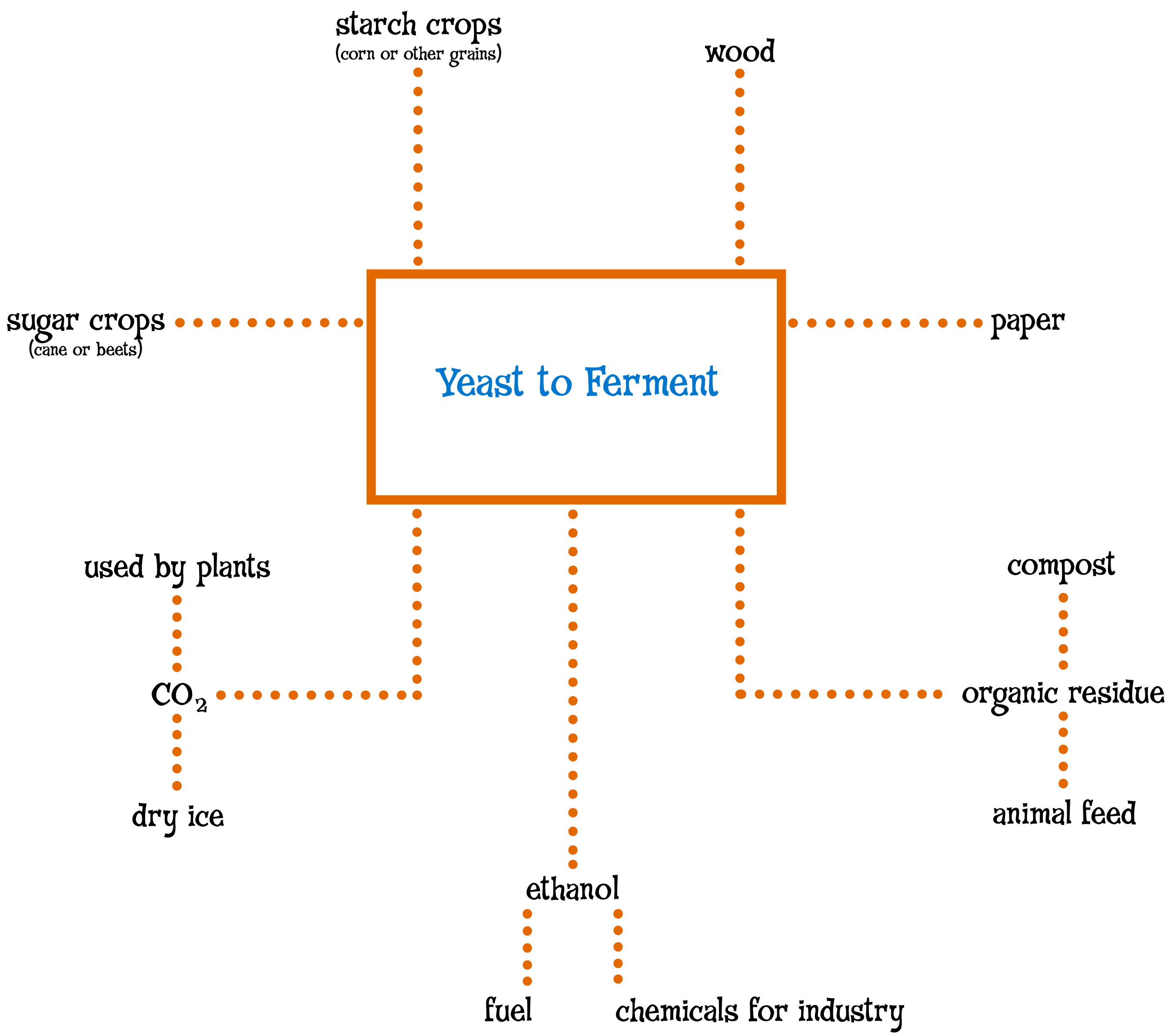
House, D. THE COMPLETE BIOGAS HANDBOOK.
N.p.: N.p., 1978.

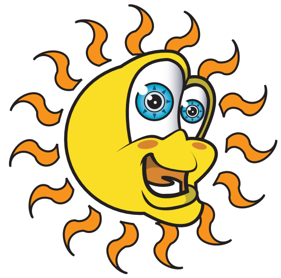
Konigsberg, J. MONTANA RENEWABLE ENERGY HANDBOOK
Helena, MT: Department of Natural Resources and Conservation, 1980.

United States Department of Energy. FUEL FROM FARMS.
(Address: Technical Information Center, DOE, P.O. Box 62, Oak Ridge, TN 37830, Attn: Fuel From Farms.)



Commercial Fermentation Process





Basic Steps from Biomass to Gas

Organic Wastes

silage from farms

manure

grass clippings

vegetables

nuts

blood

bark & decaying wood

fat

dead leaves

fruits

meat

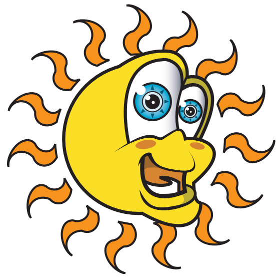
food scraps

Anaerobic bacteria digest waste in biogas digester

CO_2

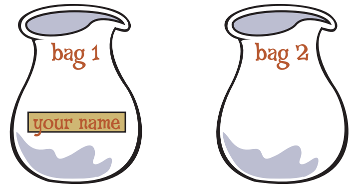
methane (fuel)

organic residue

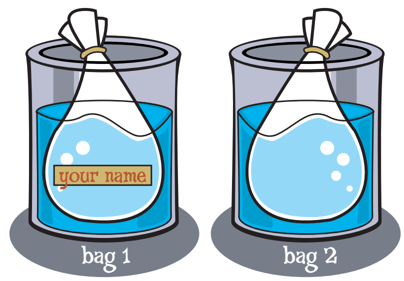


Methane from Manure

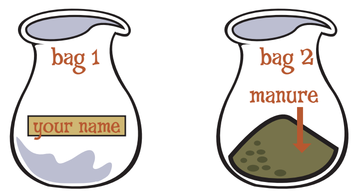
Materials: 2 heavyweight plastic bags with closures, duct tape, grease pencil, large bucket *(with volume measurements),* water, 0.5 L *(about 2 cups)* fresh manure and a thermometer.

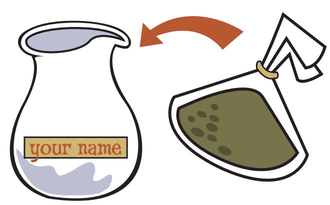


1. Prepare your bags.
   a. On one plastic bag *(bag 1)*, place an 8-cm strip of duct tape. With a grease pencil, write your initials or name on the tape.
   b. Blow air into both bags *(1 and 2)*. Close each bag tightly. Look closely for air leaks after placing the bags in water. Use only bags without leaks! Dry the bags.

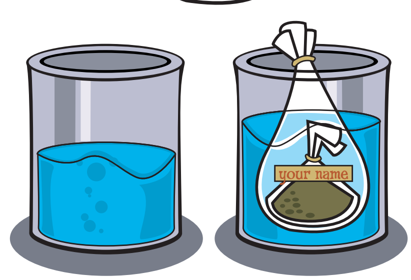


2. Prepare the biogas digester.
   a. Place about two cups (0.5 L) manure in bag 2.
   b. HANDLE ALL PLASTIC BAGS WITH CARE! DO NOT PUNCH HOLES IN THEM.
   c. Squeeze *all* the air out of bag 2 *(containing the waste)*.
   d. Close bag 2 by twisting the top tightly down about 8-10 cm only. LEAVE ROOM FOR THE GAS TO INFLATE THE BAG.
   e. Loop the twisted part of bag 2 over and tie it carefully. Let no air in!
   f. Place bag 2 *(with the waste)* in bag 1 *(with the label)*, removing all of the air in bag 1 and closing it as you did for bag 2.





3. Estimate the volume of your double bag and its contents.
   a. Submerge the closed double bag in water.
   b. Measure the water it displaces.
   c. Record this volume on the data sheet.
   d. Dry off the bag.



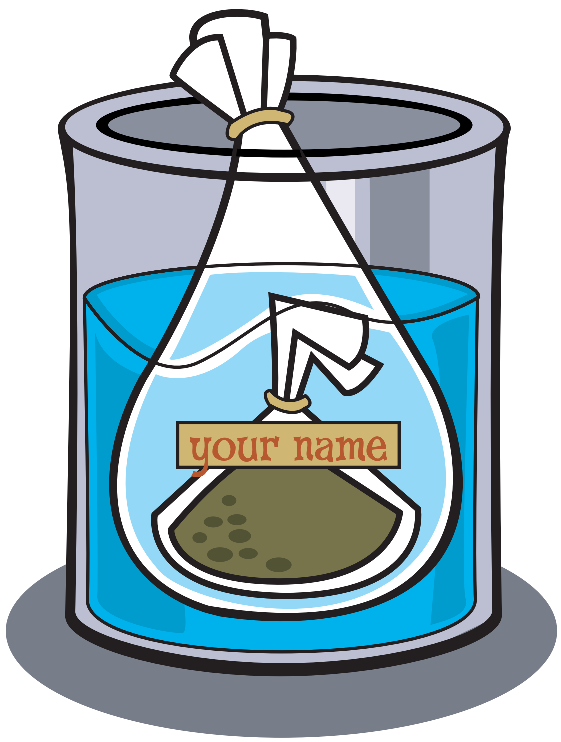
Methane from Manure continued

4. Place the bag in a room temperature, a cool, or a warm classroom location, as directed by your teacher. Record the location of your bag on the duct tape, using a grease pencil.

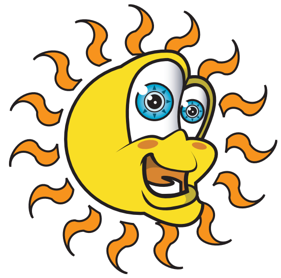
5. Be sure you have recorded the bag identification, its location, the temperature of the location, and the starting date on the data sheet.

6. Observe your bag every day. On the observation chart, record any changes or absence of changes for 5 to 10 days *(or until some of the bags in the classroom seem to be nearly full of gas)*.

7. To find the estimated final volume of the bag, submerge the closed bag in water. Measure the displaced water. Record the volume. Calculate the volume of gas in your bag *(final volume minus starting volume)*.



bag inflates



Data Sheet: Methane from Manure

Bag I.D.	Location	Temp.	Initial Volume	Start Date	Final Volume	Final Date	Volume Change (gas produced)

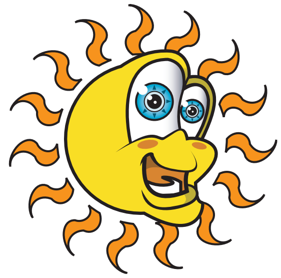
Date	Observations

Results:

1. Compare the amount of gas produced by your generator with that produced by others in your class. Which generators seemed to produce the most methane? The least?

2. What factors *(variables)* seem to influence the production of gas?

IF THE SUN DIDN'T SHINE...



SUBJECTS: Life Science, General Science Earth Science

TIME: 5 class periods

MATERIALS: transparencies, overhead projector, globe, flashlight, 2 small houseplants or pots of vegetable seedlings, filmstrip projector, prism, 6" flower pots, potting soil, corn seeds, metric rulers, 5 large cardboard boxes, cellophane *(red, blue, yellow, green and clear)*, tape, several green leaves, ethanol, beaker, hot plate or bunsen burner, piece of cheese cloth, 2 pieces of white poster board, scissors, student sheet

Objectives ***The student will do the following:***

1. Explain how the sun affects all life on earth.
2. Identify the electromagnetic spectrum, including the visible light spectrum.
3. Conduct experiments showing some of the effects of light on plants.
4. Relate the earth's tilt and rotation to the varying amounts of solar energy available at different locations and different times of the year.

Background Information

The sun is the source of the energy that sustains life on earth, providing heat and light. Through the process of photosynthesis green plants convert this light energy into the chemical energy *(food)* that keeps them alive. Photosynthesis gives off oxygen, which most living things must have to survive. The sun's warmth keeps our planet habitable and solar heat energy drives the climate and weather systems that distribute heat and fresh water over the earth's surface. Solar energy even powers the cycles of vital elements such as nitrogen in our environment.

The sun is a huge thermonuclear fusion reactor, giving off a number of different energy rays in all directions in space. A minute fraction of this energy falls on the earth. Of the energy falling on the earth, somewhat less than half is reflected back into space by atmospheric clouds and dust and the earth's surface. The remainder *(about half)* of the sun's rays affect the earth. Only a tiny portion of this energy *(far less than one percent of the radiant energy falling on the earth)* is captured by green plants. Almost all of the energy affecting the earth is converted to heat energy; it is re-radiated out into space after warming the atmosphere and surface, evaporating water, and causing wind and waves.

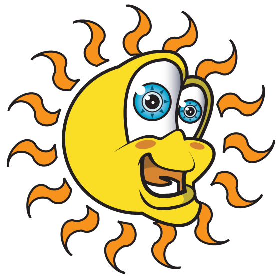
Terms

electromagnetic spectrum: the sequence of electromagnetic waves ranging from cosmic rays *(shortest wavelength)* to radio waves *(longest wavelength)*; the visible light spectrum is a very small part of it.

photosynthesis: the process by which green plants capture light energy from the sun and convert it to chemical energy; the process by which green plants combine carbon dioxide and water using light energy to make carbohydrates *(food)*.

radiation: the flow of energy across space via electromagnetic waves, such as visible light.

solar radiation: energy emitted by the sun and traveling in waves.



Procedure

I. *Setting the stage*

Ask the students to imagine what would happen to the earth and the life on it if the sun stopped shining. Have them explain their answers.
NOTE: Students should list effects in two general categories: 1) physical effects on the earth itself, such as decreased temperature, winds, precipitation, and so forth; and 2) biological effects, including effects related to the interdependence of plants and animals.

II. *Activities*

A. *Introduce the students to the essential role of the sun in life on earth.*

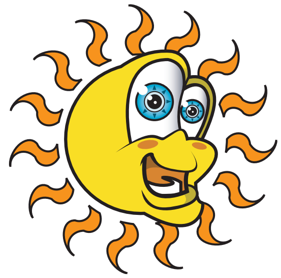
1. Share the background information with the students. Review photosynthesis briefly.
2. Have the students amend their list of the effects of the sun's ceasing to shine.

B. *Have the students examine the electromagnetic spectrum and the energy the earth receives from the sun.*

1. Use a transparency made from the teacher sheet *"Solar Spectrum" (page 117)* to show the students the electromagnetic spectrum and where solar energy fits into it. Discuss the spectrum with them, pointing out the major features on the transparency.
   NOTE: Clarify that infrared rays convert to heat energy when they strike matter and that ultraviolet rays are the component of sunlight responsible for tanning our skin. Ultraviolet light is harmful to us; the ozone layer high in our atmosphere protects us from most of these damaging rays.
2. Give each student a copy of the student sheet *"Spectacular Spectrum Facts" (page 118)*.
   a. Leave the transparency up for them to consult as they answer the questions on the student sheet.
   b. When the students have completed the questions, discuss the answers with them. The answers are as follows: 1) infrared, visible light, ultraviolet; 2) visible light; 3) infrared; 4) x-rays; 5) ultraviolet; 6) infrared, green plants; 7) light; 8) light, photosynthesis; 9) infrared; 10) red, orange, yellow, green, blue, violet; 11) violet, red; 12) infrared, visible light.

C. *Demonstrate the visible light spectrum for the students.*

1. Shine the light from a filmstrip projector through a triangular glass prism onto a white screen. *(If you do not have a projector, use strong sunlight at a window.)*
2. Ask the students to describe their observations. In what order do the colors appear? Explain that each color is a different wavelength and that each, therefore, has a different amount of energy. The prism refracts or bends the rays differently because of their differing energy.



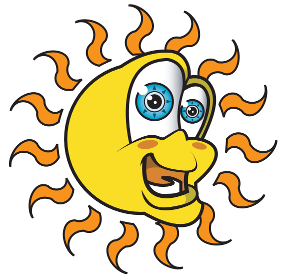
3. Ask the students how this demonstration relates to rainbows. *(Water droplets act as prisms, making the visible spectrum in sunlight separately visible to us.)*
4. Discuss with the students why humans see color. *(We see color because the retinas of our eyes are capable of receiving all the different wavelengths of visible light. Our brains then attach meaning to the signals transmitted from our eyes, and we "see" an incredible variety of colors, shades and tones. The color we see are the wavelengths reflected by the things we are looking at. The other wavelengths are absorbed. For example, a blue shirt looks blue because it reflects certain wavelengths [blue light] to our eyes and absorbs red, orange, yellow, green, and violet light.)*

D. *Have the students investigate the importance of sunlight to living organisms.*

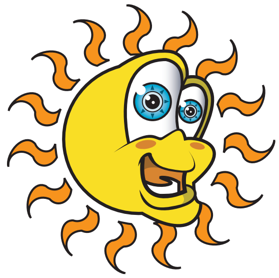
1. Discuss with the students why sunlight is important to all living organisms. Be sure to include the following terms in the discussion:
   - a. Photosynthesis *(conversion of light energy into chemical energy)*
   - b. Plants *(produce energy/food from sunlight, water and carbon dioxide)*
   - c. Animals *(consumers obtain energy directly from plants or indirectly, by eating other animals that eat plants).*

     NOTE: Make sure the students understand that all living organisms *(with a few bacterial exceptions)* get energy from sunlight, either directly or indirectly. You might use some simple food chains to illustrate this.
2. Demonstrate the effects of differing amounts of sunlight on plants of the same species.
   - a. Obtain two small houseplants of the same species and size *(Wandering Jew works well)* or plant two identical pots each with four corn or bush bean seeds *(sprouted potatoes also work well).* Maintain both specimens under the same good conditions for about two weeks.
   - b. After about two weeks, when the seedlings have emerged and the first leaves are well developed, begin the experiment. Put one pot in a sunny window and the other pot in a area of deep shadow *(under a table or desk, where it is shaded but gets some reflected light.)*

     NOTE: If using seedlings, remove some so that there are only two in each pot.
   - c. Keep the soil in all the pots moist but not wet. Check the plants before you water.
   - d. Have the students record their observations at the end of one week and again at the end of the second week. Have them observe the plants' sizes, colors, leaf and stem differences, and other characteristics.
   - e. Discuss the results with the students. The dark-grown seedlings or houseplants will be long, thin, and pale, with long stems between small leaves. *(These characteristics are known as etiolation.)* They might also lean towards the light. *(This is phototropism.)* Ask the students why plants do this. *(It is a survival mechanism; the plant grows toward the light as quickly as possible.)* Now your students are able to diagnose a common houseplant problem – long, thin stems, smaller-than-normal leaves, and leaning toward the light means that plants are not getting enough light.



3. Have the students investigate the effect of different wavelengths of visible light on green plants.
   a. Gather the following materials:
      five 6" plastic pots, package of corn seeds *(at least 50),* potting soil, 5 cardboard boxes *(large enough to completely contain one 6" pot with a 6-8" plant, open on top, and with a few holes cut around base to allow air circulation),* 5 pieces of cellophane *(green, red, yellow, blue, clear)*
   b. Plant 10 corn seeds in each of the pots *(filled with equal quantities of soil.)* Water the soil well, but do not soak it.
   c. When most seedlings have emerged, have the students carefully measure and record the height of each seedling in each pot. Have them calculate the average height of the seedlings in each pot.
   d. Place one pot in each box and cover the box top completely with one of the five different colors of cellophane.
   e. Put the pots in a location where they all get equal light. Water when the soil becomes slightly dry to the touch. Keep the moisture as equal as possible in all five pots.
   f. At the end of two weeks, have the students measure and record the heights of all the seedlings in each pot, again calculating average heights for each pot's seedlings.
   g. Post on the board the average heights for each pot before and after the colored light treatment. Have each student make a bar graph showing the growth of the seedlings. Discuss the results as a class. Which color produced the best growth and why? Which produced the least growth and why?
      NOTE: Remind the students that the colored cellophane blocks the wavelengths of the color we see and admits the other wavelengths. The fact that plants are green but photosynthesis requires red and violet wavelengths of light is sometimes confusing to students. Remind the students that the plants are green because green wavelengths of light are reflected by the plants' chlorophyll, not absorbed and used. The plants absorb mostly the red and violet light; they absorb lesser amounts of the others. Sometimes we can see these other colors in plants that are normally green. Yellow and orange pigments, for example, become visible when leaves die and the chlorophyll breaks down .
4. *(Optional)* Demonstrate the wavelengths of light that chlorophyll absorbs and the wavelengths it transmits.
   a. Gather the following materials:
      several green leaves *(torn into small pieces)*, ethanol, beaker, hot plate, piece of cheese cloth *(for a coarse filter),* prism, rectangular glass container *(clear)*, light source *(such as a filmstrip projector),* 2 pieces of white poster board.
   b. Boil the leaves and ethanol together in the beaker until the alcohol is deep green. *(This extracts the chlorophyll from the leaves.)*
   c. Pour the green alcohol into the rectangular glass container through a coarse filter *(cheese cloth)* to remove leaf bits.
   d. Cut a narrow vertical strip out of the middle of one piece of posterboard.



e. Put the posterboard with the slit cut in it in front of the projector. Have a student hold the prism in front of the slit. Have a student hold the second piece of posterboard in front of the prism.
f. Adjust the positions of the light, slit poster board, prism, and second piece of poster board so a visible light spectrum appears on the second poster board. The students will see the entire spectrum *(all colors)*. Have them record the colors they see.
g. Now put the container with the extracted chlorophyll into the line-up between the prism and the second poster board. Shine the light again and adjust the positions until a spectrum appears on the second poster board. Have the students record the colors that appear.
h. Discuss the results with the students.

E. *Discuss with the students the factors that determine the amount of solar radiation reaching the earth's surface.*

The amount given off by the sun is constant, but the amount reaching the surface of our planet varies for a number of reasons.

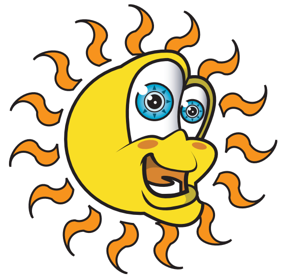
1. Have the students brainstorm a list of things that affect the amount of solar radiation received at any location. Write the list on the board. *(Be sure to include latitude, altitude, topography, cloud cover, air pollution, time of day and season.)*
2. Review with the students how the earth's tilt and its rotation around the sun affect the amounts of solar energy that different locations receive. Show them a transparency made from the teacher sheet *"Solar Energy Varies with the Season and the Place."* Use a globe and a flashlight to illustrate the points in the text on the transparency.
3. Discuss the ways that seasons and latitudes affect plants and animals. Have them list ways that living things are adapted to their habitats, particularly from the standpoints of available solar energy. Point out that the temperatures of various climates are due to the availability of solar heat energy and that the length of daylight hours and intensity of sunlight has many effects on plant growth and flowering and on animal behavior.

   NOTE: It may be helpful to list organisms typical of various biomes, such as tropical rain forests, polar regions or temperate grasslands.

III. *Follow-Up*

A. *Have the students write futuristic poems, essays, short stories, or news reports about what would happen if the earth no longer received energy from the sun.*

Let the students think up their own scenarios in which this might happen. For example, a student might write that our atmosphere has become too polluted by human and/or volcanic activity for solar energy to pass through. Another student might write that a giant asteroid has moved between our planet and the sun, blocking the sun's rays. Tell the students to incorporate information learned in the preceding activities.



B. ***Let the students share their work with the class.***

C. ***(Optional) Coordinate this writing activity with your school's Language Arts Department.***

IV. *Extensions*

A. ***Have the students further investigate the effect of day length on plant growth and flowering.***

One species that may be of interest is the poinsettia *(Euphorbia pulcherrirna)*. Growers of this popular houseplant must carefully manipulate hours of dark/light to cause the coloration of the bracts.

B. ***Have the students design an experiment to demonstrate the phenomenon of phototropism (in which plants grow toward the light).***

C. ***Have the students research chlorophyll and other plant pigments.***

Some might make charts showing the series of events that results in the fall colors of deciduous trees.

Resources

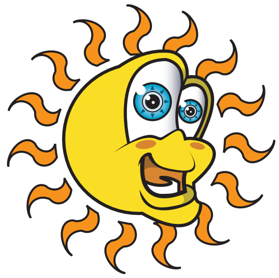
Andrews, W. A Guide To Terrestrial Ecology.
Englewood Cliffs, NJ: Prentice-Hall, 1974.

Curtis, H. Biology.
4th ed. New York: Worth, 1983.

Miller, G.T., Jr. Living in the Environment.
6th ed. Belmont, CA: Wadsworth, 1990.

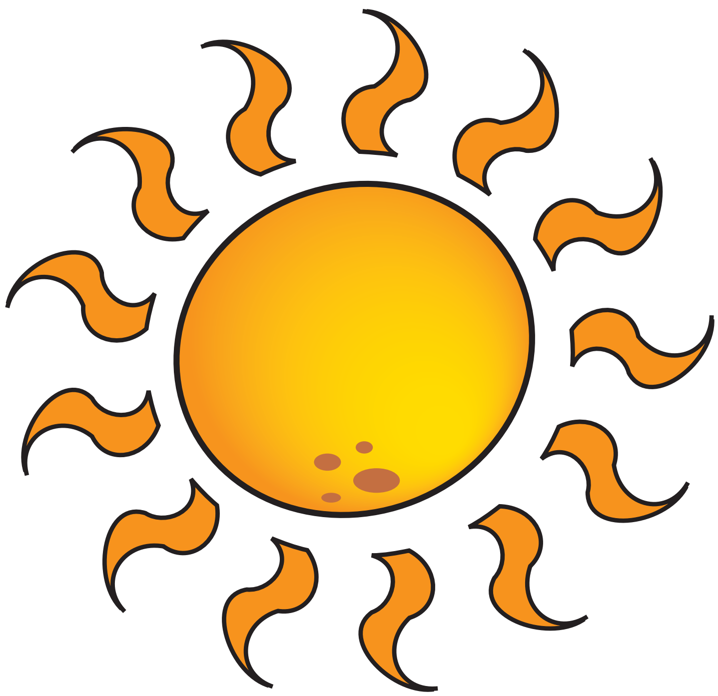
Solar Energy Handbook 1978.
New York: Times Mirror Magazine, 1978.

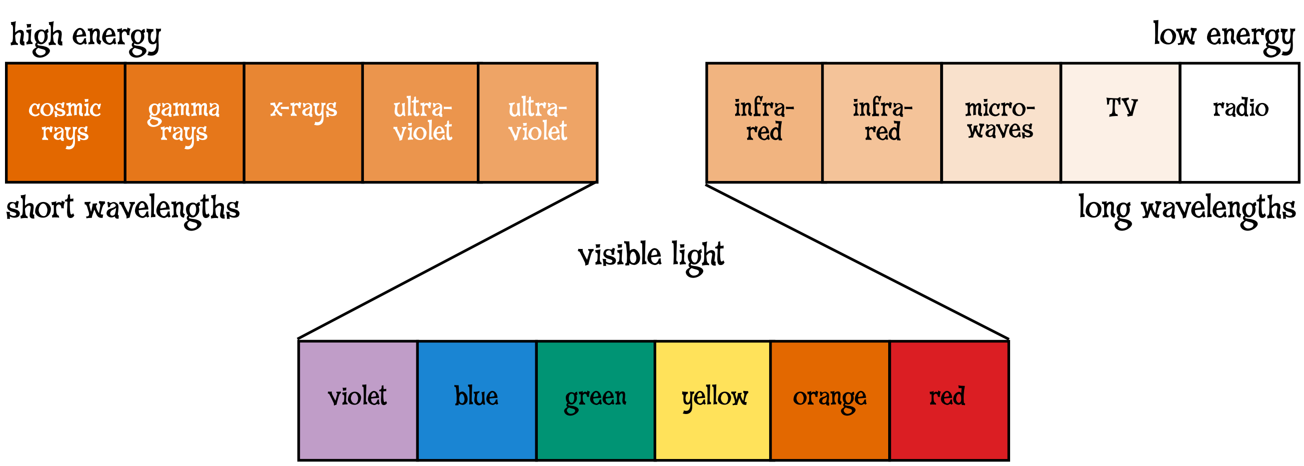
Tennessee Valley Authority. The Energy Sourcebook – Sixth Grade Unit.
N.p.: TVA, 1988.

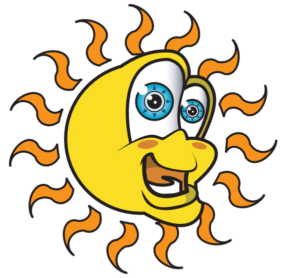


Solar Spectrum

Most of the solar rays reaching the earth's surface fall in the part of the spectrum ranging from near infrared *(heat)* waves through visible light and near ultraviolet rays.







Spectacular Spectrum Facts

1. Name the three kinds of rays that make up most of the solar energy reaching the surface of the earth.

__________________________ , __________________________ and __________________________ .

2. The human eye sees only one kind of ray. What is it? __________________________ .

3. Without solar energy, the earth's surface temperature would be hundreds of degrees below zero. What kind of ray keeps the earth from being too cold for any known life form? __________________________ .

4. Which have more energy – microwaves or X-rays? __________________________ .

5. A suntan is your body's response to skin damage from sunlight. An increase in the pigment occurs when special skin cells react to damaging solar rays. What kind of ray produces this response?

__________________________ .

6. All living things must have liquid water. That is the first reason there would be no life on a cold earth. What kind of ray makes the earth warm enough for water to exist in a liquid state? ________________________ .

The second reason there would not be life in a world without solar energy involves light. What kind of living thing depends *directly* on light energy to survive? __________________________ .

7. Which have more energy – light rays or radio waves? __________________________ .

8. Every living thing must have food – the source of the energy and nutrients necessary to maintain life. Every food chain begins with a green plant. Where do green plants get the energy they store in the food they make? __________________________ . What is the name of the process by which plants do this? __________________________ .

9. Wind results when masses of air gain different amounts of heat. Wind causes much of our weather and create ocean waves. What kind of rays convert to heat energy and cause wind? __________________________ .

10. What are the colors of the visible light spectrum? ____

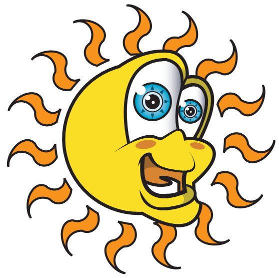
____

11. Which color has the highest energy? __________________________ .

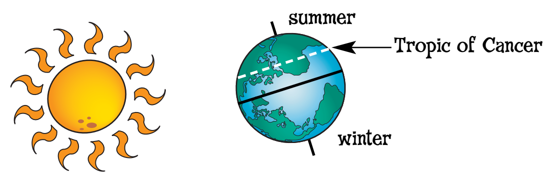
Which color has the lowest energy? __________________________ .

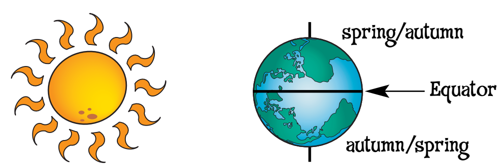
12. Name two kinds of rays that people have learned to make very useful in modern lives.

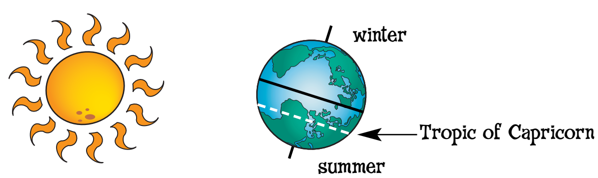
__________________________ and __________________________ .



Solar Energy Varies with the Season and the Place







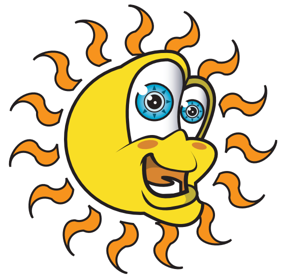
The amount of radiant energy given off by the sun is fairly constant year-round, but the amount of energy received varies at different seasons and places. The earth rotates on its axis, completing one turn every 24 hours. The side of the earth facing the sun receives sunshine. The side facing away from the sun is in darkness. The axis is tilted 23.5° from the plane of orbit. For this reason, the number of daylight hours at any given location changes as the earth orbits around the sun. The earth completes one orbit in one year.

The number of hours of sunshine affects the amount of energy received from the sun. Also, the amount of energy that reaches the earth depends on the angle at which the sun's rays strike the earth. Rays that strike the earth at an angle of about 90° pass through the least amount of atmosphere. These rays lose the least energy and transfer the most heat to the earth.

The sun's rays are most direct in the tropics, near the equator. The tropics extend from the Tropic of Cancer *(23.5°N)* to the Tropic of Capricorn *(23.5°S)*. In this part of the world, the average temperature is warm year-round. When the sun's rays reach the Arctic or Antarctic Circles, the rays are at very low angles. These rays are distributed over a large area because they have a low angle and they pass through the deepest layer of atmosphere. Therefore, the smallest amount of radiant energy reaches the earth at the North and South Poles.

Polar regions remain cold even when they receive 24 hours of sunshine. The ice cover reflects much of the radiant energy and the rays strike at such a low angle that little heat is retained. The areas between the polar regions and the tropic zone are called temperate zones.

A Little SUNSHINE IN YOUR LIFE



SUBJECTS: General Science, Home Economics

TIME: 4-5 class periods

MATERIALS: large beaker or jar, sheet of black plastic, thermometer, stopwatch, hand lens, black paper, mirror, fruit, knives, hole punch, 8 sheets of plastic window screen *(available from hardware or variety store)*, 4 sheets of cardboard, string, masking tape, 3 large *(1-gal.)* glass jars, tea bags, sugar *(optional)*, paper cups, food *(as specified)*, 3 mirrors, 3 large cardboard boxes, 3 small cardboard boxes, black nontoxic paint, paint brushes, newspaper, 3 heat-proof dishes with glass covers, 1 heavy bowl, shovels, clear plastic at least 3 feet square, rocks or bricks, potted plants

Objectives ***The student will do the following:***

1. Demonstrate several practical uses of solar energy.
2. Debate the advantages and disadvantages of using solar energy.
3. Formulate and write an opinion on solar energy's viability as a major U.S. energy source in the near future.

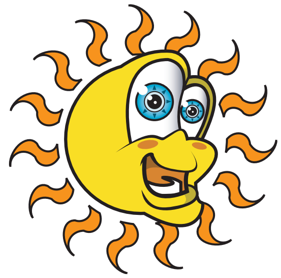
Background Information

Each day the amount of solar energy striking the earth is more than the energy potential in 22 million barrels of oil. Solar energy has many advantages in addition to its vast supply. It is available every day locally. It is not subject to political control, as are foreign oil supplies. It cannot be depleted. It does not require transportation. It is safe. It does not pollute the environment. It is free.

The history of designed use of solar energy dates back to the ancient Greek and Roman civilizations. The Greeks had created fuel problems by ravaging forests for fuel to use for healing and cooking. They also used trees to fuel smelting operations and to build houses and ships. By the 5th century B.C., Greece was almost totally barren of trees. Modern excavations indicate that the Greeks oriented their homes toward the southern horizon and even designed entire cities to gain access to winter sunlight.

Early Romans also used architectural concepts to design their homes. They used solar energy to heat the water in their public baths. They were the first to use glasses as a solar heat trap in structures similar to modern greenhouses, where they developed the science of producing fruits and flowers year-round. After the fall of Rome, greenhouses and the use of glass were lost to Europeans until the Middle Ages. Collecting solar heat for horticulture was revived in the 16th century.

Today people use solar energy in many ways, some of which work without highly developed technology. Some solar energy applications for direct drying, heating and evaporation are demonstrated simply and easily. They are the forerunners of wider industrial and home use of solar energy. When solar energy becomes a priority, we will develop the technology to increase the efficient collection, concentration and storage of solar energy.



Terms

concentrator: a device that concentrates the sun's rays on an absorber surface which is significantly smaller than the overall concentrator area.

dehydration: to cause to lose, or become relatively free of, water, as in the drying of foods to preserve them or to reduce bulk and weight.

desalinization: the removal of salt from seawater to produce fresh water.

distillation: the process of driving off gas or vapor from liquids or solids by heat and condensing the product for purification.

evaporation: the process by which a liquid is converted into a vapor.

solar collector: a device that collects solar radiation and converts it to heat energy.

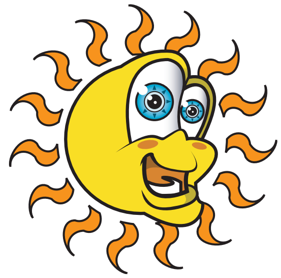
solar reflector: a device used for reflecting sunlight onto a specific point or area.

Procedure

I. *Setting the stage*

A. *Discuss with the students how they, their families, and/or their homes use solar energy today.*

1. To help get the discussion started, ask the students the following questions:
   a. What does sunshine most obviously provide? *(light by which we see)*
   b. What else does sunshine provide? For example, what happens to the students when they stand in the sun? *(They get hot and dry as the heat energy of the sun increases the temperature around them and moisture evaporates.)*
2. Point out to the students that heat, drying and light are the three things for which we all use solar energy in our daily lives.
3. Have the students brainstorm about everyday places and situations where people use solar energy. Have them state why they use it. Some examples might be greenhouses *(heat, light)*, south-facing windows *(heat)*, open drapes on sunny winter days *(heat)*, dark-colored roofs *(heat)*, outdoor clotheslines *(drying)* and skylights and windows *(light)*.

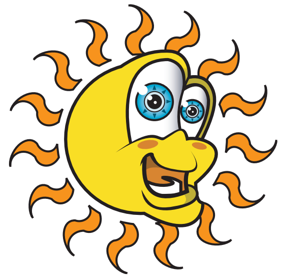


B. ***Discuss with the students the advantages of using solar energy as opposed to using fuels.*** *(Solar energy is free, nonpolluting and in unlimited supply.)* What are some disadvantages? *(The sun does not shine all the time; solar energy is hard to collect and store.)*

C. ***Distinguish between Solar Collectors, Concentrators and Reflectors.***

Many common uses of solar energy employ one of these ways of putting *"sunpower"* to work for us. Share the following information with the students:

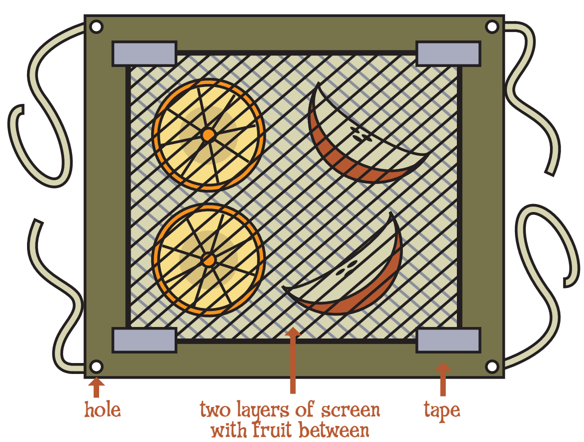
1. SOLAR COLLECTORS gather the sun's energy and store it as heat. A solar collector generally has a dark-colored surface covered by plastic or glass. Sunlight passes through the glass or plastic to the material beneath which absorbs the heat energy and the plastic or glass traps it. To demonstrate collection of solar energy, perform the following exercises:
   a. Cover a large beaker or jar of water with black plastic, and place it directly in the sun for one hour. Have the students measure and record the temperature of the water before and after the hour. The water absorbs heat energy.
   b. Measure and record the temperature inside your car before you park it in full sun and close its windows. Leave a thermometer in the car in a place where the students can read it from outside but which is not in direct sun. Have them read the temperature after you car has been parked for a while. (*Be sure that you and your students exercise all the necessary caution in the parking area.)* The air and materials inside the car absorb heat energy.
2. SOLAR CONCENTRATORS concentrate the sun's energy by focusing that energy on one spot or area. They bend the rays of solar energy. The most common concentrator is a magnifying glass. **NOTE:** A device called a Fresnel lens is made specifically for concentrating solar energy. To demonstrate solar concentration, do the following exercises:
   a. Use a magnifying glass to focus the smallest possible circle of sunlight onto a sheet of lightweight black construction paper.
      CAUTION: Protect the students and yourself from burns.
      Have the students use the stopwatch to time how long it takes to produce smoke from the area of focused sunlight.
   b. Now, cover the magnifying glass lens with a piece of black paper that has a 3-cm hole in the middle, and repeat the experiment. How much difference in time is there, and why?
3. SOLAR REFLECTORS reflect solar energy; like solar concentrators, they allow us to focus solar energy on a given spot. The most common reflector is, of course, a mirror. Some solar energy systems use special mirrors to help make the most use of solar energy even though the sun appears to move across the sky. *(The angle at which the sun's rays strike a fixed object changes throughout the day.)* Curved mirrors help direct the rays onto a point of collection. Examples of this include a solar furnace in France *(where a giant, curved wall of mirrors directs sunlight onto an elevated boiler)* and the Solar I solar power tower in California *(where the boiler for a steam power plant stands on a tower in the middle of a huge field of upturned mirrors focused on the boiler). (Can the students think of any everyday applications of solar reflectors?)*



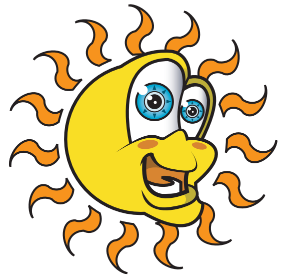
II. *Activities*

A. *Have the students build a food dehydrator.*

1. Share with the students the following introductory information:
   People have used solar energy to preserve food for thousands of years. Water in food helps create good conditions for spoiling. The sun can be used to dry foods because the heat energy evaporates most of the water. Dehydrated fruits, vegetables, and meats not only keep well because of their lack of moisture, but are easy to store and to carry from place to place. Their weights and volumes are reduced but their nutritive value is not.
2. Have the students build solar food dehydrators. Divide them into four groups, each of which will dry a different fruit.
   a. Give each group: 1 flat piece of cardboard cut out like a picture frame with a 2-inch edge *(cardboard: approximately 2 feet by 1 1/2 feet)*, 2 pieces of plastic screening *(cut to slightly smaller than the cardboard)*, string, hole punch, masking tape, small quantity of fruit *(several apples or peaches, sliced VERY thin; or several SMALL purple plums, cut in half and pitted; or 1/4 lb. seedless grapes)*
   b. The procedure for building the dehydrator is as follows:
      1. Tape one piece of screening firmly to the cardboard frame, centering it over the open part of the frame.
      2. Punch holes in each corner of the cardboard, reinforce the holes with tape, and attach strings as shown in the illustration below.



      3. Place the fruit in a SINGLE LAYER on top of the screening, place the second piece of screening over the fruit and firmly tape the edges of the screening to the cardboard.
   c. Have the students hang the dehydrators outside in a sunny spot.
      NOTE: Bring the dehydrators in every night. On damp or rainy days, keep them inside hanging in an area with free air circulation. Drying may take 2 or 3 weeks to complete.



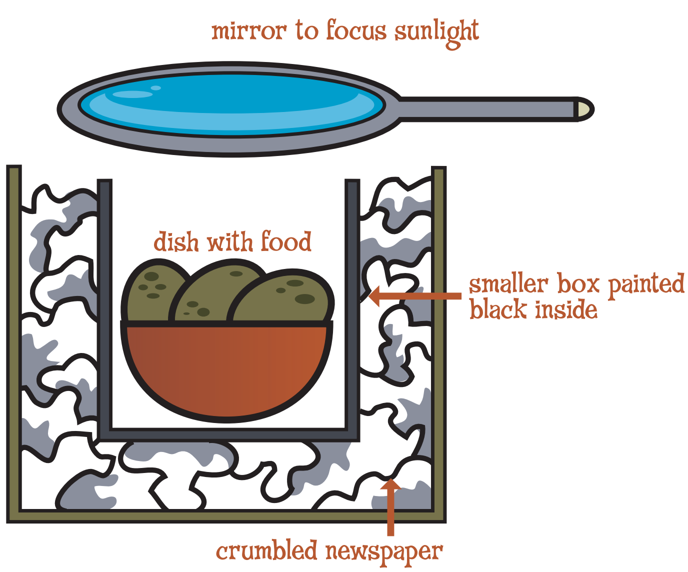
B. ***Have the students investigate the merits of "sun tea."***

Ask the students how they make tea at home. Share with the students that several years ago, a major tea company had an ad campaign touting sun tea – tea *"brewed"* by the heat of the sun rather then by heat from gas or electricity. The students will compare the taste of sun tea, regularly *"brewed"* *(and then cooled)* tea, and tea brewed in cold water.

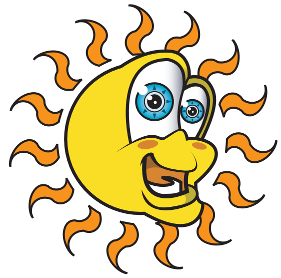
1. Prepare three batches of each in one-gallon glass jars. *(Use the same number of tea bags for each.)* Put the bags in one jar and fill it with cold water. Place it in a dark corner or in a refrigerator. Put the bags in the second jar, fill it with boiling water, and allow it to steep. Put the bags in the third jar and place it in the direct sun. Allow the jars to sit undisturbed for about four hours.
2. If desired, sweeten each gallon of tea the same way. Distribute small paper cups to the students and have a blind taste test of the three teas. Have the students record the results.
   NOTE: Make sure they are all at the same temperature and are not diluted with ice.
3. Have the students tabulate and discuss the results.

C. ***Have the students use solar energy for cooking.***

1. Share the following introductory information with the students:
   Using the heat energy of the sun to cook food has some real advantages. There is no fire hazard because there is no fire; no smoke pollutes the air and there are no ashes to clean up. Sometimes campers use simple solar cookers. If modern technology were applied to solar cooking, it could become more than just a camper's back-up. A solar oven, using the absorption of heat by a dark surface and insulation to retain heat to cook food, is the demonstration in this exercise.
2. Divide the class into three groups and provide each group with the following supplies: 2 cardboard boxes *(one bigger than the other)*, newspaper, flat black paint and a paint brush, a large hand-held mirror, a flat heat-proof dish with cover, thinly sliced potatoes, apples, and/or hot dogs.
3. Have the students construct the oven as shown in the diagram below.



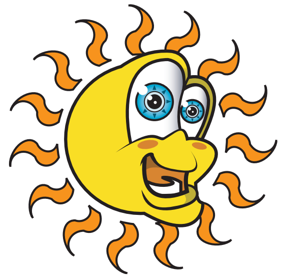
Have the students paint the inside of the smaller box black and allow it to dry. They will then place the small box inside the large box, filling the space between the two boxes with firmly crumpled newspaper to act as insulation.



4. On a very sunny day, have the students use their solar ovens.
    a. Place thinly sliced food one layer thick in the dish, cover the dish, and place it in the bottom of the small box. Set the oven where the dish will receive full sun.
    b. Have the students take turns focusing sunlight on the food using the mirror.
    NOTE: The longer the mirror is held without moving, the better.
    c. When the food is cooked, have the students sample their solar cooking.
5. Discuss situations in which solar cookers are practical. In many places in the world where people still cook over fires, there is a drastic shortage of wood for burning. In many of these places, the land has been stripped of trees and shrubs, contributing to desertification. Sub-Saharan Africa is a prime example. Solar cookers would be very helpful in many instances, but they have been resisted where they have been introduced. Talk with the students about how difficult it is to change habits, traditions and ways of life. Point out that proper training in using new technologies is essential.

D. *Have the students demonstrate water distillation using solar energy.*

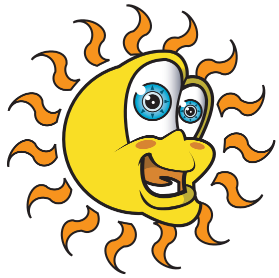
1. Share with the students the following introductory information:
Water is an abundant resource that we take for granted. While the same amount of water has been present on earth for a long time, shortages of fresh water have increased dramatically. This is due to three major factors: 1) the enormous and increasing use and pollution of water by industry and by irrigation farming in dry areas; 2) the increase in the world's population; 3) rapidly growing populations in areas of the world where natural water supplies are already scarce, such as the Middle East. Using the almost limitless supply of seawater to produce fresh water is one possible solution. However, desalinization of seawater by fossil fuel-powered distillation plants is much too expensive in terms of both money and non-renewable resources to be practical on a large scale. Solar energy has some real possibilities in this area. A simple solar still demonstrates how distilled *(clean)* water can be obtained from water that contains impurities.
2. Have the students construct a solar still.
    a. In this device, sunlight passes through plastic that covers a hole in the ground. The sun light is absorbed by the material beneath the plastic *(water, earth, plants)*. The heat evaporates the moisture, which then condenses on the bottom of the cooler plastic above. The condensed, distilled water runs clown the plastic and drops into a container.
    b. This demonstration is to be done as a class project. Gather the following items: shovels for digging, clear plastic sheet *(a shower curtain will do)*, ceramic bowl, rocks or bricks, several small, potted annual plants or large seedlings *(optional)*.
    Choose an open, sunny area with soil that is easily dug.
    NOTE: Get your principal's approval before digging.



1. Have the students dig a hole about three feet in diameter and one-and-a-half feet deep. Carefully remove the sod first and pile the soil to one side, so that you can replant the grass when the demonstration is over.
2. If the soil is dry, have the students pour a gallon of water carefully around the sides and bottom of the hole.
3. Place the bowl in the center of the bottom of the hole, making sure it is stable and will not tip over.
   (Optional: To add another source of moisture, put several well-watered potted plants upright around the bowl.)
4. Cover the hole completely with one layer of clear plastic. Use bricks or rocks to seal the edges against the surface of the ground as tightly as possible.
5. Place a small rock in the center of the plastic directly over the bowl in the hole so that the condensed water will drip into the bowl.
   NOTE: In very hot weather place a small cloth between the rock and the plastic to prevent the rock from melting the plastic and/or breaking it.
6. After 24 hours, have the students uncover the hole carefully and remove the bowl. Have them measure the amount of water collected, noting its appearance.
   (Optional: After an hour or two in the sun, water will begin to condense on the plastic and drip into the bowl. If the plastic seals the hole well, the distillation process will continue even at night, but at about half the rate. The demonstration could continue for several days, with the amount of water being recorded each day. The students should also note the cloud cover. Separate collections for day and night periods could also be made.)
7. After the demonstration is done, have the students fill the hole completely and carefully. Replant the grass if possible.
8. Discuss with the students some situations in which they might use this technique themselves. In what kinds of places in the world might this be most useful?

E. *Have the students compare using a clothes dryer and hanging clothes out to dry (using a "solar clothes dryer").*

1. Have the students determine the cost of drying clothes in an electric or gas clothes dryer. Appliance stores or the local utility company will tell them how many kilowatt hours of electricity an electric clothes dryer uses and the utility company will tell them the cost per kilowatt hour. *(They can obtain the information for gas also.)*
2. Have them discuss the trade-offs we make when we use clothes dryers and the advantages and disadvantages of both methods. *(Drying clothes outside does not use nonrenewable resources and does not pollute the environment or form hazardous waste. On the other hand, it is not as convenient as using a clothes dryer, and it cannot be done at night or on rainy days.)*



III. *Follow-Up*

A. *Have the students debate the use of solar energy.*

1. Divide the class into two groups; one will stress the advantages of solar energy and the other will stress the disadvantages. Give the class time to prepare lists of advantages or disadvantages and to develop arguments to back up their claims.
2. Have each side present its arguments.
3. Have each student write down the advantages and disadvantages that would be the most important to him/her if he/she had to make a decision about whether to put more money and technology into making solar energy a major energy source for our country.

B. *Have each student write a one-page position paper on whether or not he/she thinks solar energy is a viable energy option for the United States in the near future (e.g., 20 years).*

IV. *Extensions*

Have the students research and report on topics selected from the following:

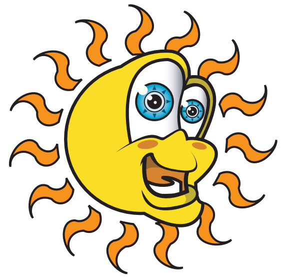
A. *The history of solar energy*

1. Greek and Roman use of solar energy – solar designed cities *(e.g., the Greek cities Olynthus, Priene, and Delos; the Roman cities of Pompeii and Herculaneum)*; Roman baths and hot rooms
2. Solar reflectors or parabolic mirrors and early *(10th century)* motors
3. Renaissance revival of solar energy use – e.g., Leonardo da Vinci's plans for industrial applications of solar energy
4. Augustin Mouchot – French scientist who, in the 1870s, invented several solar appliances, including a solar still, engine, pump, cooker, and ice maker

B. *Futuristic applications of solar energy*

1. Solar energy applications in space *(e.g., space stations)*
2. Solar energy applications in industry, including solar furnaces and food dehydrators
3. Fractional distillation of petroleum *(how solar energy could be used to separate crude oil into petroleum products)*
4. Solar energy and desalinization of seawater *(compare the cost per gallon using traditional energy sources and using solar distillation)*

3\. Possible solar-powered weapons and their uses



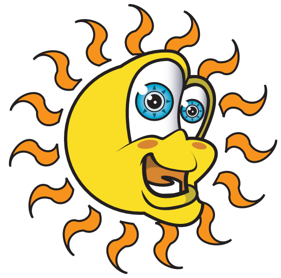
Resources

Hackett, J., and D. Adams. Merrill Science. Level 6. Columbus, OH: Merrill, 1989.

Shanks, B. Wilderness Survival. New York: Universe Books, 1987.

U.S. Department of Energy. "Science Activities in Energy: Solar Activities." N.p.: DOE, n.d.
(Address: Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830.)

SUNSHINE FOR WARMTH



SUBJECTS: General Science, Physical Science

TIME: 4-5 class periods

MATERIALS: 4 large cardboard boxes *(same size)*, aluminum foil, glue or rubber cement, strong plastic wrap or vinyl *(clear)*, rubberbands, silver duct tape, 4 small dowels, fine sandpaper, flat black paint, paint brush, scissors or linoleum knives, 8 soft drink cans, compass, 4 thermometers, support stand, 200-watt lamp with reflector and clamp, clock, newspaper, large polystyrene cup with lid, tape *(or modeling clay)*, student sheets

Objectives *The student will do the following:*

1. Differentiate between active and passive solar energy systems.
2. Build a model of a passive solar water heater.
3. Compare how efficiently different types of materials insulate.

Background Information

The sun provides an inexhaustible, nonpolluting and free source of energy for the earth. People take advantage of the heating energy of the sun in many simple ways. For example, some shelters and buildings are situated so the sun warms them on cold winter days. Some buildings have windows placed to allow maximum winter sun and minimum summer sun. Opening insulated curtains to let in solar heat during the day and closing them at night to retain it is a simple, but effective, strategy.

Using solar energy much more systematically becomes more important as people try to find renewable sources of energy. We have the technology to collect, temporarily store, and then use solar energy effectively. However, we need to develop even more efficient ways of doing this.

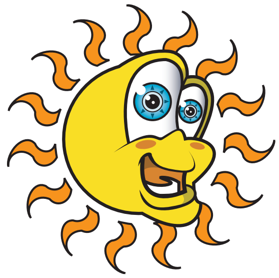
Solar energy systems are classified as either active or passive systems. Active solar heating systems use electricity to operate pumps and fans which move heated liquid or air from a collector to a storage area and then to where it is used. Passive solar heating systems use the heat energy of the sun directly or rely on basic properties of heat *(hot air or water rises; cold air or water sinks)* to transfer heat from one area to another.

Terms

active solar energy system: a solar energy system that requires external mechanical power to move solar heat energy for storage and/or use; compare *passive solar energy system*.

insulation: a material with a high resistance to heat flow.

passive solar energy system: an assembly of natural and architectural components that converts solar energy into usable or storable heat energy without external mechanical power; compare *active solar energy system*.



Procedure

I. *Setting the stage*

A. *Begin a discussion of solar energy with the students by asking the following questions:*

1. What is solar energy? *(radiant energy given off by the sun)*
2. What forms of solar energy are most familiar to us? *(heat and light)*
3. What are the major advantages of solar energy? *(nonpolluting, unlimited, free, available in almost every part of the world)*

B. *Discuss solar energy use with the students.*

1. Have the students brainstorm a list of ways they personally use solar energy and other ways they have seen or heard that solar energy can be used. Write their list on the board. *(Accept all reasonable answers.)*
2. When the list is finished, discuss it with them. Point out to them that two different kinds of solar energy use are listed. First is direct personal use of solar energy for vision, for getting warm on a cold day, or other simple uses. Second is the use of some technology by which we utilize solar energy *(such as a solar water heater)*.

II. *Activities*

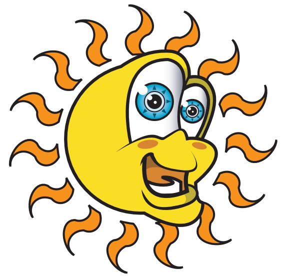
A. *Share with the students the following introductory information:*

There are two kinds of solar energy technologies – active and passive. Their names give you some idea of the difference in the ways they work.

ACTIVE SOLAR ENERGY SYSTEMS use external mechanical power to distribute collected solar heat to where it is needed. The systems often transfer heat from one substance to another. For example, in one type of active solar water heater, a fluid circulates in a closed loop, collecting heat from the sun. Water circulates around pipes containing the heated fluid, picking up the heat. Pumps and other electrical devices make this system work and carry the heat to its destination.

PASSIVE SOLAR ENERGY SYSTEMS do not use any energy source other than solar heat. Their structures allow them to collect and make use of solar energy. They rely on gravity and/or the tendency of hot water or air to rise. For example, the simplest solar water heating systems are passive. A water storage tank, painted black, absorbs solar energy though a large slanted glass or plastic window positioned to get maximum exposure to the sun. As people draw hot water from the tank for use, more water flows into the tank to be heated by solar energy.

1. Have the students list the advantages and disadvantages of both active and passive solar energy systems.
2. Tell the students they will build a model of a passive solar energy system – a small water heater.

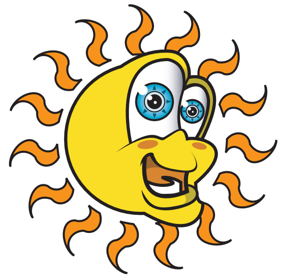


B. *Have the students build a passive solar water heater model.*

1. Prepare the soft drink cans ahead of time. Rough the surface of the cans slightly with fine sand paper. Paint them with two coats of flat black paint.
2. This activity directs the students to build and *"operate"* a passive solar water heater. Divide the class into four groups and provide each group with the following supplies: cardboard box, aluminum foil, scissors or linoleum knife, strong plastic wrap or vinyl *(clear),* empty soft drink can *(lightly sanded and painted flat black)* thermometer, glue or rubber cement, silver duct tape, rubber band, copy of the student sheet *"Build a Solar Water Heater Model" (page 134).*
3. Have the students build a solar water heater model according to the directions given on the student sheet.
4. Have the four student groups operate the solar water heater models as directed on the student sheet. Designate two groups to measure and record only the beginning and ending temperatures of the water and two groups to measure and record the temperature every 10 minutes for 40 minutes.
5. Discuss the results with the class. Why did the temperature change? Was there a difference in the temperature change between the frequently checked models and those checked at the beginning and end of the experiment? Why?

C. *Have the students investigate the effectiveness of insulation.*

1. Share with the students the following introductory information:
   To use any heating system efficiently, especially solar heating systems, we must prevent the loss of heat as much as possible. Insulation is essential to the ability of any structure to retain heat. Insulation is particularly important in solar energy systems because the collected energy is free; supplemental energy to replace *"lost"* solar heat is not free. Not having effective insulation defeats the purpose of a solar energy system.
2. Have the students test the insulating abilities of three common materials.
   NOTE: Unless you have more than one lamp available, you will have to perform the experiment as a demonstration, using student assistants. Involve as many students as possible.
3. Gather the following materials: 200-watt lamp with reflector *(clamped to a support stand)*, 4 empty aluminum cans with 1 hole in top, aluminum foil, newspaper, tape or modeling clay, polystyrene cup with lid *(big enough to completely contain a can)*, 4 thermometers, copies of the student sheet *"Effectiveness of Insulation" (page 135).*
4. Test the materials according to the following procedure:
   a. Fill each can with equal amounts of lukewarm water. *(Measure it to be sure.)*
   b. Arrange the cans in front of the lamp, making sure they are all the same distance from the lamp. Put a thermometer into each can. Use a piece of tape or modeling clay to hold it upright so it can be read without removing it. Measure the initial water temperature in each can. Have each student record the beginning temperature on his/her data sheet.



c. Turn on the light and leave it on *(without moving the cans)* for 20 minutes. During this time assemble the insulating materials: aluminum foil, thick layer of newspaper taped securely in a size to fit around a can, and a large polystyrene cup with a lid.

d. After 20 minutes, read the water temperature in each can. Have the students record these figures on their data sheets. Turn off the light, and do the following as quickly and carefully as possible:

   1. Cover two of the cans *(including the tops)*, with different insulating materials. Put the third can inside the large polystyrene cup. Do not cover the fourth can at all. **NOTE:** Make sure the bottoms of the coverings are very flat so the cans will not fall over.
   2. Make a small hole through the top insulation of each can into its opening so the thermometer will go back into the water. Hold the thermometers in place with pieces of tape or clay, so the students may take readings without removing them from the cans.

e. Have the students read and record the temperature of the water in each can every two minutes for 20 minutes. Have each student graph the cooling of the water. *(Show them how to mark each of the four lines differently so that they are distinguishable.)*

5. Discuss the results with the students.

III. *Follow-Up*

A. *Have the students identify all the insulating materials used in the solar water heater model and the insulation investigation.*

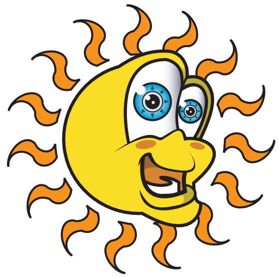
B. *Have the students brainstorm ideas for adding insulation to the solar water heater model.*

Where could it be added, when, and why? What kind would they use?

NOTE: Every part of the construction could be insulated all the time with the exception of the *"window"* of plastic facing the sun. Only when the sun goes down, or on a very cloudy and cold day, should they insulate this part.

C. *Ask the students what would have happened to the temperature of the water in the cans if they had been insulated with the different materials before they were under the lamp.*

(Any insulation would have slowed the increase in temperature. The more efficient the insulation, the less the temperature of the water would have increased.)



IV. *Extensions*

A. *Hold a "Cool Contest."*

Have the students design and make containers that will keep ice cubes from melting. The containers must be made by the students, not purchased products. They should not be larger than 25 cm in length or width. Give each student an ice cube *(make equal cubes by freezing identical amounts of water in 3-oz. paper cups)*. The student with the largest piece of ice remaining at the end of the day wins.

B. *Have the students identify the properties of water that contribute to its usefulness in solar energy systems.*

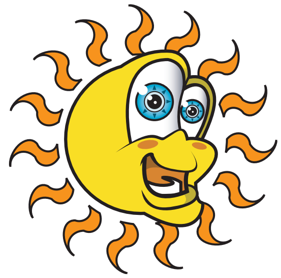
Why is water used for heat storage in solar heating systems? One property is its high specific heat, i.e., the unusual ability of water to store heat energy and release it slowly. Discuss with the students why this is important in solar heating. Have the students research the specific heat of water and other substances.

Resources

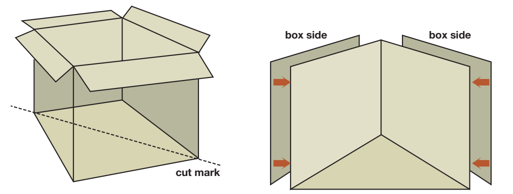
Hessen, D.T., and S. S. Leach. FOCUS ON EARTH SCIENCE. Columbus, OH: Merrill, 1989.

Norton, T.W. SOLAR ENERGY EXPERIMENTS FOR HIGH SCHOOL AND COLLEGE STUDENTS.
Emmaus, PA: Rodale, 1977.

U.S. Department of Energy. "SCIENCE ACTIVITIES IN ENERGY: SOLAR ACTIVITIES." N.p.: DOE, n.d.
(Address: Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830.)

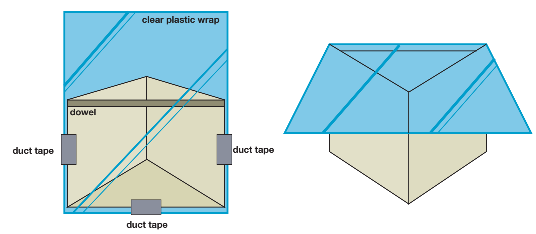


Build a Solar Water Heater Model



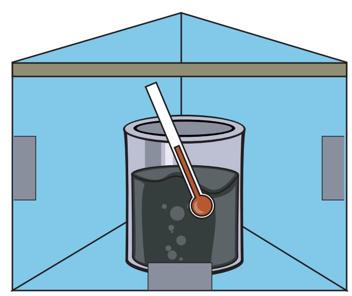
1. Cut the cardboard box in half diagonally. Cut off the top flaps. Cut the left-over half's 2 sides off and glue or rubber cement them to the outside of your box half. This adds strength and insulation.

2. Glue aluminum foil shiny side out to the inside *(sides and bottom)* of the box. Secure a small dowel across the top of the opening *(from corner to corner)* with silver duct tape to serve as a brace.



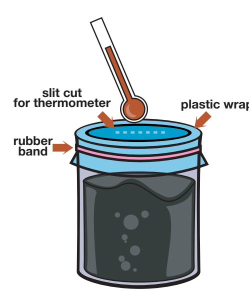
3. Cut a piece of clear plastic or vinyl large enough to tape to the underside of the box and to cover the opening and the top of the box.

4. Tape the plastic wrap securely to the underside of the box. This plastic serves as both the cover and the *"door"* for the heater. When you use the solar heater, pull the plastic up over the top of the box and tape it tightly in place.



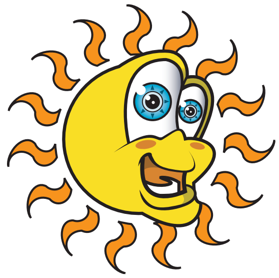
5. Fill the can with tap water. Measure and record the initial temperature of the water. Cover the top of the can with plastic wrap and secure it with a rubber band. Make a small slit in the plastic, insert the thermometer, and leave it in the water except when you are reading it.

6. Set up the model solar water heater outside so the opening of the box faces the sun; make sure it is not shaded. The direction the box must face will vary depending on the time of day.



7. Place the water-filled can inside the box and seal the box with the clear plastic cover.

8. Check the changes in water temperature as directed by your teacher. Two groups will measure and record the temperature every 10 minutes for 40 minutes. The other two groups will measure and record the temperature only at the beginning and the end of 40 minutes.



Effectiveness of Insulation

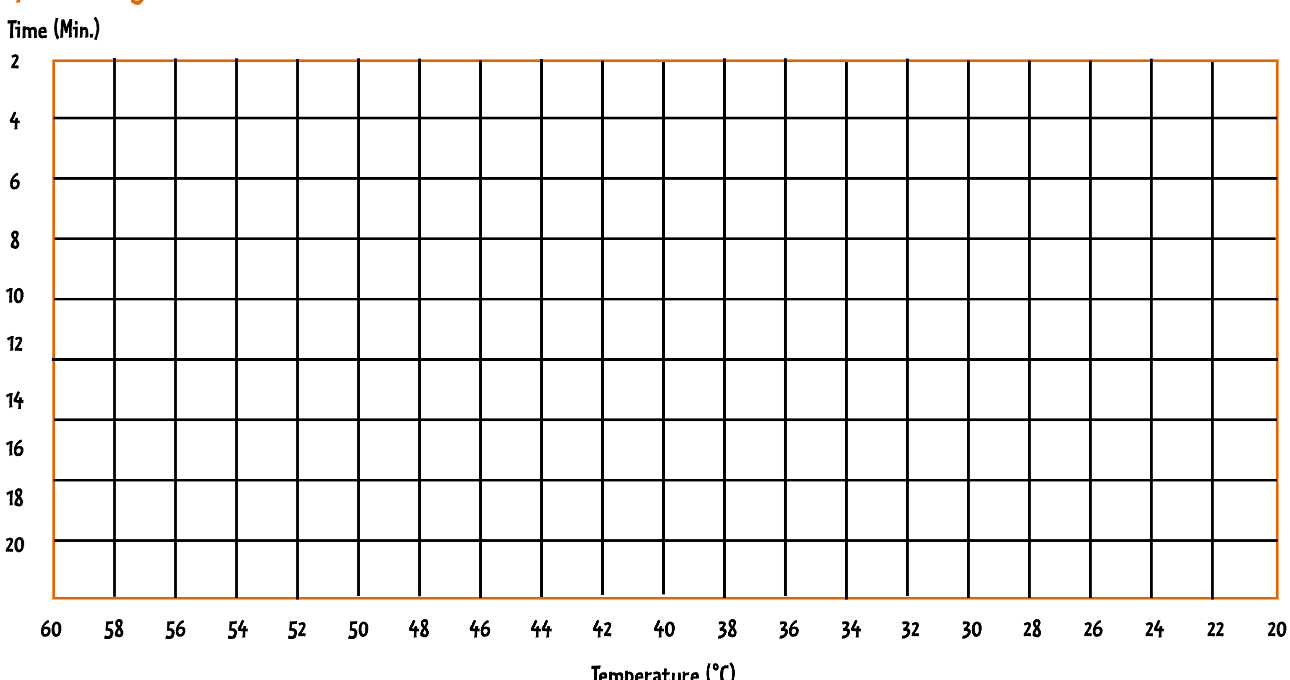
Data Table: Warming

	Can #1	Can #2	Can #3	Can #4
Beginning temp. (°C)				
Temp. after 20 min. (°C)				
Temp. difference (°C)				

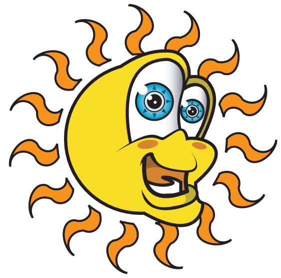
Data Table: Cooling

Can	Insulation	Temperature (°C) after elapsed time (min.)										Temp. difference (°C)
		2	4	6	8	10	12	14	16	18	20	
#1	Foil											
#2	Newspaper											
#3	Styrofoam											
#4	(None)											

Graph: Cooling



PHOTOVOLTAIC PHUN



SUBJECTS: General Science, Physical Science

TIME: 4 class periods

MATERIALS: solar cells, solder, small soldering iron, thin gauge wire, red and black alligator clips, light emitting diodes, cardboard, scissors or razor knife, transparencies, overhead projector, student sheet

Objectives *The student will do the following:*

1. Discuss the advantages and disadvantages of solar energy.
2. Demonstrate the production of electricity by solar cells.
3. Match present users of photovoltaic power with the devices they use.
4. Design a solar electric wilderness house.

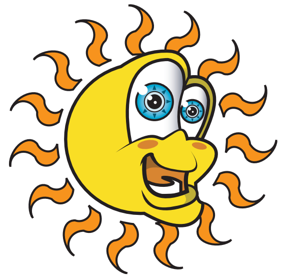
Background Information

Sunlight offers a clean, dependable source of energy for the future. Current technology has focused on two major ways of using solar energy: 1) use of solar heat energy directly or indirectly and 2) direct conversion of solar light energy into electrical energy. Photovoltaic *(solar)* cells convert light into electricity.

When photons *(packets of light energy)* strike atoms of certain elements *(such as silicon)*, the photons knock the outermost electrons of the atoms loose. The loose electrons then tend to *"flow"* from one location to another. A photovoltaic cell is made up of microscopically thin layers of pure silicon which are impregnated with small amounts of boron, phosphorus, or other semi-metallic elements. When sunlight strikes the cell, the cell's structure enhances the flow of electrons into electrical wiring. The resulting electrical current from solar cells is direct current *(DC)*, like the electricity from a battery. In the United States *(U.S.)*, electricity from utilities is alternating current *(AC)*. Electrical devices differ as to whether they use AC or DC. Using solar electricity *(DC)* to power common U.S. appliances necessitates an inverter to change the current to AC.

A solar cell about four square inches *(100 cm^2)* in area produces approximately one watt of electricity in full sun. To produce enough energy to run electrical equipment, solar cells are connected together on a rigid plate called a module. Modules are connected in panels and panels are connected in arrays. The array assembly is what is seen on roofs, facing the maximum sun exposure.

Photovoltaic electrical energy has a number of advantages. Solar cells are made of common materials. They have no moving parts. They are reliable, quiet, and require no maintenance. They use no fuel, are not dependent on conventional power plants, and produce no pollution as they operate. However, there are a number of disadvantages to their use. These include costs of rechargeable storage batteries and inverters, hazardous waste from solar cell manufacture, and inefficient energy conversion. As we develop more efficient technology and the economic and environmental costs of nonrenewable fuels continue to increase, photovoltaic energy will certainly become a common part of our energy future. Many facilities and individuals already use solar electricity. Where it is too expensive to run power lines or where batteries are not practical, solar cells supply power. Facilities in remote locations, villages in developing countries, and mobile users *(like recreational vehicles and train cars)* depend on solar cells for the electricity to run appliances, light, and communication devices.



Terms

photon: a tiny bundle of light energy from the sun.

photovoltaic: pertaining to electricity *("voltaic")* generated from light *("photo")*.

Procedure

I. *Setting the stage*

A. *Have the students make a list on the board of the advantages and disadvantages of solar energy.*
(Advantages of solar energy: free, inexhaustible, nonpolluting, available everywhere on earth, not controlled by a few countries. Disadvantages of solar energy: not available when the sun does not shine and the technology to capture and store it is limited.)

B. *Discuss with the students some of the ways people use solar energy.*
(Make sure they recognize both direct use and electrical energy production; see the background information.)

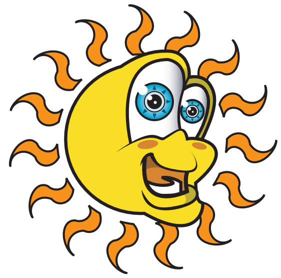
II. *Activities*

NOTE: Obtain solar cells and LEDs ahead of time if you do not already have them on hand. Check first with local electronics outlets, such as Radio Shack stores. If you must mail order them from scientific suppliers, two addresses follow:

EDMUND SCIENTIFIC COMPANY
101 East Gloucester Pike
Barrington, NJ 08007-1380
(609) 573-6250
or (609) 547-3488

CAROLINA BIOLOGICAL SUPPLY
2700 York Road
Burlington, NC 27215
(919) 584-0381
(toll free for orders only) 800-334-5551
(NC customers call) 800-632-1231

Each of these suppliers offers a variety of solar cells. The most economical *(by far)* are the "grab bags" of manufacturers' seconds. These are, however, irregular sizes and shapes *(affecting electrical output)* and are sold by weight rather than number of cells. The most durable cells are those that are encased or coated for protection; these are much more expensive. You may also purchase solar cells from manufacturers and electronics suppliers. Check your library for these contacts.

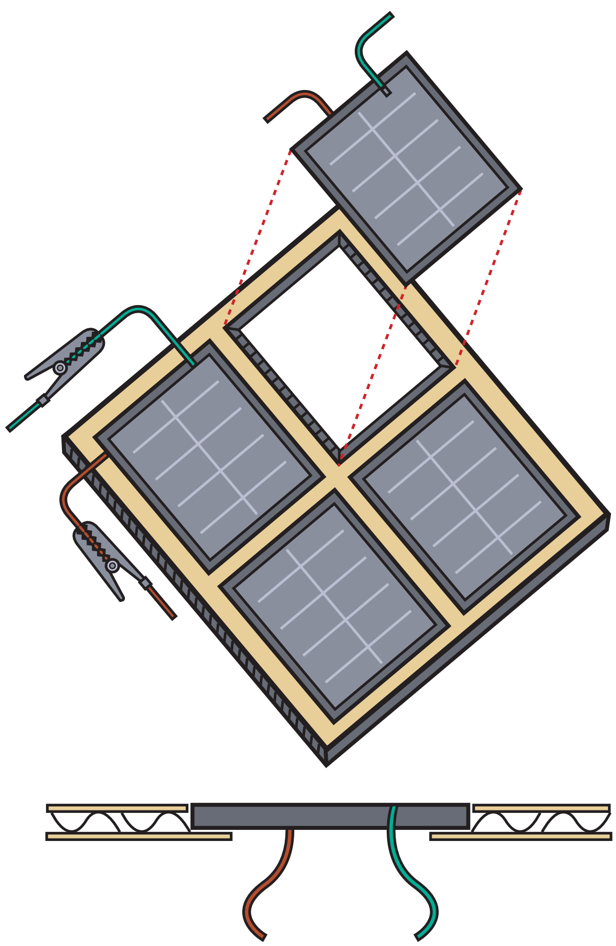


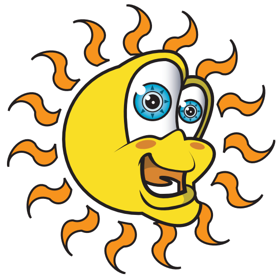
A. *Prepare the solar cells for use.*

You may have the students do this, but to save class time *(and perhaps to protect the fragile cells)*, you may chose to do this yourself.

1. Since silicon solar cells are fragile, handle them carefully to prevent breaking. Use a small soldering iron *(less than 50 watts)* and carefully solder 6-inch pieces of thin wire to the negative and positive sides of each cell. The front of the cell is negative and the back is positive.
2. Solder a red alligator clip to the positive lead wire and a black clip to the negative wire on each cell. These leads will enable the students to connect the cells in different ways. Prepare at least four cells for each small group of students. *(Decide how many groups you will have.)*
3. Make a mounting for each group of four cells using a square or a strip of heavy, double-faced corrugated cardboard. Cut holes all the way through the cardboard, trimming the front and back sides of the cardboard differently to form ledges on which to mount the cells. Be sure to cut away the back of the cardboard to prevent overheating. Label each cell using letters or numbers. You have made a photovoltaic *(PV)* cell module.

   NOTE: The cells can be arranged two-by-two as illustrated or end-to-end in a narrow strip of cardboard.





B. ***Have the students investigate the production of electricity by solar cells.***

NOTE: Do this activity on a sunny day. If possible, take the students outside; otherwise, have them perform these tests at a sunny window or with lamps.

1. Divide the students into small groups. Give each group a solar cell module and light emitting diode.
2. Have each group demonstrate that solar cells produce electricity, using the light emitting diode *(LED)*. First, have them connect the LED to the negative *(front)* and positive *(back)* leads of one cell. The LED uses a very small current, but one small *(2 x 4 cm, e.g.)* cell may not light the LED. Have them try connecting two, three, then four cells to the LED. It will produce light when the solar cells produce enough current.

C. ***Show the students a transparency made from the teacher sheet "Photovoltaic Phacts" (page 142).***

Discuss the information with them, augmenting it with additional facts from the background information.

D. ***Give each student a copy of the student sheet "Who's Using Solar Electricity?".***

Have them match the users with the photovoltaic-powered devices. The answers are as follows: 1.c., 2.h., 3.a., 4.g., 5.f., 6.e., 7.b., 8.i., 9.j., 10.d.

E. ***Show the students a transparency made from the teacher sheet "A Solar Electric Home".***

Go over the information with them, relating it to the activity in which they tested the solar cells.

NOTE: If this activity follows others that deal with solar energy, relate it to the basics of heating with solar energy and cooling by preventing unwanted solar heat gain.

III. *Follow-Up*

Have the students design solar-powered housing.

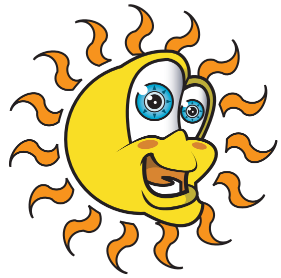
A. ***Divide the class into small groups and tell them that each group is to design a wilderness house for year-round living in hilly, forested country.***

Point out that it is too expensive to have electricity brought in by wire, so they will have to rely on solar energy.

B. ***Each student group has two tasks:***

1. Decide and list what factors will have to be taken into account in order to design an efficient solar house with the essential modern conveniences.

   NOTE: Considerations include the use of both solar light and heat energy; positioning of solar cells; types of essential appliances; room for solar cells, storage batteries and other equipment; and landscaping to allow maximum exposure of the cells to the sun.



C. ***Have each group present its design to the class.***

IV. *Extensions*

A. ***Have the students investigate the performance and costs of photovoltaic electricity.***

1. Contact solar energy companies for information on the performance and cost of various types of solar cells and rechargeable batteries.
2. Using the information from the companies, determine how much the equipment costs that will ensure a 1000-watt output 24 hours a day.
   NOTE: Students may ask the companies this directly, noting the list of equipment each recommends and both the initial and maintenance costs.

B. ***Set up a simple circuit to recharge a rechargeable battery using the output from the solar cell modules.***

C. ***Find out from local solar energy advocates if there are any solar electric homes in your area.***
If so, contact the owners and ask if you and some of your students could visit and videotape the home. Have the students make and edit the videotape. Show it to your classes.

Resources

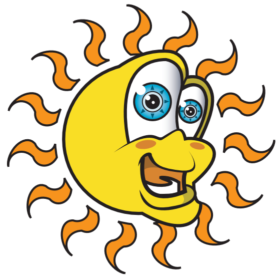
Alabama Photovoltaic Education Instruction Manual.
Huntsville, AL: UAH Johnson Research Center, 1990.

Maywick, P. D., and E. N. Stirewalt. A Guide to the Photovoltaic Revolution.
Emmaus, PA: Rodale, 1985.

Photovoltaics Demonstrator Construction Manual.
Huntsville, AL: UAH Johnson Research Center, 1990.

Tennessee Valley Authority. "Electricity from the Sun: Photovoltaics" *(factsheet)*.
N.p.: TVA, 1992.

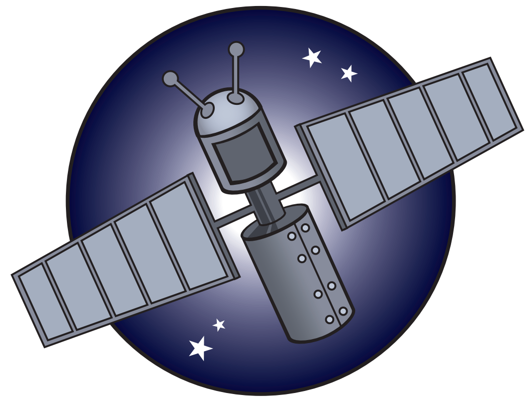
Tennessee Valley Authority. The Energy Sourcebook – High School Unit.
2nd ed. N.p.: TVA, 1990.



Photovoltaic Phacts

Solar cells were invented in the late 1950s.

The first major user of solar cells was the U.S. Space Program. *(The "wings" on satellites have thousands of solar cells and power the satellite.)*

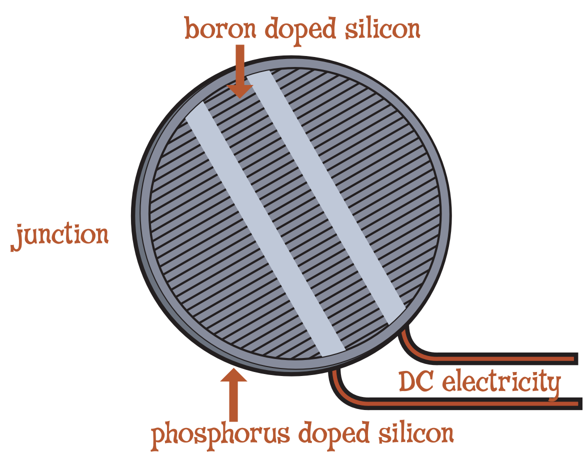


Solar cells are *"cousins"* of transistors and computer chips.

Solar cells are made mostly of silicon.

When light energy strikes the silicon atoms, some of their outermost electrons jump free. Because many photons of light energy strike many atoms at one time, and because of the way the solar cell is made, these free electrons flow into the wires attached to the solar cell. If the wires join the solar cell to something that uses electricity, this makes a circuit. The electricity will flow through the circuit.

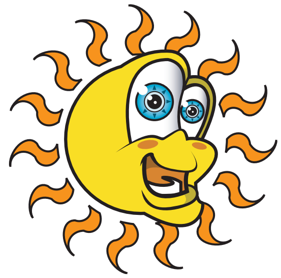
A single solar cell makes only a tiny amount of electricity. Generally, 100 cm^2 of cell surface make about 1 watt of electricity in full sun. *(Less surface means less electricity; more surface means more. Less than full sun means less electricity.)*



Solar cells make DC electricity, like batteries.

Solar cells are sometimes the best source of electricity for locations far away from electric lines, for things that are mobile electrical units *(for which batteries are not a good option)*, and for items that use very small amounts of electricity.

Solar cells do not work at night. They work best in full sun. Some are made especially to work using light from inside lighting devices.



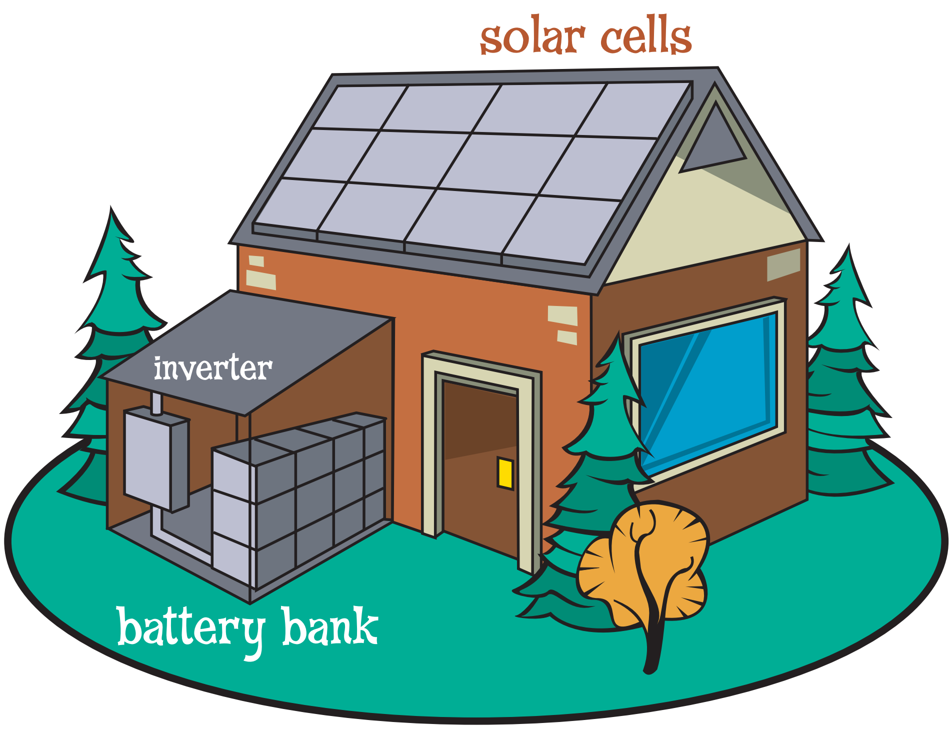
Photovoltaic Phacts continued

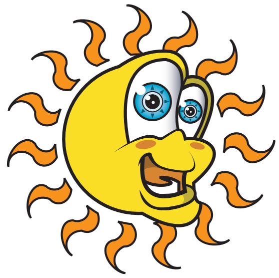
Over 6000 U.S. homes are powered by banks of solar cells, which are usually mounted on the roof.

Solar cells have been used to power experimental cars.

Using solar cells does not produce pollution.

As of 1990, electricity from solar cells was only 25 percent more expensive than electricity from most U.S. power companies.





Who's Using Solar Electricity?

Write the letter of the device powered by solar electricity next to the number of its user.

Users

_____________ 1. backpackers, hunters, and other other vacationers

_____________ 2. rancher

_____________ 3. mountain or desert village in a developing country

_____________ 4. NASA

_____________ 5. homeowner

_____________ 6. U.S. Coast Guard

_____________ 7. math student

_____________ 8. highway department

_____________ 9. farmer

_____________ 10. jungle station doctor

Photovoltaic-Powered Devices

a. communication devices *(telephone, radio)*

b. calculator

c. wilderness lodge lights and appliances

d. refrigerator for medicine

e. lighted buoys

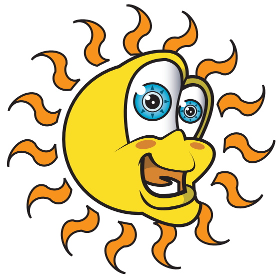
f. yard lighting

g. satellites

h. electric fencing

i. lighted highway signs

j. remote water pump for irrigation



A Solar Electric Home

Powering a home's electric appliances with solar cells requires enough solar cells to produce the needed amount of current.

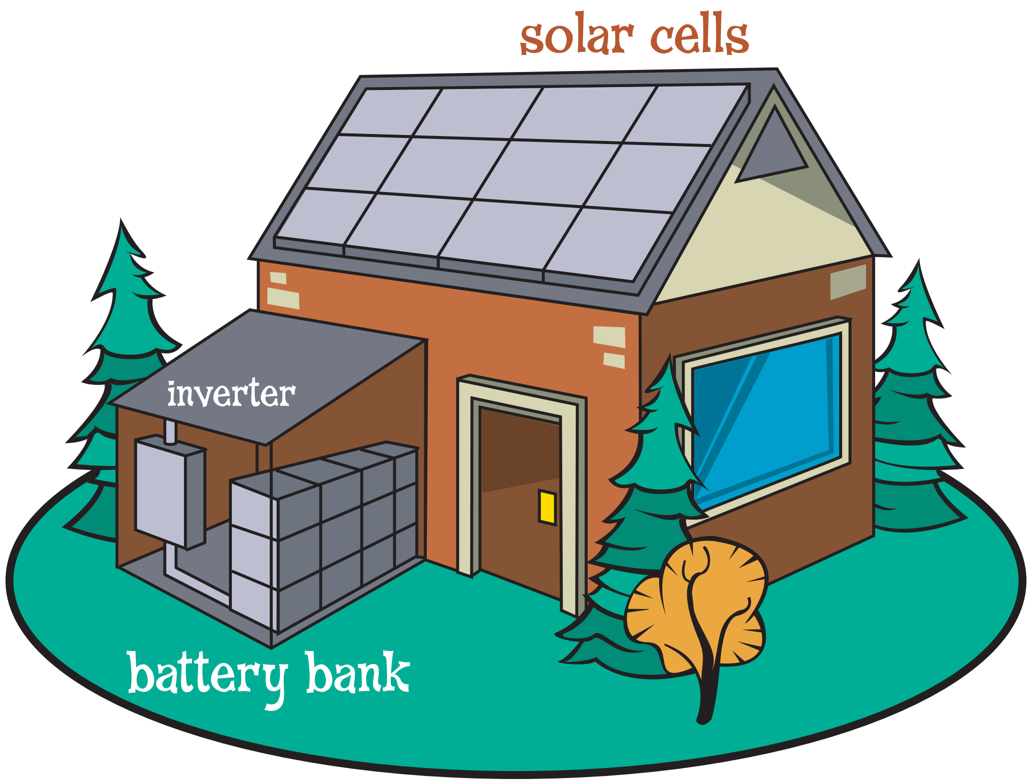
The system must include a bank of large-capacity, rechargeable batteries for times when the sun is not shining enough. These are located outside the house for safety.

The system must have a device called an inverter to change DC electricity from the cells and batteries to AC, which is what regular appliances use. A homeowner could purchase devices that run on DC but these are of limited variety.

The cells must be oriented *(faced)* and angled to receive the most sunlight.

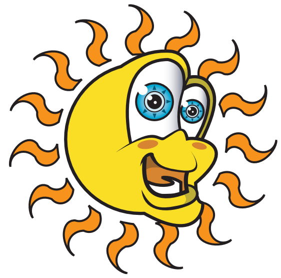
The cells must not be shaded.

Solar electricity systems are often combined with other solar energy-using design elements, such as passive solar heating and cooling. Photovoltaic systems are not suitable for most electric heating and air-conditioning systems.



fact sheet

PERSPECTIVE ON ENERGY USE



The economies of all industrialized nations, the lifestyles of most of the world's population, the tools with which we explore our universe, and even the transmission of our principal cultures all depend on a cheap, abundant and convenient supply of energy. That energy has been readily available since the beginning of the industrial revolution, and it is something that we have come to take for granted. But the fossil fuels, which account for the large majority of the energy we use, are finite resources and they will eventually be exhausted. Although that depletion is still several centuries in the future, the exponential increase in our use of fossil fuels has had an environmental impact which makes an immediate reconsideration of our energy priorities essential.

Past and Present

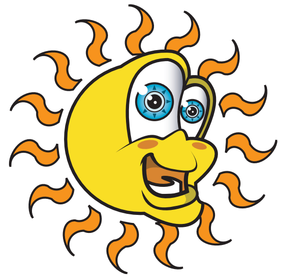
For millennia people built economies, cultures and political entities using the energy in their own muscles and the muscles of domesticated animals, the wind, water power and biomass – all renewable resources. These energy sources were more than enough to power the civilizations which developed writing, mathematics, philosophy, medicine and art. Cities of hundreds of thousands of people were sustained without fossil fuels. Empires were extended across continents with no more sophisticated form of transportation than the legs of legionnaires or the backs of steppe ponies.

The world underwent a fundamental change in the eighteenth century, as the industrial revolution multiplied our dependence on energy, and brought fossil fuels – first coal, then oil – into prominence. All aspects of our economies, our political systems, and even our cultures adopted new technologies that required enormous amounts of fossil energy. The sources of fossil energy that appeared limitless at the beginning of the industrial revolution are now seen to be finite. And the demand for them grows at an ever increasing pace as the world's population grows and more and more of our societies become industrialized.

Energy Choices

As more developing nations try to secure the obvious material benefits of industrialization for their people, the strain on the world's fuel resources becomes greater. This competition of limitless wants and limited resources imposes difficult choices, increased industrialization provides jobs and material well-being. But it also depletes non-renewable resources and has environmental impact. The choice that seems *"right"* changes as the observer's point-of-view changes. A developed country may make decisions based on future environmental impact while a poor country must base its decisions on the need to feed its people immediately.

Just as countries have different priorities in their energy choices, so do individuals. To some, the additional expense of energy-efficient appliances is well worth it for the energy – and money – which will be saved in the long term. Some people are willing to forego the convenience of driving their cars for the energy and cost savings of public transportation. Some are willing to spend the time and money to make their homes more energy-efficient. And some can't be bothered to do anything at all.



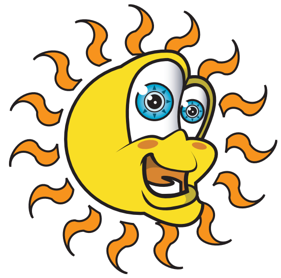
Energy choices are not simple. All involve trade-offs in cost, convenience, performance, comfort, environmental protection and many other factors. One important change is that we are beginning to realize that all energy decisions require choice. In the recent past we took for granted that we would have an unlimited supply of energy at our fingertips, and seldom considered any of the consequences.

Environmental Considerations

All significant present sources of energy have some impact on the environment. One of the choices which must be made in selecting energy sources involves weighing the relative environmental impact of each. Burning fossil fuels produces carbon, dioxide, nitrous oxides, and sulfur dioxide. And although new technologies continually reduce the output of these gases, some emissions are inevitable. Hydropower changes the ecology of the river which is dammed and floods acreage which might have been valuable farmland or animal habitat. Nuclear power entails some risk of reactor accidents, and creates nuclear waste which must be disposed of. The only way to eliminate environmental impact is to eliminate energy use, because even pre-industrial animal power created its own kind of pollution. People will not sit in the dark and freeze in order to avoid using any energy at all; but they may well decide that they have to be less profligate in their future energy use in order to enhance the quality of our environment.

fact sheet

ENERGY CONSERVATION



Energy conservation means reducing energy consumption by using energy more efficiently, by eliminating some uses of energy or by decreasing the frequency or duration of energy use. Energy conservation will help make our finite supply of fossil fuels *(coal, oil, and natural gas)* last longer. It will also reduce the need for new or expanded energy-producing facilities – including coal mines and oil and gas fields, refineries, fossil- and nuclear-fueled generating plants, and hydroelectric dams. By reducing the need for these facilities, energy conservation can help reduce the environmental impact they may cause. It can also help control the prices consumers pay for energy, by eliminating the significant expense new facilities require. New technologies and new habits are helping to conserve energy now. Additional technological advances – and increased awareness of the need and ways to conserve – will help save even more in the future.

Energy Conservation and Changing Technologies

New technologies are helping to conserve energy in many ways. Refrigerators built after 1990 use much less electricity than those built 10 or 15 years earlier. The average gas mileage of a new car today is twice as much as that of new cars 20 years ago. Compact fluorescent light bulbs use about a quarter of the energy needed by conventional incandescent bulbs and they often last 10 to 15 times longer.

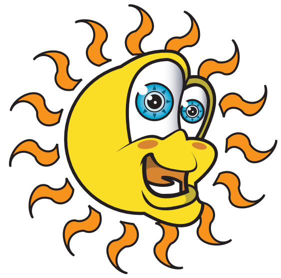
In the future more efficient generators, transformers and transmission lines will enable us to use a greater percentage of the electricity produced in generating plants. Airliners will use much less fuel for every passenger mile. And more industries will follow the example of the innovators who find energy from unexpected sources, like those who now convert old tires to carbon black using the tires themselves as fuel for the process.

Not all of the changing technologies are new, however. Some are a change back to former, more energy efficient ways of doing things. In agriculture reduced tillage and a trend away from chemical fertilizers, herbicides and insecticides is helping cut the use of heavy equipment, which reduces energy use.

Energy Conservation Construction and Indoor Spaces

The indoor spaces in which we spend most of our time use energy for heating, cooling and lighting. Some simple efficiency measures can reduce this energy consumption significantly without affecting our comfort, productivity or convenience. Heating alone accounts for between half and two-thirds of the energy used in most American homes. And much of the warmth leaks out through poorly insulated walls or around inadequately weather-stripped doors and windows.

Constructing new homes and commercial buildings with adequate insulation and weather stripping can save tremendous amounts of energy. So can adding weather stripping or additional insulation to older structures. Turning the thermostat up in the summer and down in the winter can be an important energy conservation technique. Adding deciduous trees to the south of a structure and evergreens to the north can also result in significant energy savings. The deciduous trees on the south shade the building in summer, then drop their leaves to let the sun add warmth in winter. The evergreens protect the building from cold north winds in winter.



Energy Conservation and Consumer Choice

Conserving energy can only come as a result of deliberate choice on the part of the people who use energy: consumers. All energy is, ultimately, used by individual consumers, either directly *(in the gasoline they burn in their cars or the electricity used to light their homes)* or indirectly *(in the energy which goes into the products and services they use)*.

Most of the choices will require balancing various needs and considerations. Cost, convenience, performance, and energy savings will have to be evaluated and consumers will have to decide the relative importance of each. For example, several cars now offer fuel economy which is more than twice the average. But they are all small, and offer relatively low levels of performance. If everyone chose to forego size and performance and bought one of these more efficient cars, the energy used for automobiles in this country would be cut in half immediately.

Compact fluorescent light bulbs could reduce the energy used in many lighting applications by about 75 percent. But the bulbs can cost more than 10 times as much as conventional incandescent bulbs. They last more than 10 times longer, and save many times their purchase price in electricity, but many people do not want to spend the additional initial price.

There are many other trade-offs and considerations, all of which depend on the priorities and value judgments established by consumers. The trend is toward greater energy consciousness and a willingness to pay more or perhaps accept less performance or comfort to save energy. But we aren't likely to see a time when rock fans will pass up a concert to conserve the kilowatt hours of the lights and sound system or shoppers will eliminate trips to the mall to save gas.

Recycling and Energy Conservation

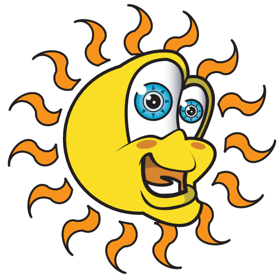
Recycling is a simple way to save energy. It also saves natural resources, reduces pollution, and helps slow the rate at which we are filling up our limited landfill space. Most aluminum cans are now recycled, at an energy savings of 95 percent over that required to smelt aluminum from bauxite ore. The potential additional energy savings from more extensive recycling of steel and paper is more than half a billion barrels of oil and $750-million in disposal costs each year. And energy savings can also be made by recycling glass and plastic.

Attitudes and Energy Conservation

The most important factor in conserving energy is people's attitudes. Many potential energy-saving products and techniques are widely known and readily available. But, unfortunately, they are underutilized. Using public transportation instead of private cars could save billions of barrels of oil each year. Yet many commuter buses and trains run at far less than their capacity in cities whose roads are choked with cars carrying just one person. Turning the thermostat down in winter or turning the lights off when leaving a room could save vast amounts of energy if everyone did it, but too few do. The United States has about five percent of the world's population, but is responsible for about a third of global energy use. Increasing energy conservation awareness, and re-ordering individual priorities will be needed if we are going to bring our consumption more into line with worldwide norms.

fact sheet

ALTERNATIVE ENERGY STRATEGIES



A number of alternatives to conventional fossil fuels, hydropower, and nuclear energy are in use or under study today. To be feasible, these alternative energy strategies must produce energy on a large enough scale to be economically viable. In addition, it is important that the energy be in a transportable form and that it be environmentally compatible.

In addition to alternative sources such as the sun, wind, geothermal energy and biomass, new energy strategies include advanced technologies which make better use of existing fossil fuel supplies.

Solar Energy

Every day the earth receives more than 10,000 times more energy from the sun than people use in all of their energy-consuming activities. Of course not all of this energy is available to power vehicles, light cities, and run appliances. Most is used to fuel our weather cycles, grow the plants which are the bases of our food chains on land and sea, provide the light of our days and the warmth which makes life possible on our planet, and to originate almost every other source of energy on earth. Utilizing just a small fraction of the energy the sun delivers to earth could provide for our energy needs indefinitely, and do so without pollution.

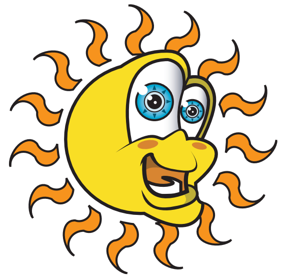
Although many proponents of solar energy call solar energy *"free,"* there is cost involved, as there is for all energy sources. The sunshine is, of course, free. But in that sense so are coal, oil, water power and uranium. No one paid to have them created. The cost is in getting to them, extracting their energy and delivering it to its ultimate consumers. A river flows at no dollar cost, but the dam needed to convert that flow to electricity costs many millions of dollars, and the power lines which take the electricity to cities, farms, and factories cost millions more. And there are ongoing costs required to operate and maintain the facilities and to distribute the energy produced. Sunlight is free, but the technology and machinery needed to capture and distribute it are not.

But, even at a cost, solar energy is a very appealing alternative to present energy sources. Whether in passive systems or in large-scale or photovoltaic active systems, it has the advantages of being virtually limitless, inexhaustible and clean. Solar energy is covered in more detail on a separate factsheet.

Biomass

All plant material on earth is the result of solar energy converted to organic form by photosynthesis, and all animal matter derives from the plant material at the bottom of its food chain. This plant and animal material is biomass, and it is the basis of much of the energy we use.

Fossil fuels – oil, natural gas and coal – were created by enormous amounts of biomass altered by geological and chemical forces over great periods of time. Oil, gas, and coal were ferns and animals hundreds of millions of years ago. They collected in enormous quantities during the Carboniferous and Permian eras and were converted to fuel in the eons since then. Our supply of fossil fuels is finite, and we are using them millions of times faster than they can form. But there are sources of biomass energy which are renewable.



Biomass – specifically trees and some other plant matter – was probably our first fuel. It is still one of the most important. In many developing countries, wood is a primary energy source for cooking and heating. It is also making something of a comeback in the United States, at least for heating, with the renewed popularity of wood-burning stoves.

Biomass is also being examined for industrial and power generating applications. Today many municipalities burn biomass from garbage as an energy source. And experiments indicate that trees may become an economically feasible fuel in the future, as their cost per unit of energy produced comes down.

Biomass has one very important attribute as an alternative fuel source. It eliminates much of its own pollution. The trees grown to fuel a biomass-powered generating plant could consume as much carbon dioxide as the plant releases into the atmosphere.

Geothermal Energy

Geothermal energy is heat from the mantle of the earth. It reaches the surface in areas where the earth's crust is thinnest or especially permeable. The heat of geothermal energy is captured in the form of steam, which is used to drive turbine generators. In the future geothermal fields without convenient hot springs or geysers may be tapped by pumping water down to the heated rocks below, and recovering it as steam. Geothermal plants are now producing electricity in some locations, most notably Iceland.

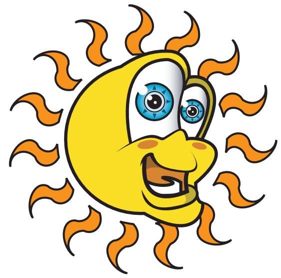
Wind

Wind, which is created by differences in temperature in areas of the earth's atmosphere and by the earth's rotation, has been used as an energy source for centuries. The windmills which powered grinders, pumps, and saws long ago have evolved into the energy sources for pumps on farms and ranches all over the world. Their modern descendants, the windmill generators, sit in rows on wind farms in areas with steady, relatively strong winds. Coming improvements in windmill design, to help capture even the faintest breezes, may help make this clean energy source more cost effective.

New Fossil Fuel Technologies

Fossil fuels are virtually finite. Although small amounts are still being created, these are infinitesimal compared to the rate at which current supplies are being depleted. That inescapable fact, and pollution are the two areas of fossil fuel study receiving most emphasis right now.

The limited supply of fossil fuels is being dealt with in several ways. One is continued exploration to discover additional resources. Another is the more efficient extraction of those resources. New techniques may make it economically feasible to extract the oil from oil shale, which has 50 times more oil than today's proven reserves. New technology may also open oil and natural gas trapped in porous rock for development.

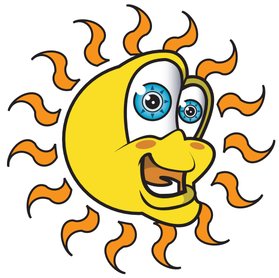


New methods are also enabling drillers to extract more oil from each well. Conventional wells leave 40 to 80 percent of the oil in the ground, but enhanced recovery through catalytic cracking, acidification and rock fracturing bring much more oil to the surface.

Additionally, new technologies are being applied to coal. Fluidized bed combustion improves coal's efficiency and reduces sulfur and nitrogen oxide emissions. Both gasification and liquification of coal are also under study to determine if a more usable form of this abundant resource might be developed.

fact sheet

SOLAR ENERGY



The sun is the source of almost all the earth's energy. Fossil fuels originated as biomass grown with the sun's energy and subsequently convened to coal, oil and gas by geological and chemical action. Wind derives much of its impetus from the sun's heating of the earth's atmosphere. All biomass is ultimately dependent on photosynthesis to convert solar energy into carbohydrates. Even hydropower is driven by the sun which gives it potential energy by evaporating moisture into the atmosphere, to be converted to kinetic energy as it falls as rain and flows downhill in streams and rivers.

Only geothermal energy *(fueled by the internal heat of the earth's core and mantle)*, nuclear energy *(derived from the so-called "weak force" which binds atoms together)*, and some of the kinetic energy produced by the earth's rotation, exist independent of the sun. Most scientists today agree that these forces have their origins in the period of frequent collisions of planetesimals which formed the earth just over four-and-a-half billion years ago.

Because of its virtually ubiquitous and inexhaustible nature, solar energy is an extremely attractive alternative energy source. Its attractiveness is enhanced by the fact that solar energy is virtually nonpolluting. The only environmental hazards of solar energy come from the manufacture of the solar collection, generation, and distribution devices. In some cases, there is no environmental down-side risk at all.

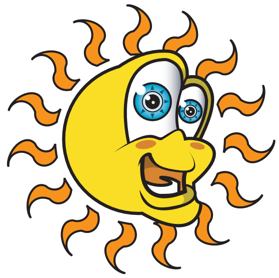
Pre-historic people used passive solar energy systems in that they chose winter dwellings with south fac-ing openings to take advantage of the sun's warmth. Many early civilizations, including the Romans, Greeks and Near Eastern and Asian cultures designed and aligned their buildings to take advantage of the sun's *"free"* energy.

But although these passive uses of solar energy have virtually no environmental impact, and no on-going expense after initial construction, the greatest potential for solar energy is in active systems used to produce electricity.

Passive Solar Energy System

Using the sun's energy to warm a space or heat water does not require any complex technology. In the simplest form, openings through which the sun's energy can pass *(like windows)* are aligned toward the sun, to allow solar energy to enter the space; *"collectors"* inside the space *(like the stone floors of caves or the marble or terrazzo floors of Roman villas)* capture the heat and release it gradually after the sun has set.

Today's passive solar designs use dark colors to trap heat, buildings constructed to permit convection currents to warm the entire building, and water-filled collector pipes *(or drums)* to capture solar energy. Although these systems can be effective, they are not yet efficient in dollars and cents. Although the solar energy which is collected is free, the systems which collect it, and structures built to take maximum advantage of it, are still more expensive than conventional energy sources. This is especially true since present-day solar technology requires a complete conventional back-up system in addition to the solar



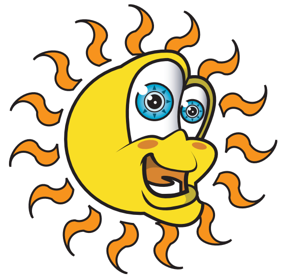
Large-Scale Active Solar Energy Systems

The use of solar energy to generate electricity in large quantities is still in the experimental stage. Present technology involves the use of a large field of heliostats *(mirrors)* which focus the sun's energy on boilers. The boilers generate steam used to drive turbines which, in turn, drive generators. The systems are not yet commercially feasible, since the true cost of the electricity produced *(which includes the initial cost of the collection and production facility)* is much higher than that of conventional energy sources. As further experimentation brings the cost down, or when consumers decide that they are willing to pay substantially more for energy which has virtually no environmental impact, large-scale solar power production may become practical.

Photovoltaic Cells

Photovoltaic cells convert solar energy directly into electricity. Similar cells were first developed in 1895. Photovoltaic cells have been used in solar-powered calculators and in satellites and other space equipment. Each cell produces a minute amount of electricity, and to develop usable quantities they are joined into solar panels *(made up of many cells)* and solar arrays *(made up of many panels)*. To maximize electric output, the cells, panels and arrays must be aligned to capture the most possible sunlight. Photovoltaic cells have been used to power experimental automobiles and in some individual households and other applications, but the present cost and efficiency preclude widespread use.

GLOSSARY



aerobic: describes organisms that must have free oxygen for respiration to live.

anaerobic: describes organisms that are able to live and gain energy without oxygen.

active solar energy system: a solar energy system that requires external mechanical power to move solar heat energy for storage and/or use; compare *passive solar energy system*.

biomass: all solid material of animal or vegetable origin from which energy can be extracted.

blade: a flat or concave projection from a rotor shaft; a rotor shaft plus its blades make up a propeller.

closed system: a system that requires nothing from outside itself to sustain itself and releases nothing to the outside.

concentrator: a device that concentrates the sun's rays on an absorber surface which is significantly smaller than the overall concentrator area.

convection: the natural movement within a fluid caused by unequal heating *(warm air rises and cool air sinks)*.

Coriolis force: rotational force of the earth which affects global wind patterns.

dehydration: to cause to lose, or become relatively free of, water, as in the drying of foods to preserve them or to reduce bulk and weight.

desalinization: the removal of salt from seawater to produce fresh water.

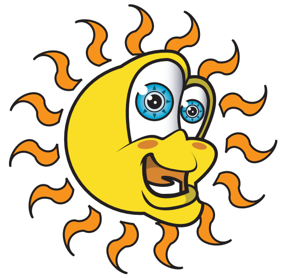
distillation: the process of driving off gas or vapor from liquids or solids by heat and condensing the product for purification.

ecosystem: a self-regulating community of living organisms interacting with each other and with their environment.

electromagnetic spectrum: the sequence of electromagnetic waves ranging from cosmic rays *(shortest wavelength)* to radio waves *(longest wavelength)*; the visible light spectrum is a very small part of it.

environment: all the physical and organic factors that surround and affect living organisms.

ethanol: a form of alcohol derived from fermentation of sugar and grain crops and used as fuel; structural formula is CH_3CH_2OH.



evaporation: the process by which a liquid is converted into a vapor.

fermentation: the breakdown of complex molecules by microbes into ethanol and carbon dioxide.

gravity: the force which attracts anything that has mass toward the center of the earth.

habitat: the place where a plant or animal lives, grows, and reproduces.

insulation: a material with a high resistance to heat flow.

methane: a colorless, odorless gas formed by the anaerobic decomposition of biomass; formula is CH_4; can be burned as a fuel.

methanol: a form of alcohol produced from a variety of materials *(including wood)* and used as fuel; formula is CH_3OH.

organic wastes: discarded or unwanted materials of living or once-living origin, such as animal wastes, crop residues, agricultural product residues and food scraps; composed of carbon-based substances.

passive solar energy system: an assembly of natural and architectural components that, without external mechanical power, converts solar energy into usable or storable heat energy; compare *active solar energy system*.

photon: a tiny bundle of light energy from the sun.

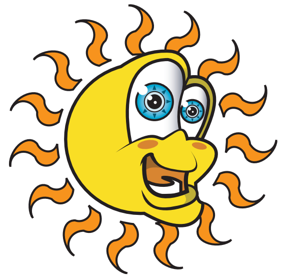
photosynthesis: the process by which green plants capture light energy from the sun and convert it to chemical energy; the process by which green plants combine carbon dioxide and water using light energy to make carbohydrates *(food)*.

photovoltaic: pertaining to electricity generated from light *("photo")*.

radiation: the flow of energy across space via electromagnetic waves, such as visible light.

recycling: reusing waste products.

rotor: the rotating part of an electrical or mechanical device; transfers mechanical energy from its source *(such as wind or flowing water or steam)* to the device.



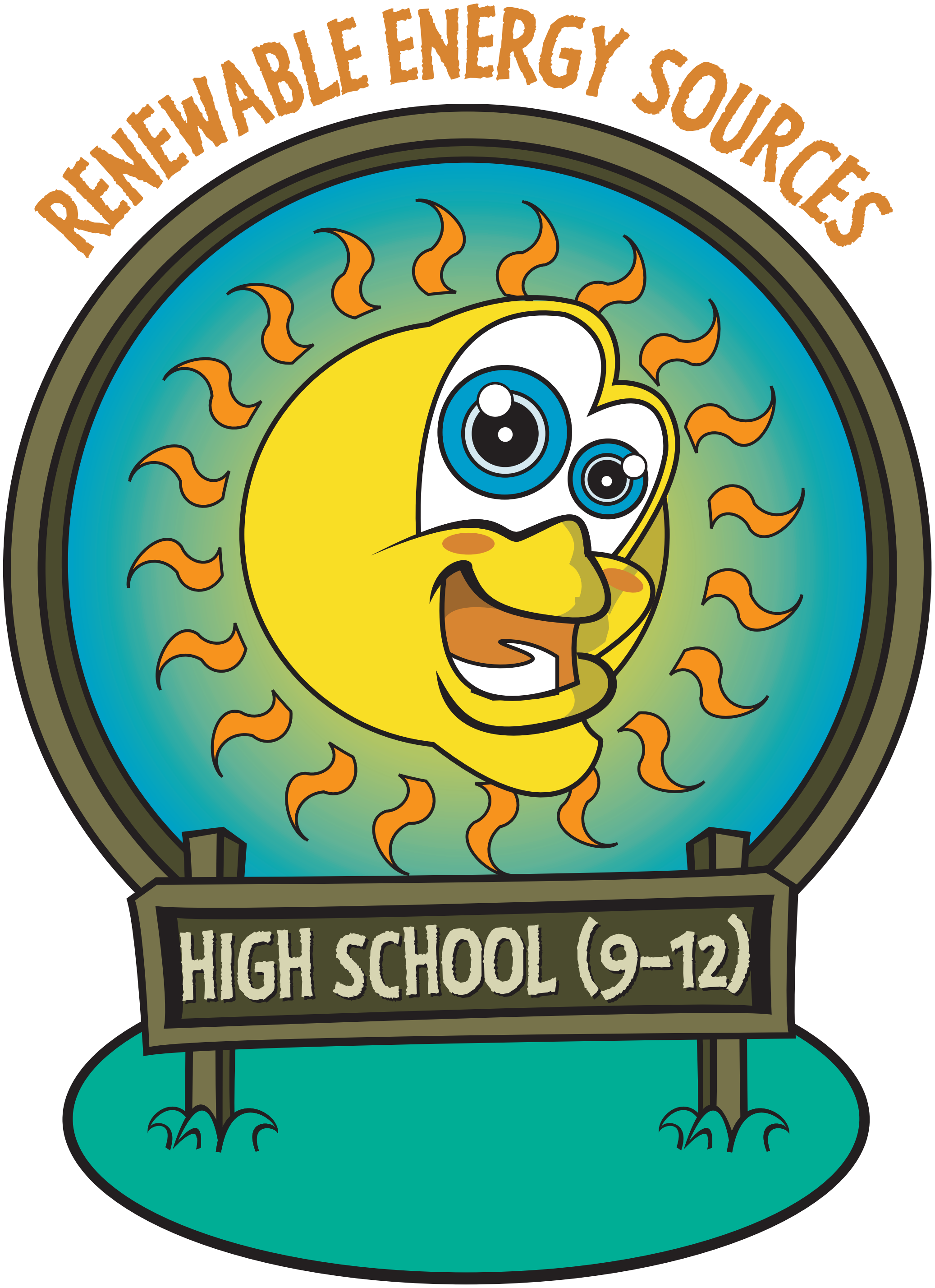
solar radiation: energy emitted by the sun and traveling in waves.

solar collector: a device that collects solar radiation and converts it to heat energy.

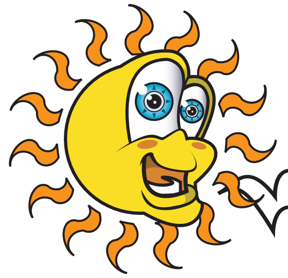
solar reflector: a device used for reflecting sunlight onto a specific point or area.

waste: materials generated as the result of an activity and discarded as no longer wanted or needed.

wind: moving air masses; especially, natural air movement parallel to the surface of the earth.


RENEWABLE ENERGY SOURCES
HIGH SCHOOL (9-12)

IS IT TOO LATE?



SUBJECTS: Mathematics, General Science, Economics

TIME: 1-3 class periods

MATERIALS: student sheets

Objectives *The student will do the following:*

1. Analyze graphs of energy production and consumption.
2. Demonstrate an understanding of the relationship between production and consumption.
3. Estimate depletion rates for fossil fuels in the United States.
4. Infer from the analysis of graphs and data what sources of energy will be important in the year 2050.

Background Information

Renewable energy sources are those not depleted by use if they are properly managed. Unlike coal, petroleum and natural gas, renewable energy resources are quickly replaced. Examples of these resources are the sun, wind, falling water and biomass. States are requiring investments in renewable energy technologies. The generation capacity needed to meet demands will depend upon renewables. Estimates are that states will require 5,065 megawatts of central station renewable generating capacity from 2000-2020.

Grid connected photovoltaics are projected to add nearly 900 megawatts to the U.S. market.

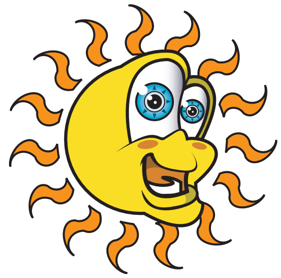
Wind power could be harnessed in parts of the United States, such as in the Plains States. Total wind capacity is expected to double in the year 2020 (2,900 megawatts).

Hydropower, energy available from falling or running water, could supply 4.8-5.5 percent of the United States' needed energy by the year 2001.

Biomass provides energy stored in trees and other plants. It is an energy source with great potential for the United States. Burning biomass, such as wood, crop residues and other wastes, generates heat. Decomposing biomass produces methane *(a burnable gas that can be used to generate heat)*. Biomass can be converted into alcohol *(a liquid fuel)*. Biomass is projected to supply the largest renewable energy increase, from 36.6 B Kwh in 1999 to 65.7 B Kwh in 2020. Landfill gas in projected to increase by 15.9 B Kwh from 1999-2020.

Producing or converting energy near the location at which it will be consumed is efficient and appropriate technology. For example, small digesters, used to convert organic waste to methane, can be located on farms, in homes or at industrial complexes to provide fuel at these sites. Similarly, solar collectors can be used at homes to heat water inexpensively.

Appropriate technology, together with the development of alternative, low-cost energy sources, is essential if the United States is to become energy self-sufficient.



Procedure

I. *Give students simple definitions of renewable and nonrenewable resources.*

II. *Give each student a copy of the student sheet "U.S. Energy Reserves & Consumption – 1977" (page 162).*

As an introduction, ask the students to examine the chart and answer the questions on the handout. Discuss the questions with the students, making sure they understand the difference between renewable and nonrenewable resources.

III. *Give each student a copy of the student sheet "U.S. Energy Consumption – 1983" (page 163), and have them compare those data with the earlier data (1977).*

Go over the questions with them.

IV. *Discuss fossil fuel "reserves" and "production" with the students.*

A. Read the following paragraph to the class and discuss its meaning with them.
The term *"production"* means the amount of fuel made available for use *(e.g., in a given year)*. The term *"reserves,"* as applied to fuel, indicates how much of a fuel exists and could be profitably obtained under present economic conditions and using current technology.

B. Give each student a copy of *"Petroleum, Coal, and Natural Gas: Proven Reserves and Production" (page 164)*. Explain to the students that to **estimate** how long domestic supplies of a given fuel will last, the "*reserves*" of the resource are divided by its *"production"* for a given year.

1. Work this example on the chalkboard:

1984 COAL SUPPLY DEPLETION ESTIMATE

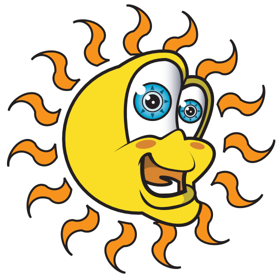
$$\frac{\text{478.7 billion short tons* } \textit{(U.S. proven reserve in 1984)}}{\text{.82 billion short tons per year } \textit{(U.S. production in 1984)}} = \text{years of fuel supply remaining}$$

The estimated length of time before the United States runs out of coal *(using 1984 data)* is 583.8 years.

Some assumptions:

1. Coal continues to be used at the 1984 rate.
2. No more coal is discovered in the United States.
3. No new technology is developed to allow production of reserves currently unavailable.

*A short ton is 2000 lbs *(as opposed to a metric ton, which is 2,000 kg)*.



2. Be sure that the students understand the changeable nature of reserve estimates and the fact that many assumptions are made in making such depletion estimates. Can the students think of some assumptions that are not listed above?
3. Have the students use the information in Tables I and II on the student sheet to estimate the depletion dates of U.S. natural gas and oil supplies *(using 1984 data)*. Ask them to list some of the assumptions upon which these estimates are based.
4. Ask the students to assume that *(a)* we continue to use coal, petroleum and natural gas at the 1984 rate; *(b)* new technologies are not developed; and *(c)* new reserves are not discovered. In this scenario, which fossil fuel will be depleted first? Last?
5. Have the students examine the pie chart student sheets and the information from B.3. *(above)*. Make sure they have noted the disparity between U.S. oil reserves and the rates at which we consumed oil in these two years. Have them look at their calculations of a U.S. oil depletion estimate. According to this calculation, the domestic supply of oil may be exhausted before 1993. Why is this not likely? Make sure they understand our dependence on imported oil.

V. *Discuss what happens when the following situations occur:*

A. Something becomes *"rare"* or *"harder to find."* What happens to its price? Could this happen to our nonrenewable energy resources?

B. Oil and gas become rare and harder to find. Will people be willing to pay more for these resources? Will people be willing to pay more for new technology, new exploration for these resources or imports? Will people use more coal? *(If yes, how will this affect our coal reserves?)* What are some implications for transportation?

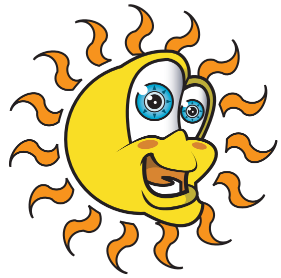
VI. *Give each student a copy of the student sheet "Consumption of Energy by Source, 1950 – 1995" (page 166).*

Have them answer the questions on the handout. Discuss their answers.

VII. *Give each student a copy of the student sheet "U.S. Wood Energy Consumption by Region" (page 167).*

Have them answer the questions and discuss the significance of the data with them.

VIII. *Continue with follow-up below.*



Follow-Up

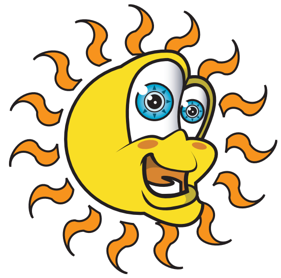
I. ***Examining energy consumption data, ask the students if they think more alternative energy sources were being used in the 1980s than in the 1970s.***
What do they predict will happen to fuel-use patterns as the year 2020 approaches? What alternative energy sources are most abundant in the region in which they live?

II. ***Considering class discussion, examination of graphs and calculations made to answer questions, what do the students think the most important energy sources will be for the United States in the year 2050?***
What about the region in which they live? On what assumptions are they basing their predictions?

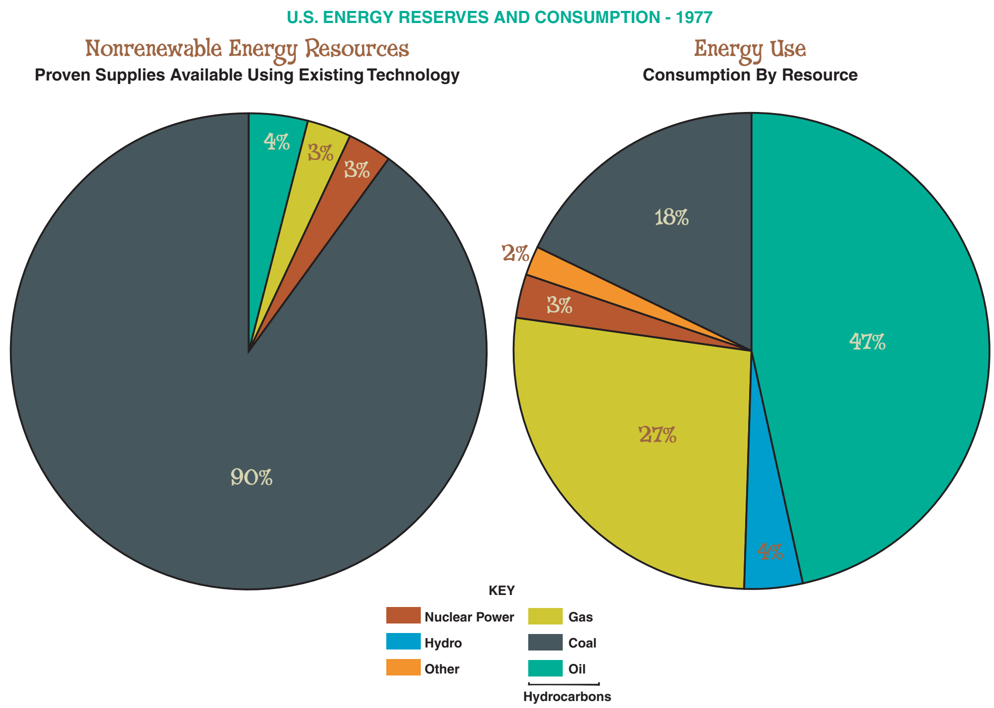
III. ***Extension***

The students might develop a game to simulate our consumption of the fossil fuels, water, biomass and other resources used in meeting our energy demands.
Colored paper can be used as game pieces to represent supplies of energy resources. In making up the game, the students should decide how to identify resources, their relative amounts and the accessibility of the resources. For example, coal could be represented by black slips of paper; it is abundant. Blue could be used to represent natural gas, and so forth. Some slips of paper could be visible but not accessible *"until new technology is available,"* such as those for oil shale. Other slips could be well-hidden to represent undiscovered resources.
The students should also consider differences in the ease of using the resources and in the renewable/nonrenewable aspects of the resources. Questions to be considered might include the following:

1. Why are we using one resource more than another?
2. Is accessibility the only reason?
3. How can we represent a breakthrough in technology which will allow access to resources that are unavailable to us now?
4. How can we simulate a renewable resource, such as biomass, that must be managed properly in order for it to remain available?
5. What do we do when a resource is depleted?



U.S. Energy Reserves & Consumption - 1977



(Data from Federal Energy Administration, Energy in Focus: Basic Data, Washington, D.C., 1977.)

Examine the circle graphs above and answer the following questions.

1. Most of the energy we consume is in the form of what resource? ______________________
Is it a renewable or nonrenewable resource? ______________________
How do our domestic supplies of this resource compare to our consumption of it?

____

2. What nonrenewable energy resource is most abundant *(using existing technology)*?

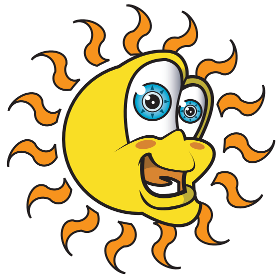
____

3. According to the energy use pattern, what percentage is provided by *"other"* resources? What do you think this category includes? *(Name several resources.)*

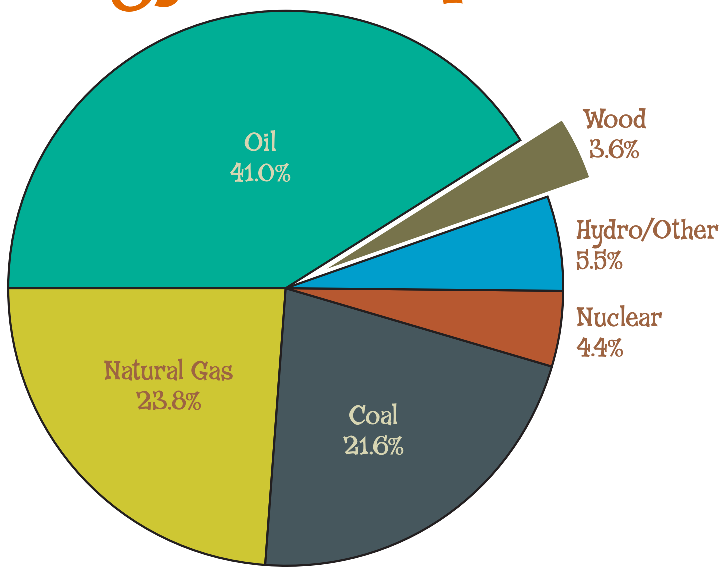
____

Are these renewable or nonrenewable resources?

____



U.S. Energy Consumption – 1983



Note: *In Estimates of U.S. Wood Energy Consumption. 1980-1983,* wood data was added to the primary energy total given in *Annual Energy Outlook 1983* (DOE/EIA-0383[83]), Washington, D.C., May 1984.

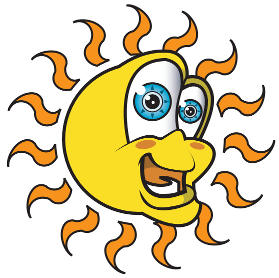
(Data from Energy Information Administration, *Monthly Energy Review, Washington, D.C., 1984*.)

Examine the circle graph above and "U.S. Energy Reserves & Consumption – 1977" and answer the following questions.

1. How does the data for hydrocarbon fuel *(coal, oil, gas)* use in 1977 compare with the 1983 data?
   ____
   Is there a general trend? If so, what is it? ______________________________

2. Looking at the consumption graphs for 1977 and 1983, which of the fossil fuels *(hydrocarbons)* was being used most? ______________________________
   How does its annual consumption rate compare for the two years? ____________________
   ____

3. Noting that data for the use of wood has been inserted in this chart, what can you say about the use of wood as an energy resource? ______________________________
   ____
   In general, did the use of renewable resources increase? ______________________
   ____

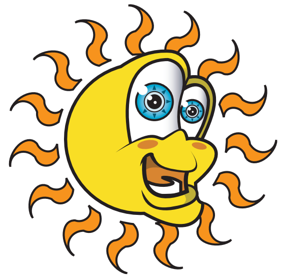


Petroleum, Coal, and Natural Gas: Proven Reserves and Production

Table I: Petroleum, Coal, and Natural Gas Proven Reserves

Resource	As of 1/1/80	As of 1/1/81	As of 1/1/82	As of 1/1/84	Number of Years U.S. Supply will last (at current rate)
Petroleum *(in billion barrels)*					
U.S.*	29.8	29.8	29.4	28.4	
World **	641.6	648.5	670.3	700.1	
Coal *(in billion short tons)*					
U.S.*	472.7	not available	not available	478.7	
World **	975.2	not available	not available	986.2	
Natural Gas *(in trillion cubic feet)*					
U.S.*	201.0	199.0	201.7	145.3	
World **	2,573.2	2,638.5	2,915.0	3,401.8	

*U.S. *(Domestic)* figures from Annual Energy Review, 1982.
**World figures from International Energy Annual for 1979, 1980, and 1981.
Both published by the Energy Information Administration, Department of Energy.

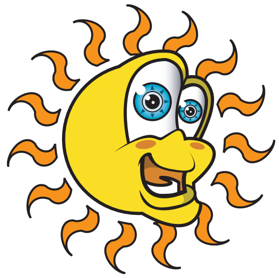


Petroleum, Coal, and Natural Gas: Proven Reserves and Production

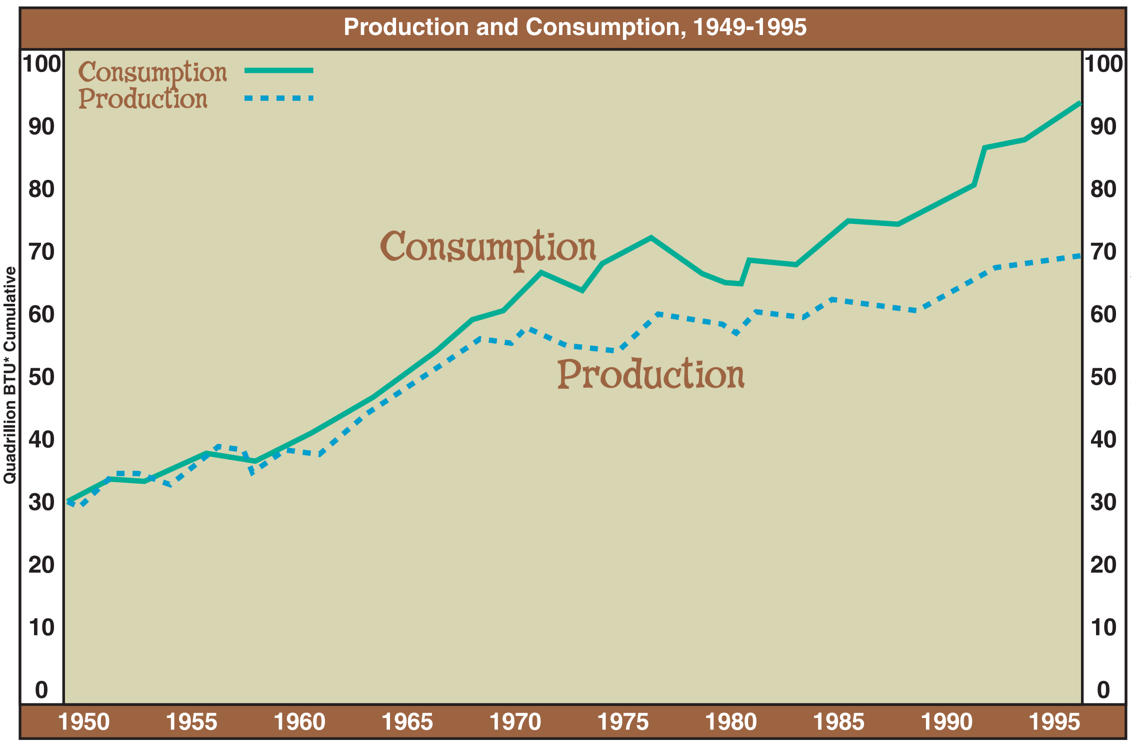
Table II: U.S. (Domestic) Production of Petroleum, Coal, and Natural Gas*

Resource	1978	1979	1980	1981	1982	1984	Number of Years U.S. Supply will last (at current rate)
Petroleum Million barrels per day Billion barrells per day	8.71 3.18	8.55 3.12	8.60 3.14	8.57 3.13	8.67 3.16	8.88 3.24	
Coal Billion short tons per year	.67	.78	.83	.82	.83	.82	
Natural Gas Billion cubic feet Trillion cubic feet	19,974.0 19.7	20,471.0 20.47	20,379.0 20.38	20,178.0 20.18	18,462.0 18.46	17,392.0 17.39	

*Figures from *Monthly Energy Review*, June 1983, published by Energy Information Administration, Department of Energy.



U.S. Consumption of Energy by Source, 1950-1995*



*One quadrilion BTU is 10 BTU (10 is one followed by 24 zeros)

Examine the graph above and answer the following questions.

1. What has been the general trend in energy use? ______________________________

2. What energy resource shows the greatest change in usage over these years? ______________
Was it an increase or a decrease?______________________________

3. How does the overall use of renewable resources compare to that of nonrenewable resources?

____

4. Compare the amount of petroleum consumed in 1950 with that consumed in 1990.

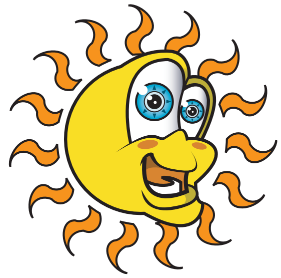
____

5. Compare the amount of energy provided by all fossil fuels in 1960 with that for 1990.

____

6. Identify trends in energy consumption by resource over the twenty-year period ending in 1995.

____



U.S. Wood Energy Consumption by Region
1980 - 1983

Year	Trillion Btu from Wood by Region				Total Energy from Wood (Trillion Btu)
	South	West	Northeast	North Central	
1980	1,380	388	386	329	2,483
1981	1,349	416	395	335	2,495
1982	1,392	385	358	343	2,478
1983	1,526	411	380	323	2,640

Note: Totals may not equal sum of components because of independent rounding.

Data from: Estimate of U.S. Wood Energy Consumption, 1980-1983, Department of Energy, Washington, D.C.

Examine the data above and answer these questions.

1. What has been the general trend in the use of wood as an energy resource?

___

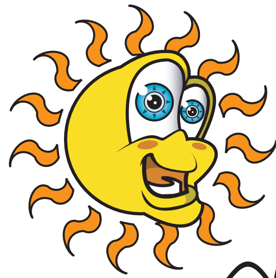
2. In which region has there been the greatest increase in the use of wood?

___

3. In which region has there been the greatest percentage increase in the use of wood?

___

MEASURING WIND SPEED



SUBJECTS: Earth Science, General Science, Physical Science, Physics

TIME: 3-5 class periods

MATERIALS: ping-pong balls, dark thread *(8" segments)*, glue, file folders, small weights *(1-oz sinkers or 1/2" flat washers)*, stapler, long sewing needle, tape, student sheets

Objectives *The student will do the following:*

1. Demonstrate an understanding of the feasibility of using wind as an energy source.
2. Construct a device to measure wind speed.
3. Calculate average wind speed.
4. Determine whether or not wind provides sufficient energy to produce electricity in the local area.

Background Information

Differences in the amounts of solar radiation received, atmospheric conditions, and the surface of the earth produce uneven heating and cooling of the earth's atmosphere. This uneven heating results in the movement of air masses – wind.

Wind may be as gentle as a breeze or as strong as a tornado or hurricane. Wind helps control climates *(including rainfall amounts)* and moderates changes in temperature.

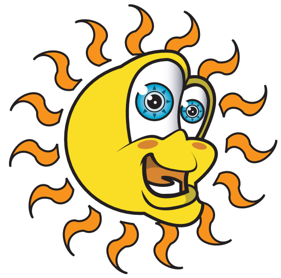
Wind has been used as an energy source for a long time. One example of this is the historic use of windmills to pump water. Today we are using the winds of high altitude jet streams to facilitate the speed of airplanes and save fuel.

There is a problem, however, in attempting to harness wind energy to produce electricity; wind does not blow at a constant speed or from a consistent direction. Generating electricity requires a constant wind speed of at least 13 kilometers per hour *(km/hr)*. A device that measures wind speed is called an anemometer.

Procedure

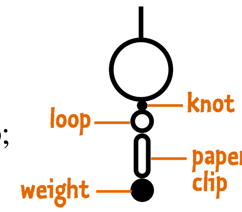
I. *Have the students assemble wind speed detectors (anemometers).*

A. Share the background information with the students, discussing with them the use of wind energy. Point out that a wind speed of 13 km/hr or more is needed to generate electricity. The wind must strike the blades of a wind generator with adequate force to turn the modified windmill at speeds sufficient to generate electricity. Lower wind speeds may turn the blades, but not fast enough to generate electricity. Is wind a viable option for use as an energy resource in your community? Ask the students to identify where they could get daily or hourly information about wind speed in the local area.



B. Divide the students into groups of three. Give each group a copy of the student sheets *"Wind Speed Detector"* and *"Protractor Pattern" (pages 171-172)*.

C. Show the students how to assemble the ping-pong ball component of the wind speed detector. Thread the needle with an 8-inch piece of thread. Push it through the ping-pong ball and knot to make sure it remains tied. Open a paper clip; hook one end over the thread loop and use the other end to hook the weight *(sinker or 2-3 washers)*.



D. Have the groups follow the directions on the student sheets to assemble their wind speed detectors.

II. *Have the students measure wind speed.*

A. Give each group a copy of the student sheets *"Measuring Wind Speed"* and *"Wind Speed Data Sheet"* (page 173-174). Take the students outside. Have each group use the wind speed detector to determine the wind speed at some location near the school – near an entrance, between buildings, on windward *(direction **from** which wind blows)* and leeward *(direction **to** which wind blows)* sides of buildings, on the football field, or other locations. *(Each group should select a different location.)*
Note: Attempt this activity only when wind velocities are predicted to exceed 15 miles per hour *(a moderate breeze)*.

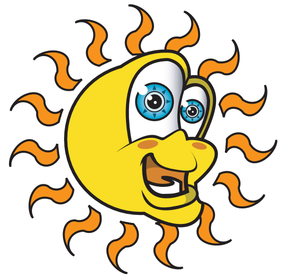
B. Have the students record wind speed observations on the data sheet for the next three to five days. If several classes are doing this activity concurrently and data for various times of the day obtained; this could be very useful.
Option: Students could continue collecting data throughout the year.
The students should enter the data and time, the angle of their wind speed detectors, and the angle-to-km/hr conversion figure from table on *"Measuring Wind Speed."*

C. Ask the class to complete the conversion of the data to miles per hour *(mph)*.

D. Give each group of copy of the student sheet *"Beaufort Scale of Wind Speed" (page 175)*to be used as a reference for converting km/hr to mph and classifying the winds they measured. They are to enter this information on their data sheets.

E. After collecting data for several days, have the groups construct bar and/or line graphs to better display the data. Have them mark the graph at 13 km/hr; this line will enable them to see quickly how the data compare with the wind speed necessary for generating electricity.

F. Working together as a class, make another graph showing the wind speeds at **all** locations where data were collected. Ask the students to compare wind speeds at various locations *(such as the windward and leeward sides of the building)*.



Follow-Up

I. *Discuss the following questions with the students.*

A. Could wind be used to generate electricity in your community? If so, discuss some likely locations. If not, what is the problem? Can the problem be overcome? What could be changed?

B. Is wind feasible as an energy source in mountain passes? What problems exist there?

C. Is wind power a renewable or nonrenewable resource?

D. What are some of the advantages and disadvantages of using wind as a source of power? *(Advantages include that it is free, nonpolluting, and renewable. Disadvantages include the unreliability and unavailability of wind at some places, and the high cost of the equipment to capture wind power.)*

II. *Extensions*

A. Have the students compare their findings with the television or radio weather reports. Do they differ? How? Why?

B. Discuss with the students the significance of the length of string holding the ping-pong ball. How will the angle of displacement be affected by a given wind speed *(force)*? Have them work out their hypotheses mathematically. Taking readings with different string lengths should verify the results.

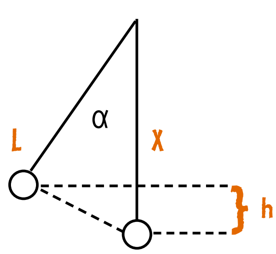
C. Have the students investigate land and sea breezes. Where do they occur? What would be necessary in order to use them to generate electricity? How did the Netherlands use them in the past?

D. Have the students measure wind speeds around their homes, in tree-covered areas, in the middle of fields, or in other locations and record their data for making comparisons later in class. Does the time of the data collection make a difference? Should the time of day be recorded? Why?

E. Some students could make reports on the modern wind turbine.

F. *(For advanced students.)* Have the students calculate the potential energy of the wind, using the angle to which the wind lifts the ping-pong ball.

1. Take the mass of the ping-pong ball.
2. Using trigonometry, determine how high the ball was lifted by the wind.



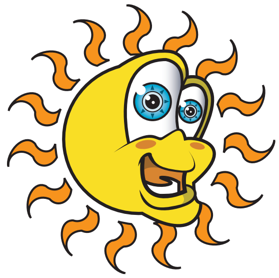
$h = L - X$

$\text{Cos}\ \alpha = \dfrac{X}{L}$

$X = L\ \text{Cos}\ \alpha$

$h = L - L\text{Cos}\ \alpha = L(1 - \text{Cos}\ \alpha)$

3. Solve for potential energy *(P.E.)* using the equation P.E. = mgh, where m = the ping-pong ball's mass; g = the acceleration of gravity; and h = L – LCos α.



Wind Speed Detector

Assembly Instructions

1. The frame *(Use a file folder, scissors, and a stapler.)*

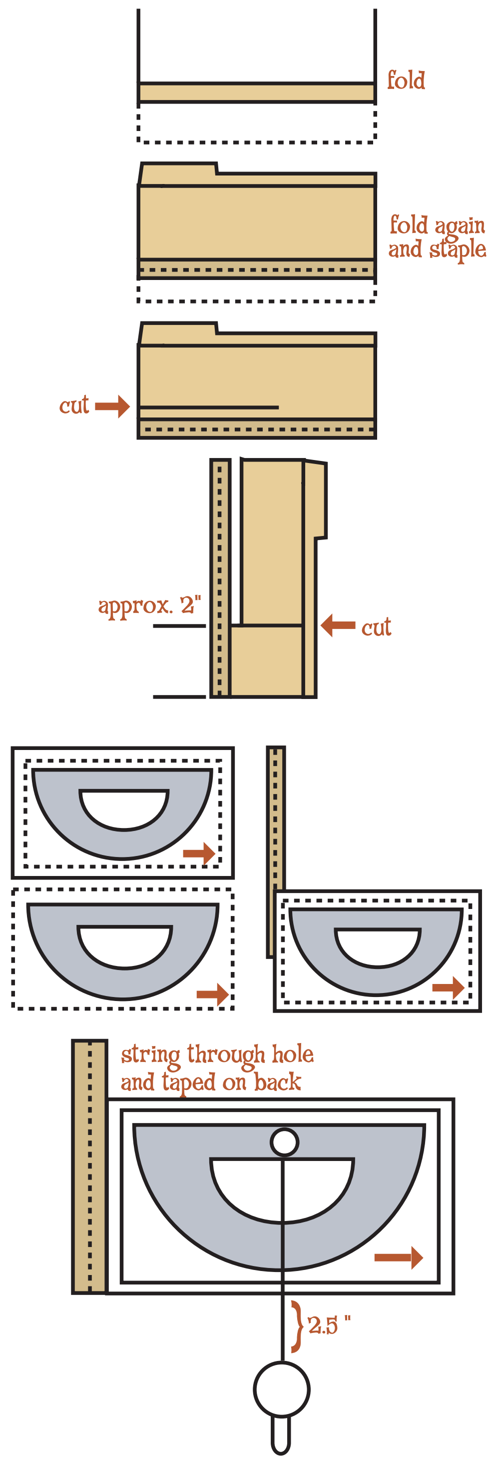
- With the file folder closed, fold up the long edge of the folder 1" to 2" on the side where it is prefolded.
- Fold it a second time, and staple the folded layers together at 5 to 6 places from one end to the other.
- Cut along the edge of the folded layers, stopping about 2" from the end.
- Turn the folder up on its end and cut across – perpendicular to the folded layers – leaving a 2" extension at the bottom.

2. The protractor *(Use the pattern handout, scissors, and tape.)*

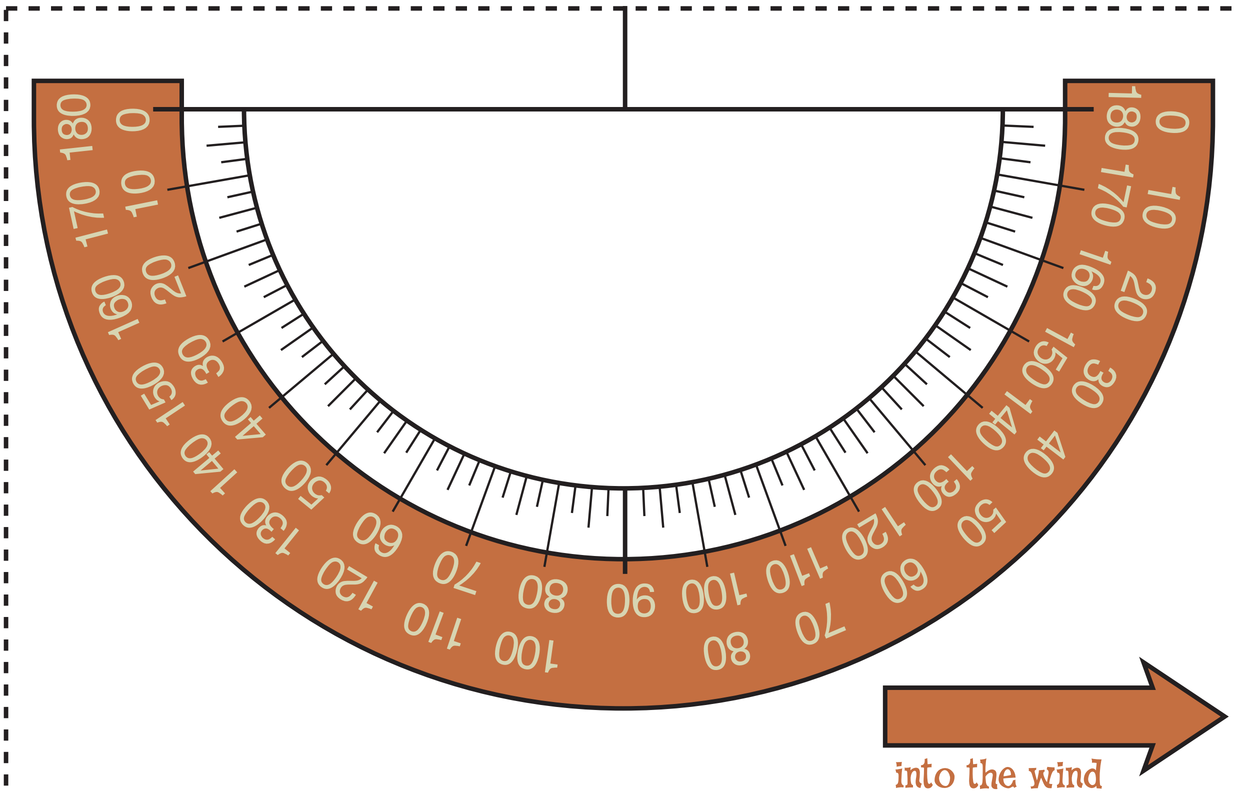
- Cut the protractor out of the handout along the dotted lines.
- Tape the protractor pattern to one piece of the left-over file folder.
- Tape this entire *"protractor"* to the extension of the frame, so that the straight edge of the protractor is at the top of the 2" extension.

3. The ping-pong ball *(Use the ball with the thread, paperclip, weight, and tape.)*

- Assemble the ping-pong ball component as demonstrated by your teacher.
- Punch a small hole at the protractor's center mark and pass the thread through the hole. Knot the thread and tape the knot firmly to the back of the protractor, so that the thread measures 2-1/2" from the bottom of the protractor to the ball.
- Be sure that when the protractor is held level and out of the wind, the ball component hangs at exactly 90°.



Protractor Pattern

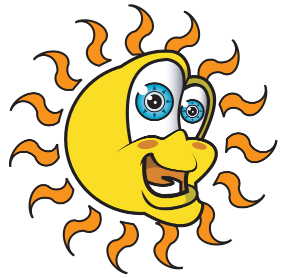


1. Cut out along dotted line.

2. Tape to stiff backing.

3. Tape to frame.

4. Punch hole at center mark to attach ping-pong ball component.

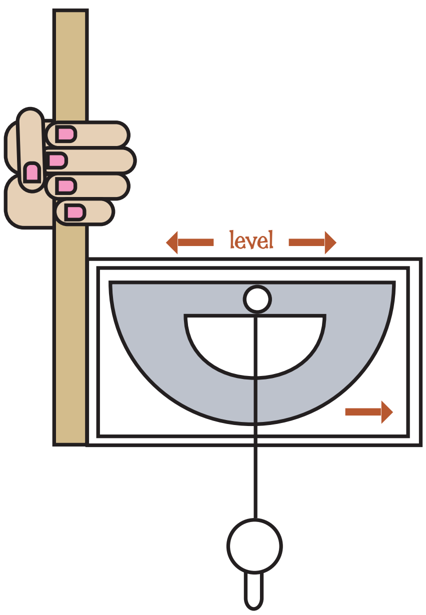


Measuring Wind Speed

Angle	Wind Speed km/hr
90°	0
85°/95°	6.5
80°/100°	13
75°/105°	16
70°/110°	19
65°/115°	21.5
60°/120°	24
55°/125°	26.5
50°/130°	29
45°/135°	31.5
40°/140°	34
35°/145°	37
30°/150°	41
25°/155°	46
20°/160°	52

1. On the *"Wind Speed Data Sheet,"* enter the date, time, and location of the site where the data is going to be collected.

2. Face into the wind and hold the wind speed detector at arm's length in front of you so that:
   a. the flat edge of the protractor is level with the ground
   b. the protractor arrow is pointing **into** the wind
   c. the ball can swing freely in the wind
   d. the thread hangs at exactly 90°.



3. One group member should then carefully remove the paper clip and weight. *(To improve the accuracy of your data collection, practice before recording the measurement.)* Record on the data sheet the highest angle that the thread reaches on the protractor when the ball is pushed by the wind.

4. Use the chart above to find out the wind speed that the angle reading indicates. This is measured in kilometers per hour *(km/hr)*. Record the speed on the data sheet.

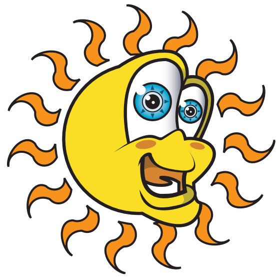
5. After you finish collecting data, convert km/hr to miles per hour *(mph)*. Refer to the left-hand column on *"Beaufort Scale of Wind Speed."* Record this speed on the data sheet. Note the wind classification in the right margin of the data sheet.

Example:

Wind Speed Data Sheet

Location: football field

Date	Time	Angle	km/hr	mph
October 25	8:30 a.m	110°	19	12 *(gentle breeze)*



Name________________________________

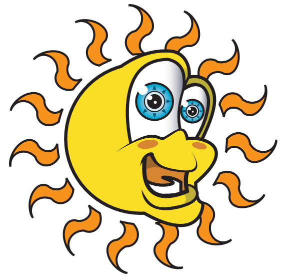
Name________________________________

Name________________________________

Wind Speed Data Sheet

Location____

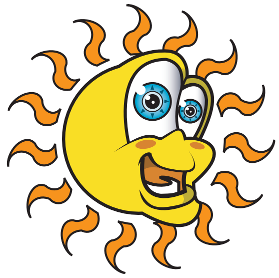
Date	Time	Angle	km/hr	mph



The Beaufort Wind Scale

Approximate Speed	Classification of Wind	What You Can Observe
Up to 1.6 km/hr (1 mph)	Calm	Smoke rises vertically
1.6 to 5 km/hr (1 to 3 mph)	Light breeze	Smoke drifts
6 to 19 km/hr (4 to 12 mph)	Gentle breeze	Leaves and twigs move
21 to 29 km/hr (13 to 18 mph)	Moderate breeze	Dust and loose paper move
30 to 50 km/hr (19 to 31 mph)	Strong breeze	Small trees sway; large branches move
51 to 74 km/hr (32 to 46 mph)	Moderate gale	Whole trees move; twigs break off trees
75 to 86 km/hr (47 to 54 mph)	Strong gale	Some structural damage of buildings
88 to 101 km/hr (55 to 63 mph)	Whole gale	Trees uproot; much structural damage
102 to 122 km/hr (64 to 75 mph)	Storm	Widespread damage
Over 122 km/hr (75 mph)	Hurricane	Very extensive damage

FAQ ABOUT LANDFILL METHANE PRODUCTION



Introduction

Landfill gas is created when landfill wastes decompose. The gases that are produced include 50% methane *(CH_4)* and about 45% carbon dioxide *($C0_2$)*. These gases generally escape into the atmosphere where they may cause local odors and contribute to local smog and global climate change. Methane is a flammable material and landfill emissions could be hazardous. Current technologies allow for the collection of the gases and use of methane as an energy source. Included below is additional information provided in the form of Frequently Asked Questions *(FAQ's)*.

FAQ # 1 *How can landfill gas be used for energy?*

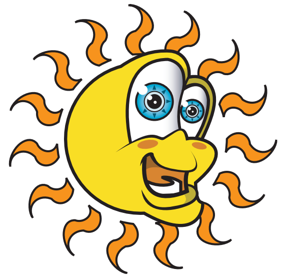
Landfill gas can be a locally available energy source that can be tapped to replace the use of nonrenewable resources such as gas and oil. In fact, the combustion of methane from landfills actually removes this air pollution component from the atmosphere! Landfill gas can be converted and used in a variety of ways. It can be used to directly produce electricity, heat or steam. It may also be utilized for modified automobiles. The Environmental Protection Agency estimates that there are currently about 6,000 landfills across the U.S. and they have approximately 270 projects in place to capture and utilize the methane produced from the decomposing garbage in these sites. The EPA estimates that if we were to add about 700 more methane gathering systems in additional landfill sites, we could produce enough electrical energy to power 3 million homes across the U.S.

FAQ # 2 *What are the economic benefits of using landfill gas as a resource?*

Construction of these methane collection systems in landfills provides a direct cost benefit for the landfill operators, counties or utility districts that operate the landfill. They can produce profits from the production of electricity. Jobs within the communities are also stimulated as construction requires engineers, construction firms and managers. Local employment will be stimulated during all phases of the implementation of the conversion of the landfill to a methane collection system. The community also benefits as the captured gas can be sold for use as a fuel and sold on the energy market. This renewable *"green power"* source can be a tremendous asset for a local economy using garbage as a productive asset!

FAQ # 3 *What are the social benefits of using landfill gas as an energy resource?*

Innovative and responsible communities can utilize their local landfill resource to produce new jobs and demonstrate their commitment to be environmental leaders. The reduction of landfill emissions into the atmosphere by converting them to usable forms of energy allow the community to benefit from reduced air pollution problems and smog formation. Surrounding properties benefit from the reduction of the odor of methane from the landfill area. Communities that invest in the harvesting of landfill gases are likely to be viewed as environmentally concerned and proactive in ensuring the well-being of its citizens.
FAQ # 4



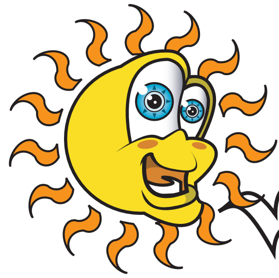
FAQ # 4 ***What are the environmental benefits of using landfill gas as an energy source?***
If we utilize landfill gases for our energy needs, we can reduce our demand on nonrenewable energy resources like coal and oil. At the same time we will be reducing the air pollution caused by the landfill gases! Methane is an air pollution component that has been linked with the global climate change concern. Communities that develop a landfill gas management system will directly benefit from cleaner air and reduced methane as a *"greenhouse gas."*

FAQ # 5 ***Who uses recovered landfill gas?***
Landfill gas cna be used for a wide range of purposes. A logical option is for local utility companies to buy the electrical power generated from the methane. Purchasing landfill gas allows utilities to add a renewable energy resource to their power production capabilities. Local industries may also directly pipe the gas to their site.

FAQ # 6 ***Why promote the use of landfill gas?***
Using landfill gas ends up being a win/win deal for the local community and the landfill operations team. Citizens want environmentally sound techniques for reducing air pollution and conserving limited energy resources. Furthermore, clean air contributes to public welfare and safety issues. Most communities would appreciate increased environmental protection, improved waste management, and responsible community planning.

FAQ # 7 ***Why is EPA interested in landfill gas projects?***
Landfills are the largest source of methane emissions in the U.S. This accounts for over 40% of the methane emissions. This energy can be captured and utilized for a wide variety of applications. As we strive to reduce greenhouse gas emissions, this is a very cost effective route. New regulations by the EPA are setting standards for target emissions from landfills. Landfill operators will be expected to work to *"flare off" (burn)* or work to capture it. By working to collect and use the methane, landfill owner/operators gain environmental, social and economic benefits. We can truly convert garbage in landfill to gases that provide us with a renewable energy resource.

THE SUN IN MYTHOLOGY AND HISTORY



SUBJECTS: General Science, World History, World Geography, English

TIME: 2-3 class periods

MATERIALS: *Icarus* by the Paul Winter Consort *(recording)*, world map outline

Objectives *The student will do the following:*

1. Explain the significance of mythology.
2. Demonstrate library skills.
3. Summarize sun myths and scientific knowledge about the sun.
4. Present summaries of information in a variety of ways.

Background Information

Daedalus, a character in Greek mythology, was a famous architect and sculptor. According to the myth, he grew jealous of one of his students, Talos. He killed Talos and fled from Athens to Crete, taking his son, Icarus, with him. In Crete, he built the Labyrinth of the Minotaur for King Minos. Daedalus soon fell from favor with the king, and both he and Icarus were imprisoned by Mines. In order to escape, Daedalus built two pairs of wings made of wax and feathers. He cautioned Icarus to fly low over the water and not to get too high or the wax would melt. Icarus, filled with the joy of flying, failed to heed his father's warning. He flew too near the sun, and his wings melted. He plunged into the sea and drowned.

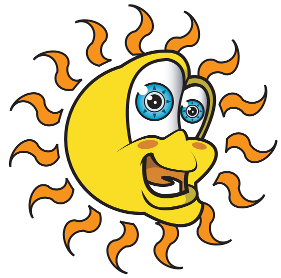
Procedure

I. *Play Icarus, a recording by the Paul Winter Consort, for the students.*

- **A.** Ask the students to describe what the music brings to their minds. *(You could have them make drawings.)*
- **B.** Ask if anyone knows the meaning of the title, *Icarus*.
- **C.** Relate the myth above.
- **D.** Ask the students to draw morals from the myth; discuss mythology and its cultural significance.

II. *Have the students research sun myths and beliefs.*

- **A.** Divide the class into five groups. Assign each group one of the early cultures listed below. Ask the students to find sun myths or beliefs belonging to their assigned cultures. Have the students conduct library research *(either during class time or outside of class)* to find the information they need.
  1. Japanese
  2. New World Indians *(Aztecs, Incas, Mayas)*
  3. Egyptians
  4. Babylonians
  5. Greeks, Romans



B. Have the students present their findings to the class. Encourage a variety of presentations *(skits, illustrations, etc.)*.

III. ***Discuss present astronomical knowledge about the sun and ask the students to describe some current solar energy technologies.***

A. Have each student return to the library to research our present knowledge of the sun and our use of its energy. Have them construct solar time lines based on the information they gather.

B. Have students locate each culture and each time line entry discussed in class on a world map.

IV. ***Continue with the follow-up below.***

Follow-Up

I. ***Why did so many early cultures have sun myths?***

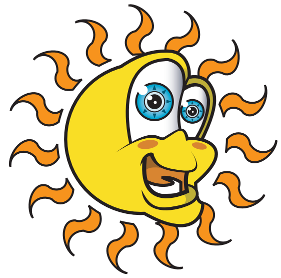
People developed mythologies to explain things they did not understand. This has been especially true of natural phenomena. For example, since one natural phenomenon all cultures experience is the rising and setting of the sun, it is quite natural that mythological explanations of this daily occurrence are common.

II. ***What is an appropriate scale (interval) for the time line? Why was an appropriate interval difficult to determine?***

The early myths establish one end of the time line and the more recent astronomical and solar energy developments establish the other. Because there are many recent developments of significance, the recent end of the time line needs small divisions. One way to deal with this problem is to use a broken time line with two scales. For example, the earliest mythological information can be recorded on a scale measuring thousand-year intervals, but the astronomical and recent solar technology developments need shorter intervals.

III. ***Why are there so many more late entries on your time line than early ones?***

The discussion should center on the incremental effect of scientific discoveries, i.e., one discovery leading directly to several more. There has been a geometric increase in the amount of information gathered in recent years in most subject areas. Advances in information retrieval systems and data collection mechanisms as well as the increased longevity of the population and improving economic conditions have contributed to the explosion of information.



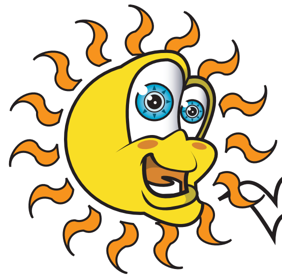
IV. ***What inferences can be drawn from an examination of the world maps on which these cultures and events were located?***

Two possible explanations might be that large parts of the world have not contributed to our solar knowledge or there are areas whose contributions the class has not yet discovered. Hypotheses to explain these two viewpoints should be developed, and each hypothesis could become the focal point for future library research.

Resources

Paul Winter Consort. ICARUS. Epic Records, 1972.

TRACING THE FLOW OF SOLAR ENERGY



SUBJECTS: General Science, Physical Science, Environmental Science

TIME: 1-2 class periods

MATERIALS: student sheets

Objectives *The student will do the following:*

1. Trace the flow of solar energy.
2. Associate the First Law of Thermodynamics with the concept of energy transformation.
3. Recognize the relationships between the sun and the following: coal, wind power, hydropower and the food chain
4. Identify examples of: light and heat, potential energy and kinetic energy.

Background Information

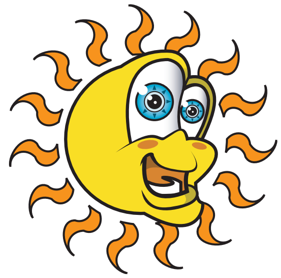
The First Law of Thermodynamics, better known as the Law of the Conservation of Energy, states that energy can neither be created nor destroyed. Energy can be changed from one form to another, but again it cannot be created or destroyed.

When we use energy, it has usually been converted from one form to another. These conversions are not 100 percent efficient; that is, at each conversion, some energy is “lost” in waste heat, friction, noise or other unusable forms. Most energy use processes include several energy transformations. With energy loss at each conversion, the energy we finally use is but a fraction of the amount of energy available at the start of the process.

The sun provides an enormous amount of energy to the earth. Almost incalculable amounts of radiant energy from the sun have reached the earth throughout its history. A small amount of the energy available to the ancient earth was captured by plants living at that time. Green plants capture light energy to perform photosynthesis, assembling energy-rich carbohydrates from carbon dioxide and water. This ancient energy, stored as chemical energy in fossil fuels, provides most of the energy powering vehicles, industries and electric generating facilities today. The energy stored by present-day green plants provides all the chemical energy necessary to maintain life on our planet. Every living thing – including human beings – depends on the solar energy stored in food.

The sun’s energy also powers the hydrologic cycle by providing the energy necessary to evaporate water from the earth's surface. We use this energy when we use electricity generated at a hydroelectric power plant.

Radiant energy from the sun also causes wind. Different air masses absorb heat at different rates. Warmer air rises and cooler air moves in, creating currents of moving air in the atmosphere. We can use the energy of wind to provide mechanical energy, and the mechanical energy may be used to provide electricity.



Procedure

I. ***Give each student a copy of each of the four student sheets (pages 184, 186, 188 and 190).***

Explain that they are to trace the flow of energy originating in the sun through each of the four energy use schemes depicted.

A. Review with the students the definitions of radiant energy, kinetic energy, and potential energy. Be sure they understand that radiant energy includes light and heat energy; kinetic energy includes mechanical energy and electricity; and potential energy includes stored chemical energy. Have them label each step as to the type of energy represented there.

B. Discuss with the students the concept of the conservation of energy and how energy transformation is related to that law. Have the students label each transformation with the types of energy that are *"lost."*

II. ***Continue with the follow-up below.***

Follow-Up

I. ***Ask the students how the efficiency of energy transformation might be maximized.***

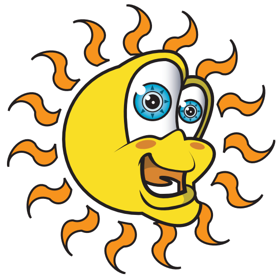
(In other words, what could we do to get the most usable energy out of our energy conversions?) Some possible answers might be the design and use of more efficient generators and machines; more uses of solar energy for lighting, heating and photoelectricity; and energy use processes that involve fewer steps from start to finish. *(If possible, discuss some of the implications of their answers.)*

II. ***Trace the flow of energy used to power an automobile.***

The energy came to the earth in the form of sunlight many millions of years ago. Ancient green algae converted the light energy into potential *(chemical)* energy through photosynthesis. The microscopic plants and the animal plankton that ate them died and sank to the bottom of the ancient seas, where they were buried by sediment and partially decayed. The resulting oil was recovered and refined, and the gasoline made from it was used to fuel the automobile. Burning the gasoline converts the chemical *(potential)* energy to kinetic energy, causing the expansion of gases in the cylinder of the engine. The expanding gases force the pistons down; the piston rods turn the crankshaft, which turns the driveshaft, turning the axle, which turns the wheels – all forms of kinetic energy.

III. ***How is energy "lost" in an automobile?***

The heat and noise given off by the engine do not contribute to the automobile's motion; this is *"wasted"* energy. Sometimes the gasoline does not burn thoroughly. If the engine needs a tune-up, for example, energy is lost by incompletely burned gasoline going out in the exhaust.

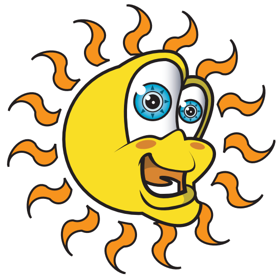


IV. *How is energy "lost" in the food chain?*

Only green plants can make use of the light energy falling on their leaves. Herbivores *(plant-eaters)* take in the energy stored in the plants, but the herbivores must use this energy to stay alive. Therefore, not all the energy herbivores take in is available to carnivores *(meat-eaters)* since some of it has been used in metabolism. In birds and mammals, much of this energy is used to maintain the animal's body temperature, and energy lost to the environment as body heat. Additionally, digestion is not a completely efficient process as animal wastes have energy content and can be used as fuel.

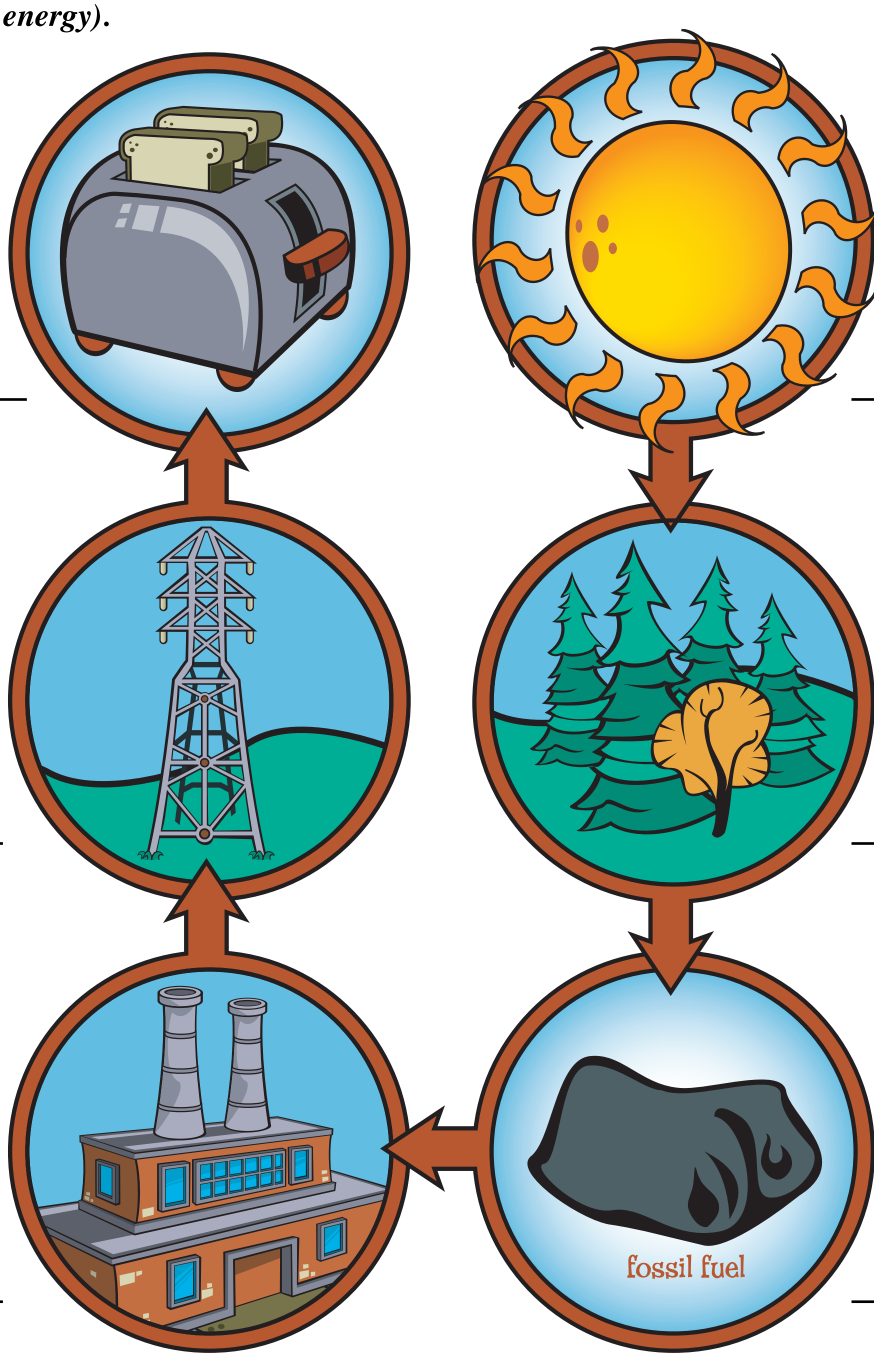
V. *Can there ever be an electricity generation and transmission system which loses no energy?*

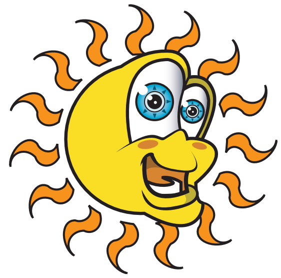
No, a 100 percent efficient system is impossible. Friction between moving parts "*steals*" energy. The energy loss in a power plant is substantial because it is difficult to capture and use waste heat energy. It is also impossible to transmit electricity at 100 percent efficiency. Resistance of the conductors in the system to the flow of electricity causes a loss of energy. *(You may want to discuss superconductors.)*



Tracing the Flow of Solar Energy

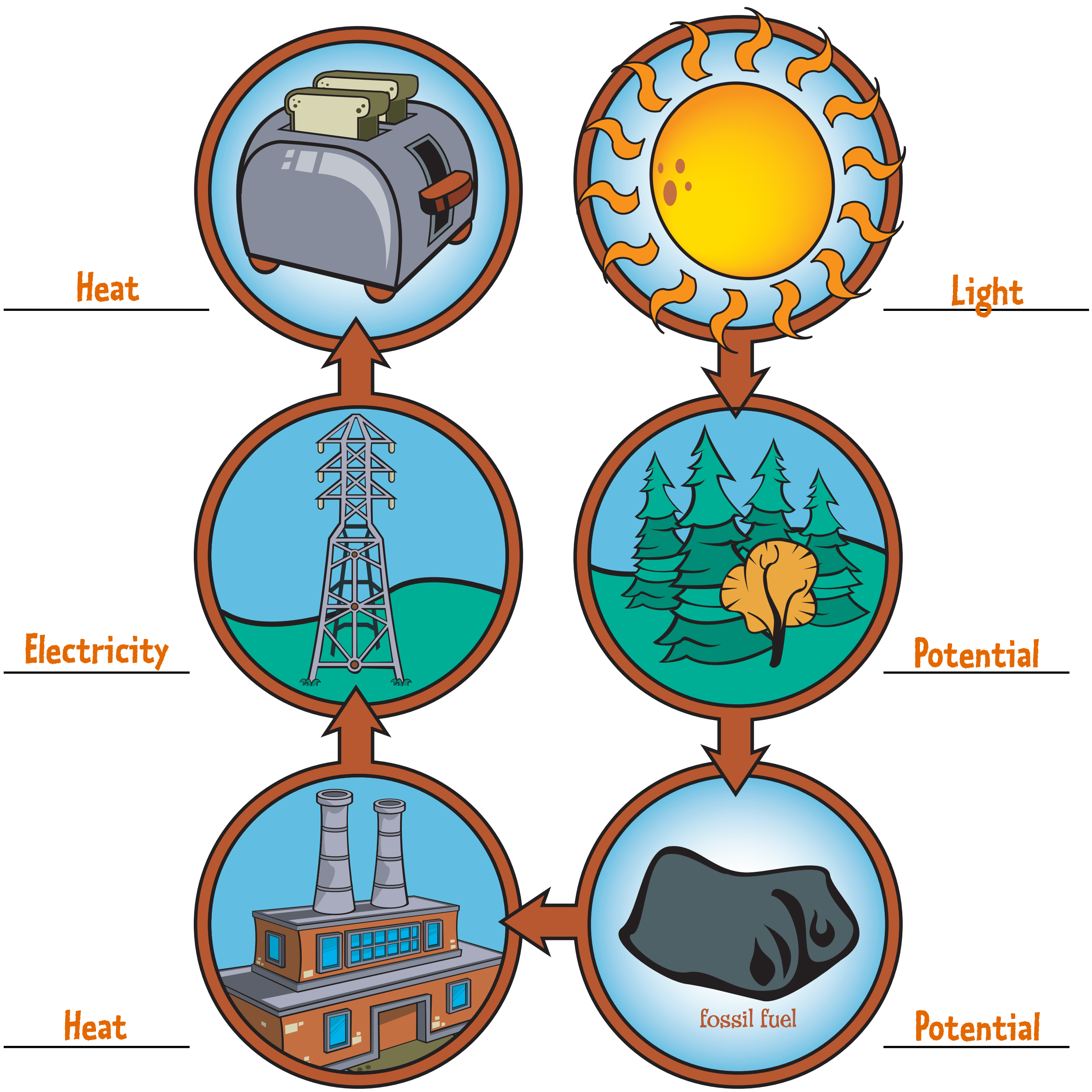
Beginning at the sun, arrows show the energy flow to each step in the process of using this energy. Indicate the energy's form in each step by filling each blank with one of the following: heat, light, kinetic (motion or mechanical) energy, potential (stored or chemical) energy, or electricity (a specific type of kinetic energy).

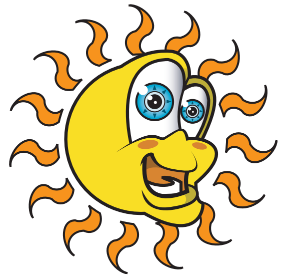




Tracing the Flow of Solar Energy

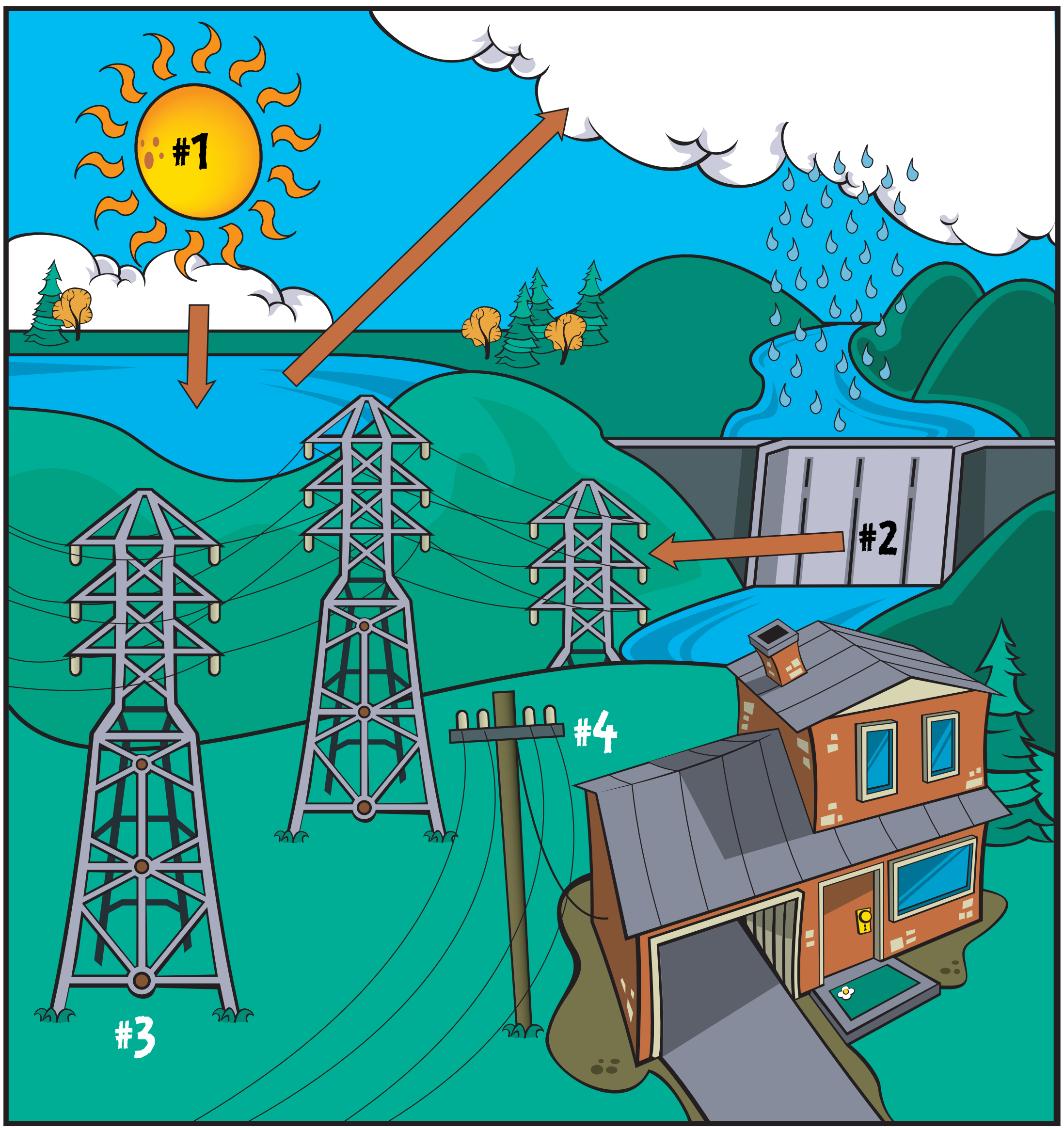
Teacher Key





Tracing the Flow of Solar Energy

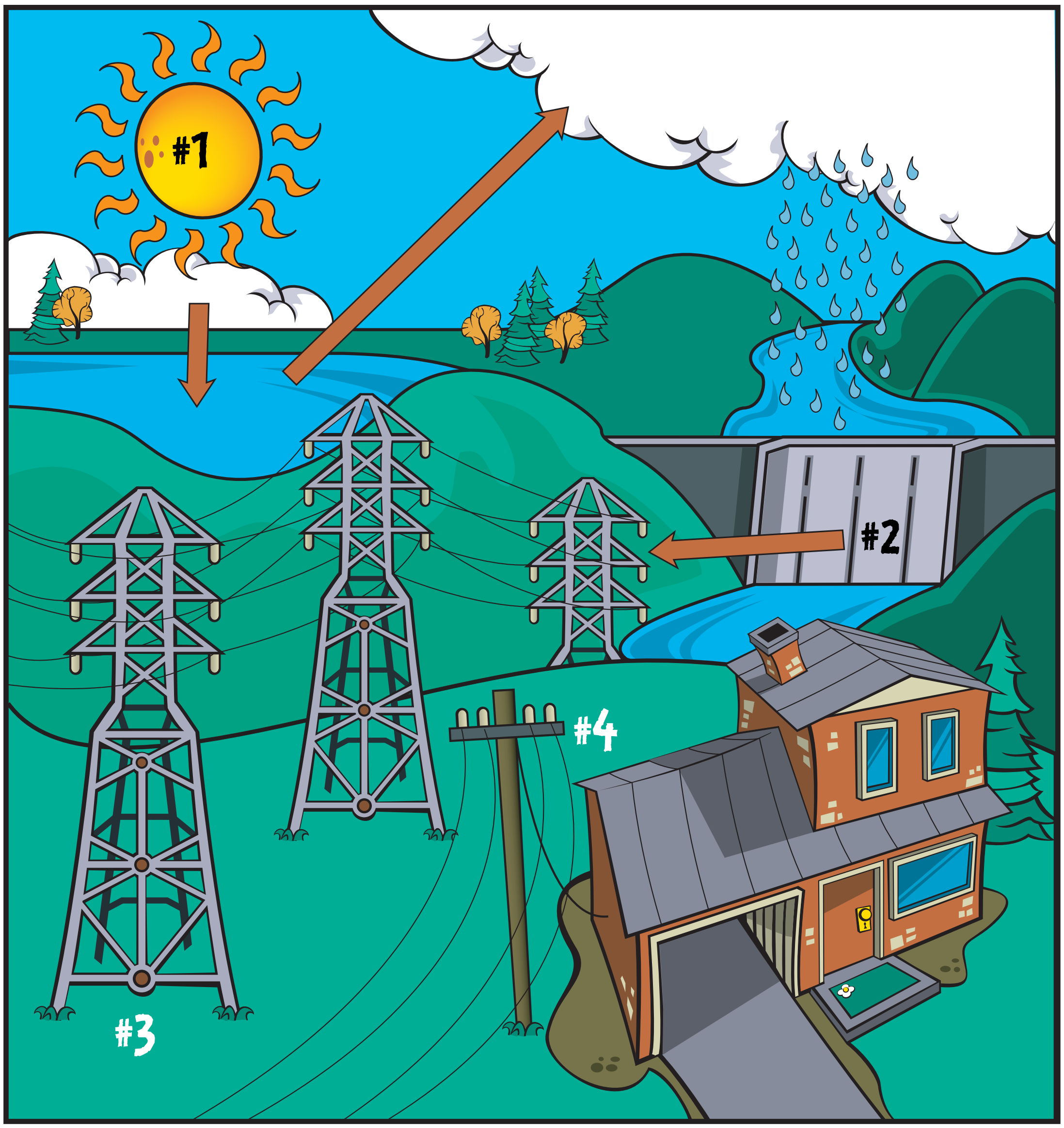
Beginning at the sun, arrows show the energy flow to each step in the process of using this energy. Indicate the energy's form in each step by filling each blank with one of the following: heat, light, kinetic (motion or mechanical) energy, potential (stored or chemical) energy, or electricity (a specific type of kinetic energy).



#1 ______________ #2 ______________ #3 ______________ #4 ______________

Tracing the Flow of Solar Energy

Teacher Key

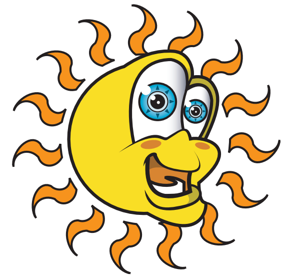


#1 Heat

#2 Potential

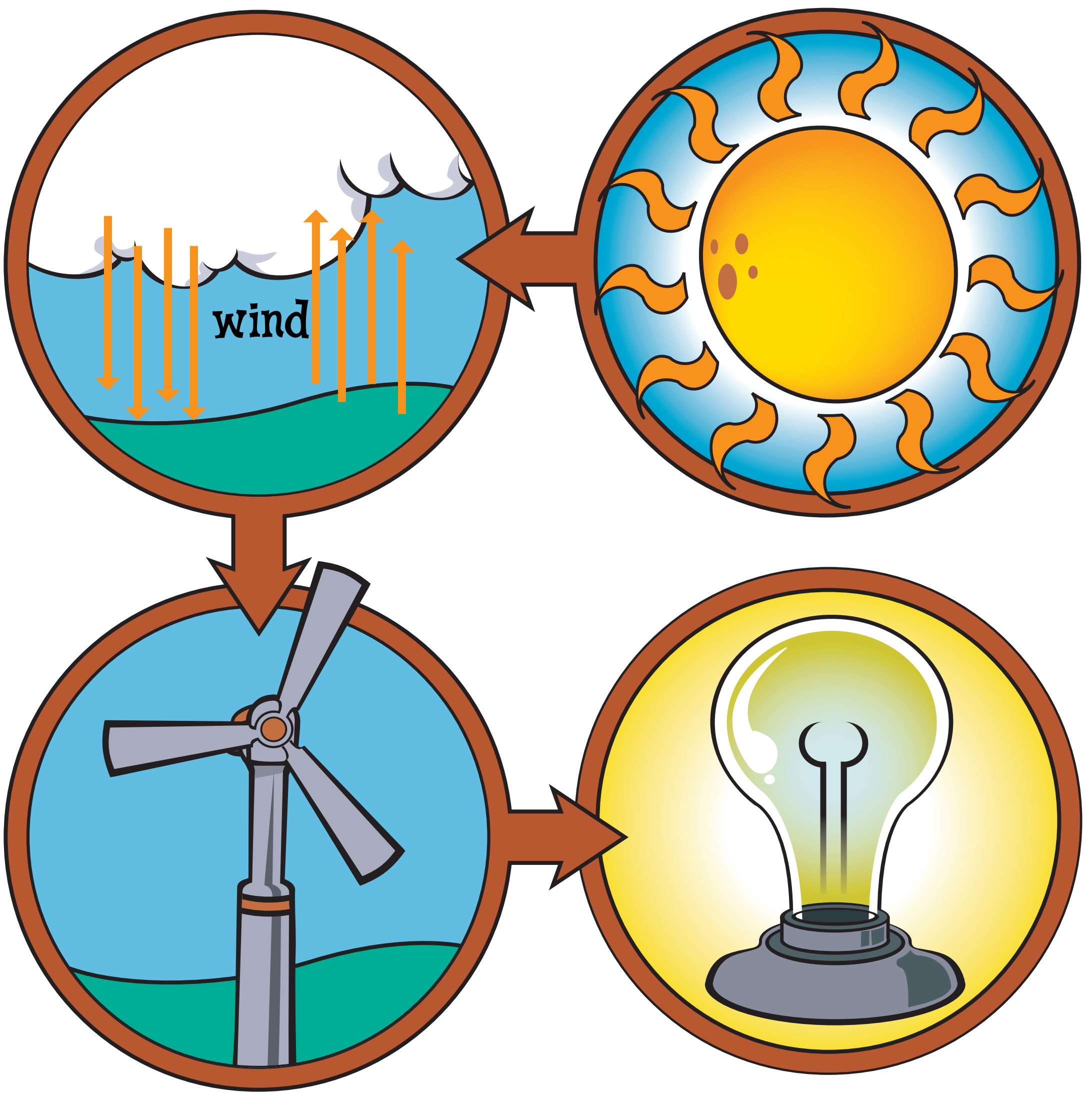
#3 Kinetic

#4 Electricity

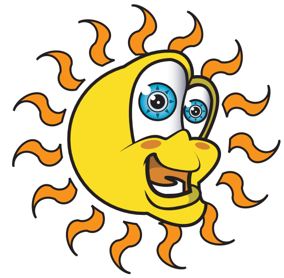


Tracing the Flow of Solar Energy

Beginning at the sun, arrows show the energy flow to each step in the process of using this energy. Indicate the energy's form in each step by filling each blank with one of the following: heat, light, kinetic (motion or mechanical) energy, potential (stored or chemical) energy, or electricity (a specific type of kinetic energy).

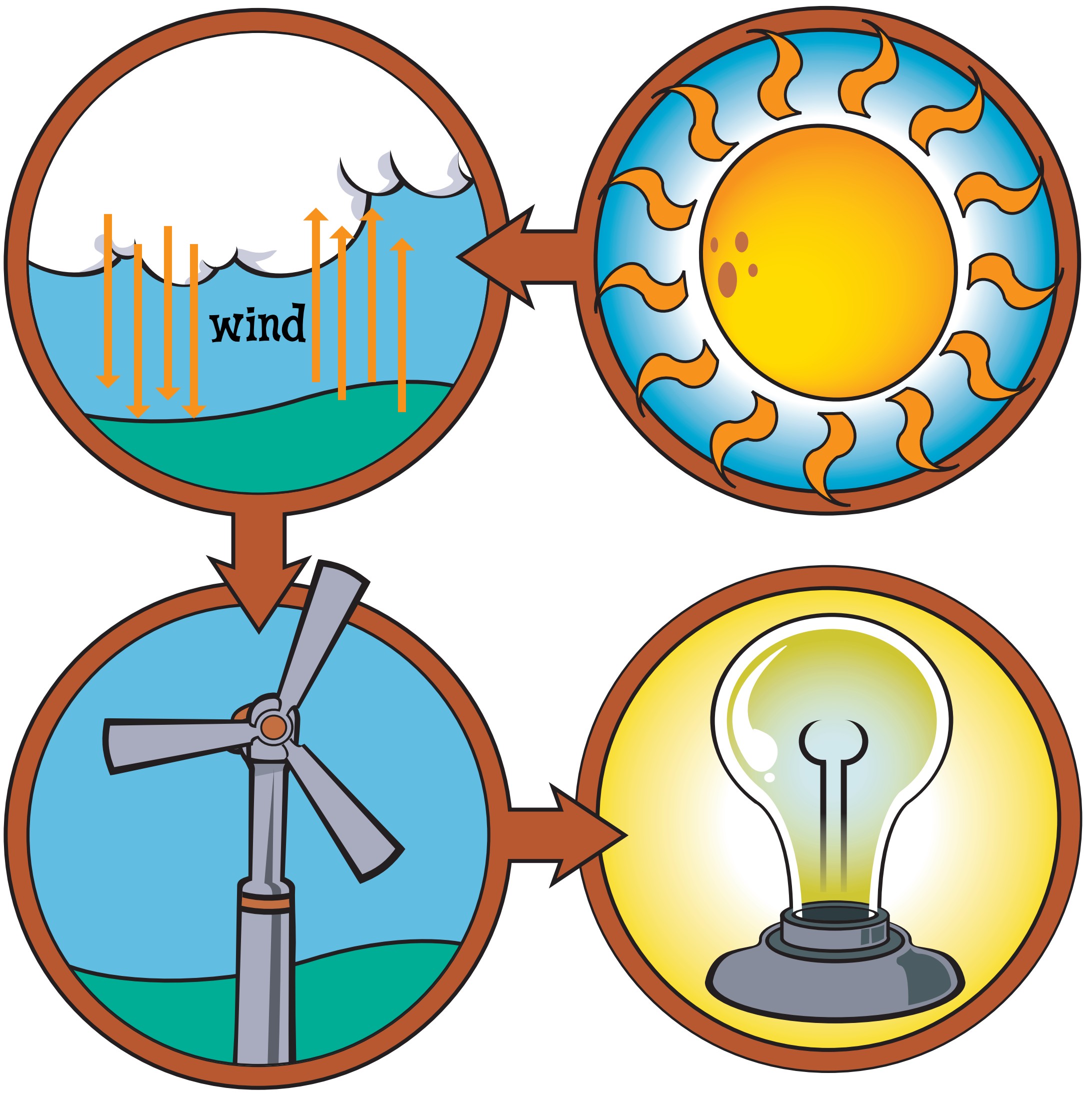


#1 ____________ #2 ____________ #3 ____________ #4 ____________

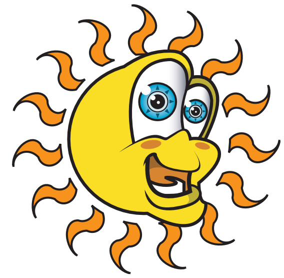


Tracing the Flow of Solar Energy

Teacher Key

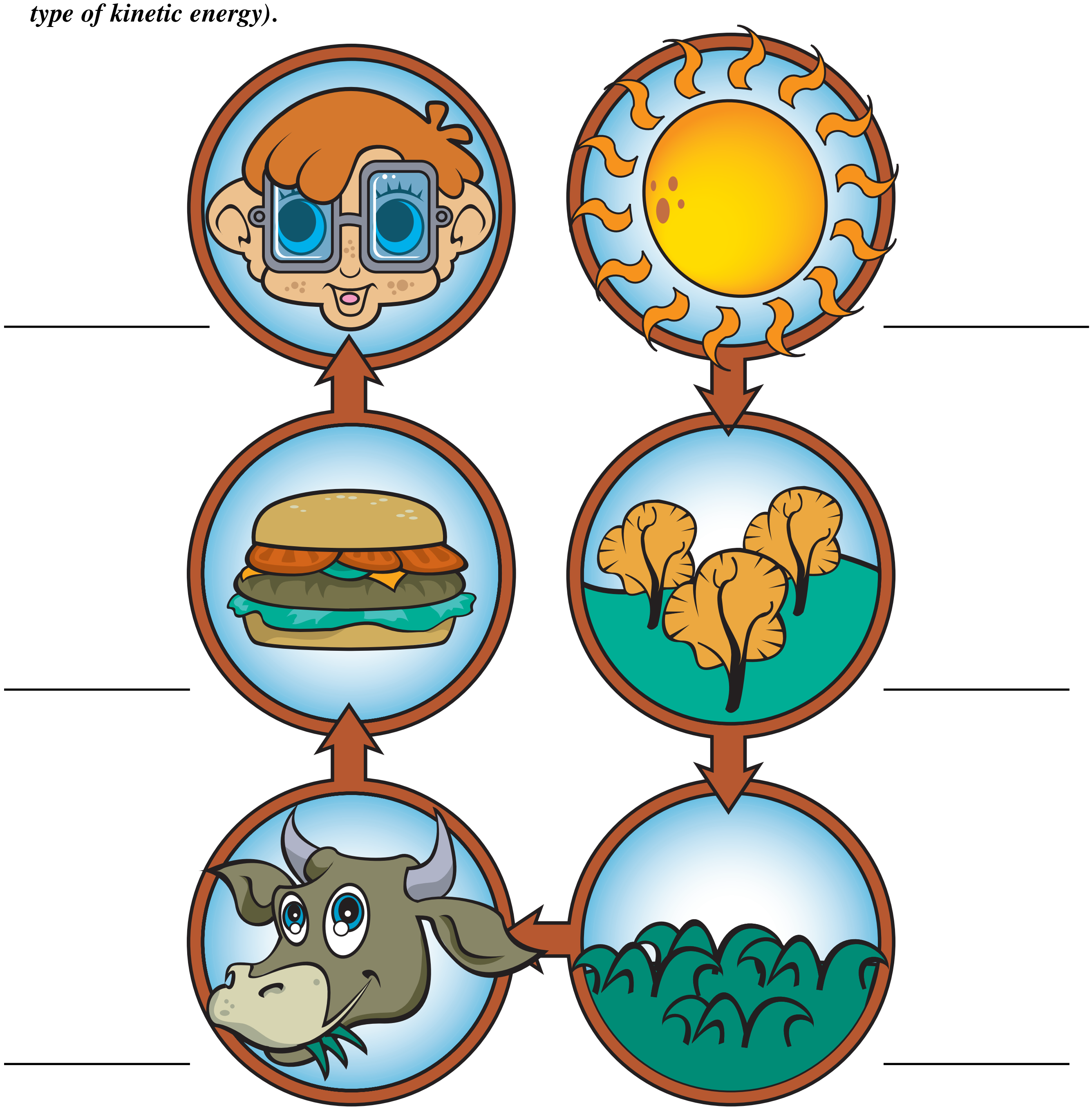


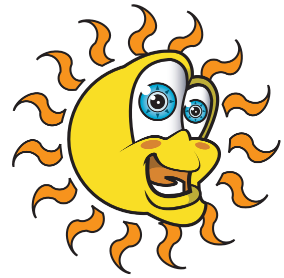
#1 Heat　　#2 Kinetic　　#3 Kinetic　　#4 Electricity



Tracing the Flow of Solar Energy

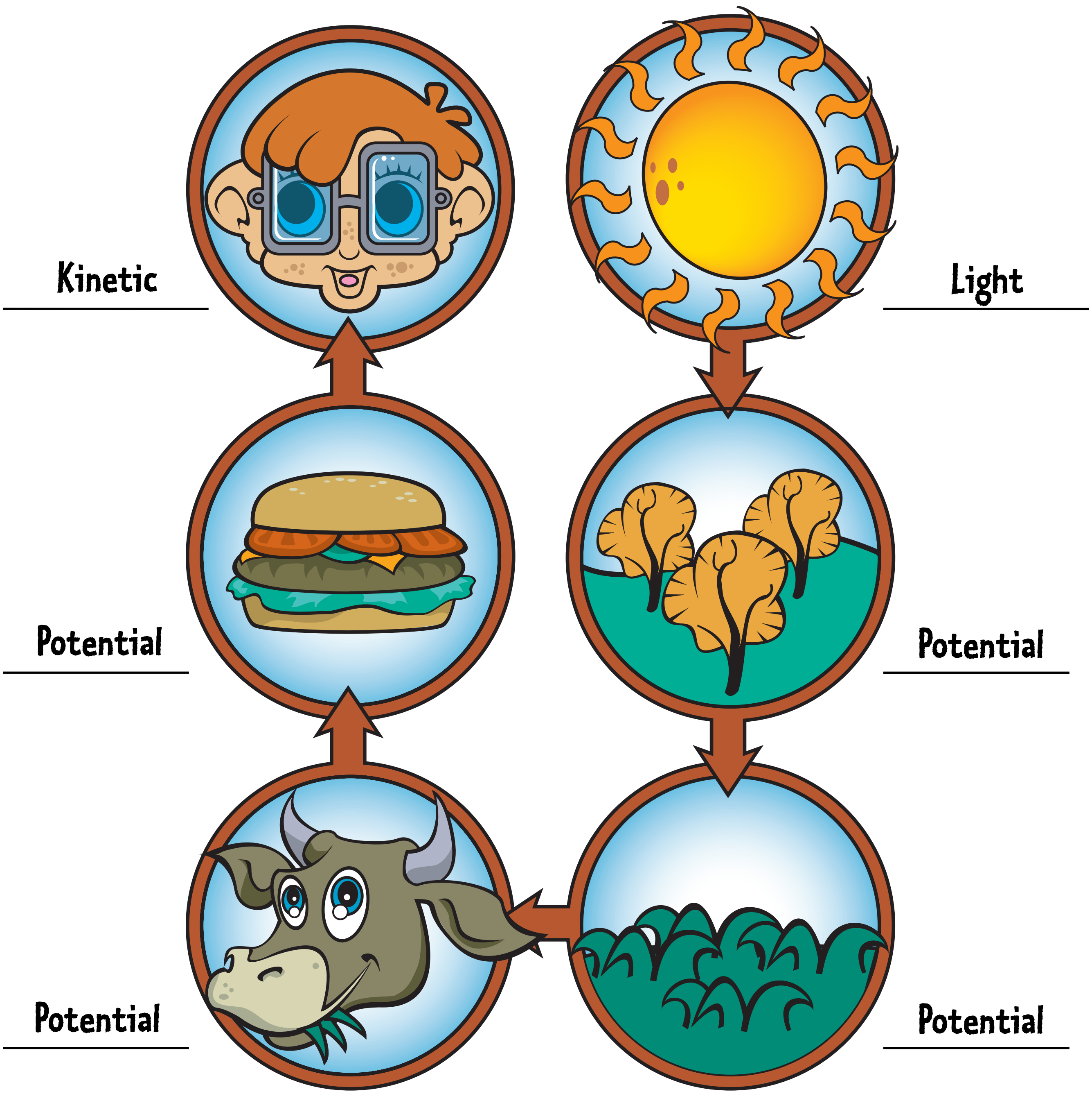
Beginning at the sun, arrows show the energy flow to each step in the process of using this energy. Indicate the energy's form in each step by filling each blank with one of the following: heat, light, kinetic (motion or mechanical) energy, potential (stored or chemical) energy, or electricity (a specific type of kinetic energy).



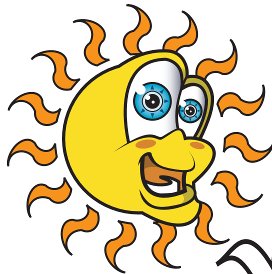


Tracing the Flow of Solar Energy

Teacher Key



PURIFYING WATER WITH SUNLIGHT



SUBJECTS: General Science, Physical Science, Outdoor Education

TIME: 2 class periods

MATERIALS: *(for each student)* clear plastic wrap, 1 drinking glass or beaker, 1 large pan or tub, muddy or salty water, a small weight, student sheet

Objectives *The student will do the following:*

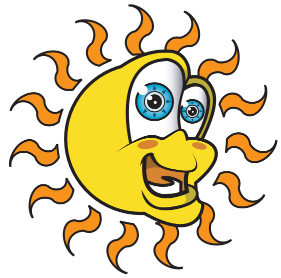
1. Build a simple solar still.
2. Distill water using the sun as the energy source.
3. Explain how using the sun as an energy source could help provide potable water and wastewater treatment.

Background Information

Heat energy from the sun is constantly evaporating water from the surface of the earth. People can make use of the sun's evaporative energy to make salty or muddy water potable. When water evaporates, the solid substances dissolved or suspended in it do not. The evaporation of salt water is a good example. The water molecules enter the vapor phase, leaving the sodium chloride behind. This is because water has a much lower boiling point than salt. If alcohol, which has a lower boiling point than water, is added to water and the mixture is heated, the alcohol will evaporate first, leaving the water behind. Most of the chemical impurities in water, however, are solids with relatively high boiling points. Bacteria will also be left behind as water evaporates. Evaporation is a process which takes place molecule by molecule; that is, individual water molecules leave the liquid phase independently of each other.

To use the sun's energy to produce potable water, we need a device for capturing and concentrating the diffuse energy of sunlight, evaporating water and condensing purified water. Such a device is called a solar still. A still is a device which captures vapor and condenses it back into the liquid phase. The condensate is said to be distilled.

A solar still's operations can be explained by the Kinetic Theory. As the water in the pan absorbs the heat energy from sunlight, the water molecules vibrate with increasing energy. In the liquid phase, molecules are free to move and to collide with one another. The heat energy of the sun is transformed into the energy of motion – kinetic energy. Some water molecules near the surface gain enough energy to leave the liquid state and enter the air as vapor. Vapor has greater kinetic energy than does liquid. When the vapor molecules strike the plastic covering, they lose energy because the plastic covering is slightly cooler than the air and vapor within the still. The energy loss causes the vapor to re-enter the liquid phase. Pulled by gravity, the water then flows down the concave plastic covering and drips into the container at the center of the still.



Procedure

I. ***Gather the materials for each student's solar still.***
Mix enough salty or muddy water for the class *(several gallons)*.

II. ***Introduce the activity by sharing the background information with the students.***
Explain that they will build simple solar stills and use them to distill salty or muddy water, making the water potable.

III. ***Distribute the student sheet and the materials needed for the solar stills.***
Supervise the students as they complete the activity.

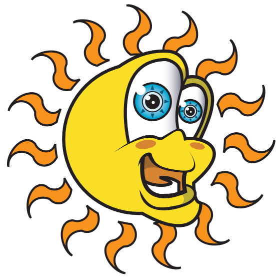
IV. ***If it is more practical to do this activity as a demonstration, you may prepare one solar still.***
Likewise, if it is not possible to put the still in the sunlight, you may place it under a lamp for a period of time *(perhaps overnight)*.

V. ***Continue with the follow-up below.***

Follow-Up

I. ***Explain how the solar still works. What was the energy source? How was the water cleaned?***
The energy for this process originated in the sun. Light passed through the plastic wrap. The light energy was changed to heat energy as it struck the water, and the heat was then trapped within the pan by the covering. The covering allows visible light to pass through but will not allow infrared energy *(heat)* to pass back through as readily. The solar still acts as a heat trap, similar to a greenhouse. The sunlight provides the energy for the evaporation of the water in the container. The water vapor travels up to the covering, where it condenses because the covering is cooler. Droplets form and gravity pulls them down the weighted covering's slope. At the lowest point, drops form and fall into the glass or beaker located under the weight.

II. ***How might you speed up the distillation process?***
Increasing the energy input will speed up the process, but it is not possible to control the sunlight itself. Therefore, we must improve our collection of the sun's energy. This might be accomplished by increasing the surface area of the water by using a larger pan. Perhaps the pan could be painted black. Some light is being reflected away from the water by the covering; it might be possible to find a less reflective covering material. Concentrating the sunlight might be possible.



III. *What areas of the world might benefit from large-scale solar-powered water purification plants?*

Places lacking fresh water but having access to sea water and abundant sunshine might someday benefit from this technology. Examples are Southern California and the Middle East.

IV. *Could a solar still be used to clean up toxic wastes in water?*

Any substance with a boiling point higher than that of water will remain behind as the water evaporates. Many substances *(particularly organic substances)* have boiling points lower than that of water. These substances often change chemically at high temperatures. Though distillation or evaporation cannot solve our wastewater treatment problems, many waste treatment plants allow the water to evaporate into the atmosphere. This reduces the volume of waste that must be disposed of. The residue is gathered and disposed of in special landfills.

V. *How could this method be used as a survival tactic in the desert where there is no surface water?*

Drinking water can be distilled from the moisture in the ground. First, a hole is dug a few feet into the ground. The hole is covered with a large sheet of plastic or waterproof tarp, and a weight is placed in the center of the covering. A container for catching the condensate is placed directly below the center. Moisture from the soil evaporates, is trapped and condenses.

Resources

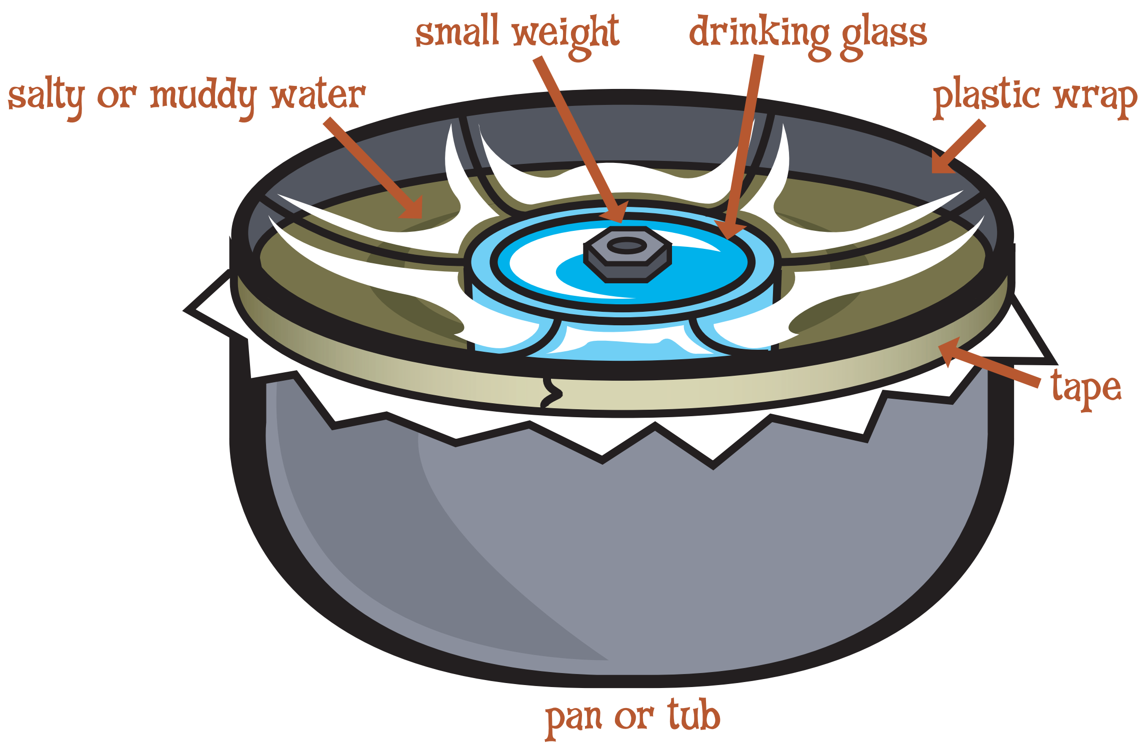
Oak Ridge Associated Universities. SCIENCE ACTIVITIES IN ENERGY: SOLAR ENERGY, N.p.: U.S. Department of Energy, reprinted 1980.

Purifying Water

Instructions

1. Fill a pan or tub to a depth of 5 cm with salty or muddy water. Place a clean drinking glass or small beaker in the center of the pan.

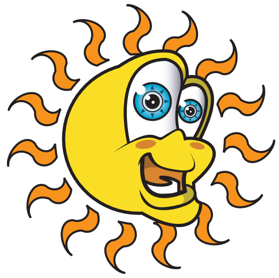
2. Cover the pan with plastic wrap. Tape all the way around the edges, forming a good seal. Place a small weight in the center of the plastic *(above the glass)*.



3. Place the solar still in direct sunlight for several hours.

4. Check the still after the time has elapsed. If you began with salty water, taste the water in the glass. If you began with muddy water, do not taste it. Just look at it; the water will be clean.

THE INFLUENCE OF COLOR ON HEAT ABSORPTION AND LOSS



SUBJECTS: General Science, Physical Science

TIME: 2 class periods

MATERIALS: *(for each group)* paint *(several colors, including white and black)*, one disposable aluminum pie pan for each color of paint, Celsius thermometer, water, clear plastic wrap, newspapers, student sheet

Objectives *The student will do the following:*

1. Compare the influence of various colors on heat absorption.
2. Compare the influence of various colors on heat loss.

Background Information

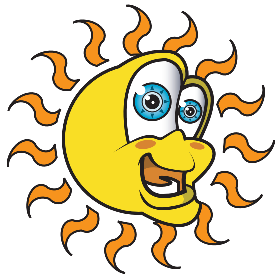
Ben Franklin did an exquisitely simple experiment on the subject of color and heat absorption. He placed a white cloth and a black cloth of the same size and same fabric on a snow bank in the sun. The snow under the black cloth melted, while that under the white cloth did not. One of the fundamental principles of solar technology is that white reflects most light and much heat, while black absorbs most light and much heat. That's why black looks black – it is reflecting almost no light back to the eye. Red absorbs all visible light except red, which it reflects. Yellow surfaces absorb all but yellow, and so on throughout the visible spectrum. This is why solar collectors have dark surfaces – to maximize heat absorption.

Procedure

I. ***Divide the class into groups of five or six students each.***
Give the groups the listed materials. Have them paint the inside of each pie pan a different color, making sure to paint one white and one black. One may be left unpainted. *(To save class time, you may want to do this ahead of time.)*

II. ***Have them follow the instructions on the student sheet (page 198).***

III. ***When both procedures are completed, continue with the follow-up.***



Follow-Up

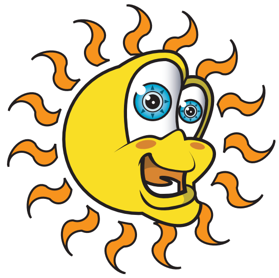
I. ***Why are the pans covered with plastic wrap?***
The covering makes the pans act as heat traps. Air is not free to circulate because, if it were, the heat collected would be *"blown away."*

II. ***Why are the pans placed on books or stacks of newspaper?***
The metal pans are very good heat conductors. Without the insulating effect of the books or newspapers, heat would be transported by the metal to the ground too quickly.

III. ***What were the results of your experiments? Why?***
Share with the students the information given in the background preceding the instructions for this activity.

IV. ***Why are solar collectors black?***
The color increases the efficiency of the solar collector as a heat trap.

V. ***Which parts of a house should be painted white or a light color?***
In the South, air conditioning costs sometime outweigh heating costs. In this case, a house with a white roof will save on the annual energy bill. Also, south-facing walls should be white or light colored.



Color and Heat

Put 500 ml of water in each pan. Measure and record the temperature of each. Cover each pan securely with clear plastic wrap. Place them on books or stacks of newspaper in direct sunlight. After 15 minutes, measure and record the temperature of each. Compute the temperature change for each pan.

Color of pan	Initial temp (°C)	Final temp (°C)	Change in temp (°C)

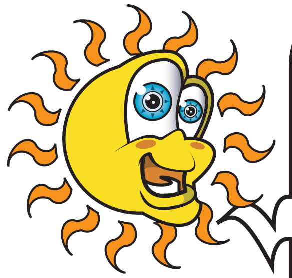
Which color gained the most heat? ______________________ the least heat? ______________________

Put 500 ml of hot water in each pan. Measure and record the temperature of each. Repeat this procedure every 5 minutes for 20 minutes. Compute the overall temperature change for each pan.

Color of pan	Temperature (°C)					Overall change in temp (°C)
	0 min	5 min	10 min	15 min	20 min	

Which color loses heat most quickly? ______________________ most slowly? ______________________

ORIENTATION OF SOLAR DEVICES



SUBJECTS: General Science, Physical Science, Industrial Arts, Environmental Science

TIME: 1 class period

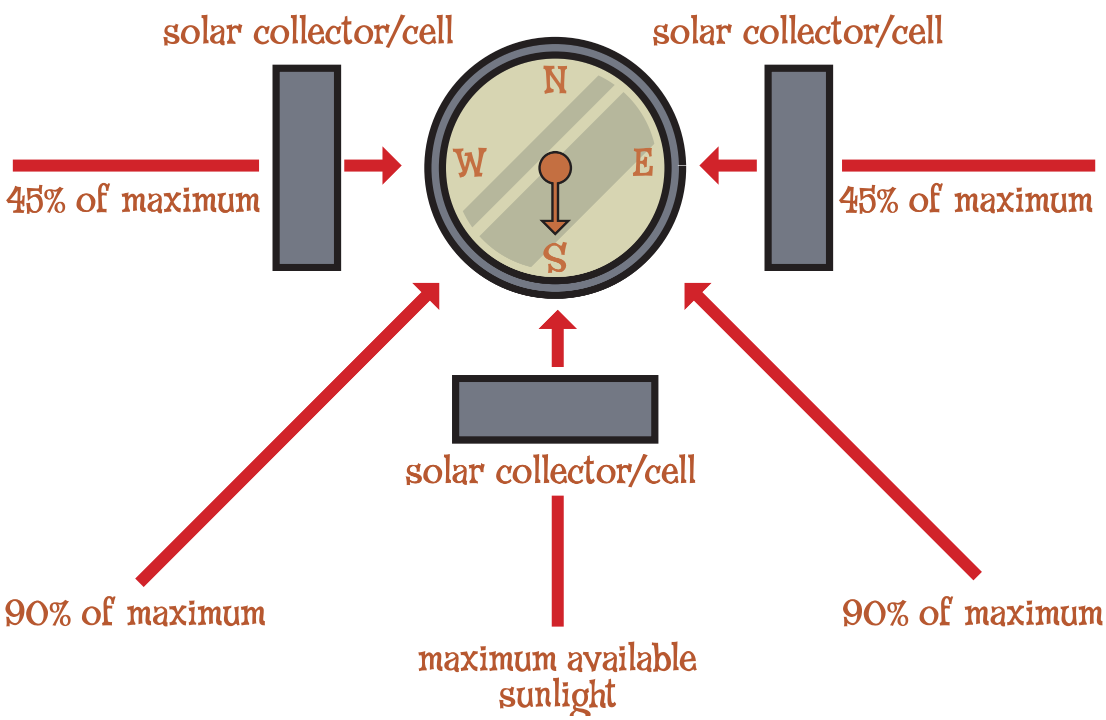
MATERIALS: compass, student sheet

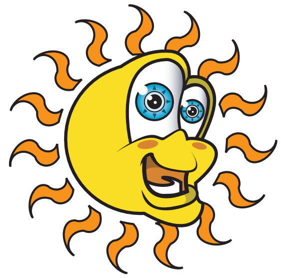
Objectives *The student will do the following:*

1. Use a compass to determine the orientation of the exterior walls of the school.
2. Determine the degree of variance of the southern-oriented wall from true south.
3. Compare the orientations of the walls to observations of the amounts of sunlight hitting them.

Background Information

The effective use of energy-saving solar devices depends upon careful selection of their locations. The collectors or cells must be oriented so that they receive the greatest possible amounts of solar energy. To receive maximum amounts of sunlight throughout the year, the southern exposure of a building and/or the solar devices should be oriented as close to true south as possible. If this orientation is not feasible, the direction may vary by up to 30 degrees east or west of south. This will result in only about a 10 percent reduction of the amount of available sunlight. Deviations greater than 30 degrees from true south may significantly affect the energy collection of the system.





Procedure

I. ***Discuss the importance of orienting solar devices or systems to maximize their energy collection.***

II. ***Demonstrate the use of the compass.***
Explain that the students will use compasses to determine the orientations of the walls of the school.

III. ***Divide the class into small groups (or pairs).***
Distribute the student sheets. Direct the students to the major exterior school walls. Have them determine the orientation of each major wall.

IV. ***Determine which wall has the southernmost exposure.***
When they determine which wall has the southernmost exposure, have them use the *"Sun Finder" (page 202)* student sheet and their compasses to determine the wall's degree of variance from true south.

V. ***Continue with the follow-up below.***

Follow-Up

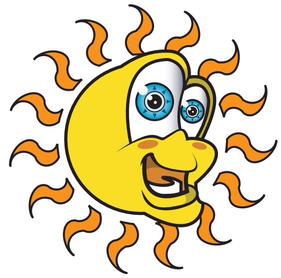
I. ***Which school walls face north? east? west? south?***

II. ***How many degrees east/west of true south is the south-facing wall?***

III. ***If variance from true south cannot exceed 30 degrees east or west without seriously affecting the ability of a solar device located there to collect energy, is the southern wall of the school a suitable place for a solar device?***

IV. ***Ask the students to compare the data collected on the orientation of the school's walls to their observations of the amounts of sunlight hitting the respective walls.***
East-facing walls are exposed to morning sunlight but shadowed in the afternoon. The opposite is true for western walls. Students may have observed that walls with a southern exposure receive sunlight for more hours of the day throughout the year.

V. ***Ask the students for ideas as to how they might be able to demonstrate that the wall whose orientation is nearest to true south receives more solar energy than other walls.***



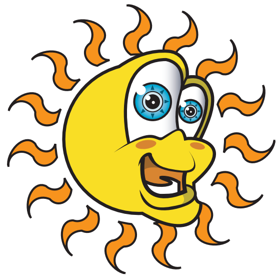
Orientation of Solar Devices

Instructions

1. Using the compass, determine the orientation of at least four walls of your school building that have different exposures. Record the directions they face in the data table.

2. Return to the wall that is the most south-facing. Use the "*Sun Finder*" handout to determine the number of degrees east or west of true south that the wall deviates. Record this data in the column called "*Degrees of Variance*."
3. Observe the exposure of each wall to sunlight at various times of the day. If this is not possible, try to recall each wall's exposure at other times of the day. Describe the amounts of sunlight.

Wall	Describe Location of Wall	Orientation of Wall	Degrees of Variance	Describe Exposure to Sunlight
1				
2				
3				
4				
other				



Sun Finder

Find the exact direction for your solar system example.

What you need

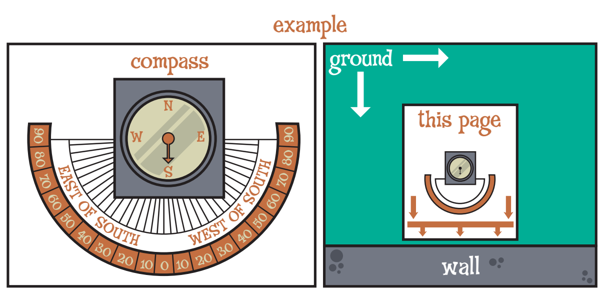
1. this page
2. compass

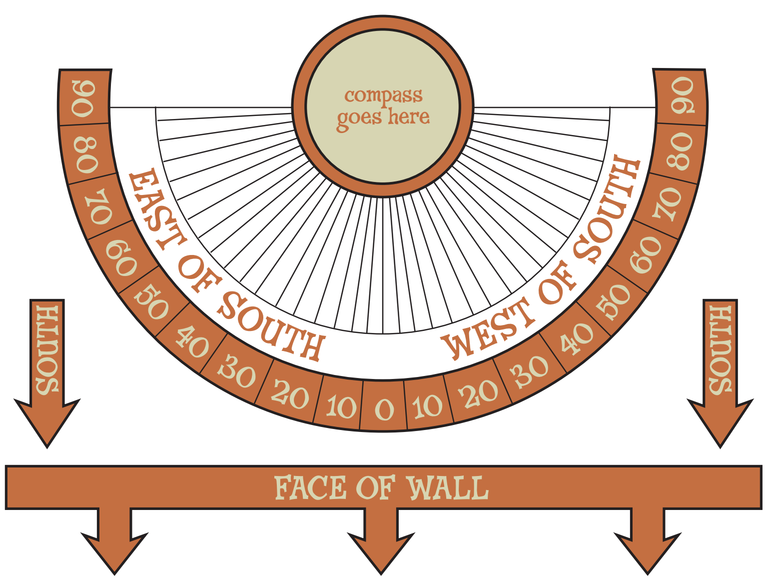
Where to Place

1. Using the compass, decide which wall faces closest to south.
2. Place the arrows at the bottom of this page against the face of the south wall.
3. Put your compass exactly in the center of the circle marked "*Compass Goes Here*."

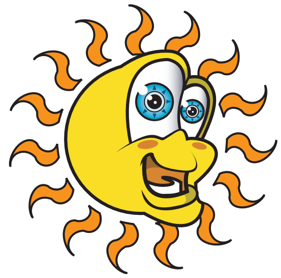
How to Use

1. The compass needle will point to an angle printed on this page.
2. This angle will be either east or west of south.
3. This will tell you how many degrees off south your wall faces.





REFERENCES



"Agricultural Feedstocks of the Future." ***Alternative Sources of Energy*** 63 *(1983)*: 58-60.

"Army Tests Methane as Helicopter Fuel." ***Aviation Week and Space Technology*** 120 *(1 6 January 1984):* 135.

Bennett, G. "Dutch Wind Power Not In Vain." ***New Scientist*** 100 *(27 October 1983)*: 268.

Blazej, A. "Processing a Vegetable Raw Material into Fuel and Organic Products: One of the Possibilities for Replacing Mineral Raw Material." ***Ropa a Uhlie*** *(Czechoslavakia) (1982)*: 385-97.

Bolton, J. R. "Solar Cells – A Technology Assessment." ***Solar Energy*** 31, no. 5 *(1983)*: 483-502.

Bungay, H. R. ***Energy: The Biomass Options.*** New York: Wiley Interscience, 1981.

DaSilva, E. J. "Biofuels and Their Generation from Biomass: An Overview." Vol. 1 of ***Fuel Gas Production from Biomass,*** D. L. Wise, ed. Boca Raton, FL: CRC Press, 1981.

Dell, R. M. "Hydrogen as a Future Alternative Fuel." ***Journal o f the Institute of Energy*** 53, no. 416 *(1980)*: 416-119.

Ehrenreich, H. "Comments on Current Photovoltaic Technology." ***Solar Cells*** *(1984)*: 45.

"Energy and Man – Yesterday, Today, and Tomorrow." ***Compressed Air*** 83 *(January 1978)*: 6-11.

Eveleigh, D. E. ***Biomass Utilization.*** New York: Plenum Press, 1983.

Ferber, R. R. "Photovoltaic Power – An Important New Energy Option." ***Mechanical Engineering*** 105 *(December 1983)* : 16-23.

Fowler, J. M. ***Energy and the Environment*** 2nd ed. New York: McGraw-Hill, 1984.

Hodgman, C. D., R. Weast and S. M. Selby. ***Handbook of Chemistry and Physics.*** Cleveland: Chemical Rubber Publishing Company, n.d.

"Hybrid Windmill Maintains Power Output in All Winds." ***Mechanical Design*** (l983) : 84.

Karol Media. *(film)* ***Search for Solutions: Trial and Error,*** n.d. *(Address: 22 Riverview Drive, Wayne, NJ 07470.)*

Kupchella, C. E. and M. C. Hyland. ***Environmental Science: Living Within the System of Nature*** 2nd ed. Boston: Allyn and Bacon, 1989.

Miller, G. T., Jr. ***Environmental Science: An Introduction*** Belmont, CA: Wadsworth, 1986.

Paul, S. "Forest Biomass and Wood Energy Systems." ***Bio-Energy Re-News*** *(1983)*: 16-25.

Pyramid Films. *(film)* ***Why Man Creates***, n.d. *(Address: Box 1048, Santa Monica, CA 90406.)*

"Small Hydropower Dam to Produce Hydrogen." ***Hydropower*** (1980): 17.

"Sunny Side Up." ***Mechanical Engineering*** 105 *(December 1983)*: 80-84.

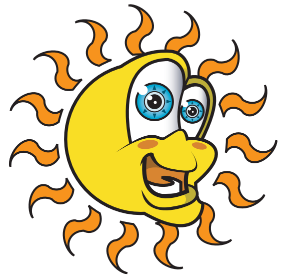
Tennessee Valley Authority. ***Waste: A Hidden Resource.*** N.p.: Author, 1988.

Trainer, F. E. "The Limitations of Alternative Energy Sources." ***Conservation and Recycling*** (1984): 27

"Wind Blows Cool." ***Nature*** 306 *(1 December 1983)*: 412.

fact sheet

ALTERNATIVE ENERGY SOURCES



We are searching for less expensive, more reliable, and less environmentally harmful energy sources. The increasing prices of conventional, heavily-used fuels; the impending depletion of domestic oil and gas reserves; the possibility of political interruption of foreign oil supplies; and increasing social and environmental concerns have led us to realize that we must not only conserve energy, but also find new ways to provide the energy we need.

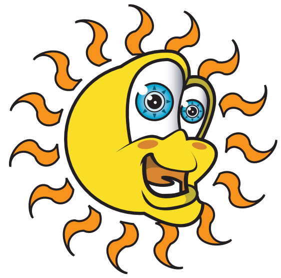
For purposes of our discussion here, all energy comes from resources classified as either renewable or nonrenewable. Renewable, or nondepletable, energy resources include the sun, wind, crops, forests and water. Nonrenewable, or depletable, energy resources include fossil fuels – coal, oil and gas. Uranium, used to fuel nuclear power systems, is also depletable.

The *"energy crisis,"* brought on by the oil embargo imposed on the United States *(U.S.)* by the Arab members of the Organization of Petroleum Exporting Countries *(OPEC),* began late in 1973. In 1974, 94 percent of all the energy used in the U.S. was from nonrenewable resources – meaning that only 6 percent was from renewable resources. During the years following, energy prices escalated, and yet, the consumption of nonrenewable energy resources continued at a high rate. In 1983, 91 percent of the energy used in the U.S. was still from nonrenewable sources – only a slight reduction from the 1974 figure! As we approached the end of the 20th century, we still relied on depletable sources for about 90 percent of our energy.

A number of renewable energy resources are being investigated as possible alternatives to traditional nonrenewable resources. The alternative energy sources that are most applicable in the Tennessee Valley are biomass, wind, and waste.

Biomass is the general term for all of the materials of organic origin – plant materials and animal wastes – from which we may obtain energy. The chemical energy stored in biomass is a form of solar energy. Plants capture solar energy through photosynthesis, converting carbon dioxide and water into higher-energy compounds, such as carbohydrates. Trees, grains and other crops, aquatic plants, and animal manures are the principal sources of biomass. These raw materials can be burned to produce heat, which may be used directly or used to drive a generator to produce electricity. Biomass can also be converted into liquid or gaseous fuels and petroleum substitutes.

Using the energy obtainable from biomass is nothing new; it is the oldest known source of fuel. People have always burned wood and other plant materials. Even today, much of the world's population depends on this simplest use of biomass to supply energy, primarily for cooking. Wood remained the chief source of energy in the Western world until the industrial revolution, when coal replaced it as the primary energy resource. Today, oil is the primary energy resource in the U.S., largely due to the use of the automobile. We still use coal



heavily; coal-fired power plants generate most of the electricity we use. Biomass can help supply fuels for residences, vehicles, industries and power plants. The use of biomass can be on a large industrial/commercial scale or a very small scale, for example, using a woodburing stove to heat one's home.

Energy from biomass is important in the Tennessee Valley and may well become even more important in the future. We have extensive and well-located sources of biomass, such as forest and agricultural lands. Major potential benefits of increased employment of biomass include the constructive use of wastes that otherwise contribute to pollution, the opportunity to improve forest productivity, and the displacement of more environmentally harmful energy sources.

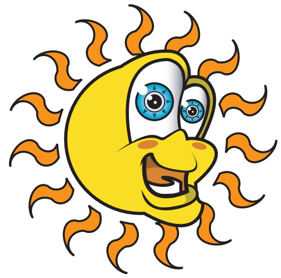
The current most popular biomass uses – wood for residential heating and alcohol fuel from grains – have some potential for environmental damage, as does the use of any energy source. Large increases in wood stove use may lead to increased air pollution and house fires resulting from their improper installation, use and maintenance. The potential problems from using more fuel from grain include increased erosion of crop lands and ecosystem displacement by expanded crop acreage. Nevertheless, if biomass resources and their conversion processes are managed properly, their use has the potential for less environmental damage than the present use of coal and oil or the proposed use of synthetic fuels derived from coal.

In the Tennessee Valley region, wood is a major biomass resource. It serves as a fuel in the form of logs and residues *(excess forest growth and insect-infested or diseased trees)*. Silvichemicals *("silvi" comes from a Latin word for "forest"),* such as turpentine and resin, and carbon-based compounds made from wood's lignin and cellulose are other energy-related wood derivatives. Wood can be used to produce a variety of chemicals such as methanol, aldehydes, ketones and acids, which can be substituted for petrochemicals as either fuels or raw materials.

Herbaceous *(nonwoody)* plants such as grasses have potential as cost-effective energy sources. These plants have a high-yield capacity and can grow on marginal lands with minimal management.

Crops such as corn, wheat, sorghum and sweet potatoes *(as well as sugar beets and sugar cane in other regions)* are processed for their carbohydrate content to make ethanol. Ethanol has many uses; it is being used as a gasoline extender now in the blended fuel called *"gasohol."* Cellulosic materials from crops such as corn and beans can be converted by liquefaction to fuel oil.

Animal manure can be used to produce methane gas by a process called anaerobic digestion *(decomposition in the absence of oxygen)*. Methane, which is the principal component of natural gas, could supply farmers with an alternative energy source for farm operations. This could result in a higher degree of energy self-sufficiency for farmers.



Elsewhere in the country, kelp and algae are potential aquatic sources of biomass. They also have potential as futuristic sources of hydrogen, which may be used as a fuel. Through a process called biophotolysis, a blue-green algae produces hydrogen as a waste product. Kelp produces hydrogen gas through photoelectrolysis, another biological process that uses the energy of sunlight.

Wind is air movement caused by the uneven heating of the earth and atmosphere by energy from the sun. Wind energy is an indirect form of solar energy.

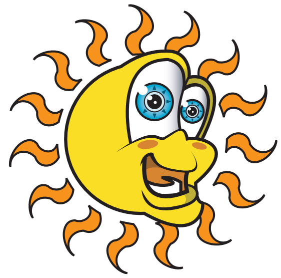
For centuries wind power has been used to supply energy for mechanical tasks throughout the world. Widespread use of windmills in the U.S. began in the 1850s. In the early 1900s, windmills were used to produce electricity on farms and in other rural locations. In 1935, the creation of the Rural Electrification Administration *(REA)* brought a cheap, reliable, centrally-produced supply of electricity to rural areas and windmills began to disappear. The dramatic increases in the costs of conventional energy sources in the 1970s, however, caused us to again consider wind power as a possible energy alternative.

In some regions of the country – the Plains States, sea coasts, and some mountain passes, for example – wind is a viable alternative energy option. In the Valley region, its potential as a significant energy source is limited to a few locations where the wind is consistently strong enough to be useful. In our society, we have relatively few needs that could be met with the mechanical energy provided by windmills, but windmills could effectively generate electricity in some locations.

The use of wind-powered energy production systems has several advantages over centralized fossil fuel or nuclear systems. Wind is abundant, free, powerful and clean; it displaces nonrenewable and/or imported fuels and increases the self-sufficiency of its user. The disadvantages of wind energy systems include possible safety hazards, a lack of constancy, the high initial investment in wind machinery and energy storage systems, and the difficulty of storing the power.

Waste materials can also be used as a source of energy. Our lifestyles, often characterized as *"throwaway"* lifestyles, are marked by a high degree of consumption of one-use products. This – along with the degree to which most of these products are packaged – has caused a tremendous increase in the amounts of waste generated in every community. Waste disposal now represents a major problem. . The use of wastes for energy may help solve disposal problems, as well as helping meet our energy needs.

Much of our waste is combustible and could be burned as fuel. Burning waste provides heat to produce steam for heating buildings, powering industries, or generating electricity. Waste materials may also be used to produce methane. The anaerobic decomposition that takes place spontaneously in landfills produces methane that can be collected and used to heat homes or other buildings.

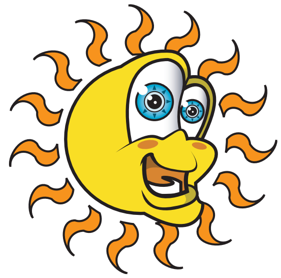


Using waste for fuel or as a source of fuel is not a panacea for our energy supply or waste disposal problems. Incinerating waste produces air pollutants which are not only damaging environmentally, but are also expensive and difficult to control. The ash left must still be disposed of somehow. Burying waste in landfills requires valuable land space and can threaten groundwater resources. Reducing the amounts of waste we generate and recycling are ultimately more desirable than burning waste, but gaining useful energy from waste we have already accumulated is an attractive, feasible option.

Alternative energy sources – renewable, dependable, domestically available, and less environmentally detrimental than the energy sources on which we now rely – offer us opportunities we cannot afford to pass up. Research and development of alternative energy technologies and resources are essential, and must be increased; it takes many years for new alternatives to become practical and economical. We must continue to search for alternatives.

fact sheet

SOLAR ENERGY



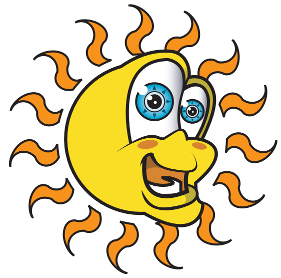
Almost all of the earth's energy originates in the sun. Through photosynthesis, the sun's radiant energy is converted to chemical energy by green plants. This chemical energy – the food value in plants – forms the basis of every food chain. The sun's energy not only supports life, but solar energy that reached the earth long ago powers our cars and cities in the form of fossil fuels. In addition, the sun's heat drives the wind and water cycles. Obviously, we are absolutely dependent on this source of constant, readily available energy; however, solar energy is diffuse and cannot be controlled by human measures. Capturing solar energy and converting it to a usable form is one of the major technological challenges of our time.

Solar energy, unlike the resources currently providing most of our energy, has the tremendous advantage of being renewable. It is a source of **free** fuel for billions of years to come. Solar energy has a great advantage over fossil fuels in that it causes no air pollution. Unlike nuclear power, solar energy produces no dangerous wastes. Solar energy does not have to be mined. Sunlight is available everywhere on earth. Admittedly, there are some disadvantages in the use of solar energy, as there are with all energy resources. Solar energy technologies often require large initial investments. The availability and strength of sunlight differs at various locations, and we have no control over weather factors which affect the use of solar energy. Perhaps the major drawback is that sunlight is not available at night when heating needs are greatest.

We we are researching and developing new technologies to make use of this important resource although using solar energy is not a new idea. Humans have always used the sun's warmth and light. Throughout history civilizations have not only made direct use of the sun's energy but also have used it indirectly by using wind power in sails and windmills, hydropower technologies like waterwheels, and biomass fuels. The sun's energy has played an important role in human history. Early people dried animal pelts and food in the sunlight. Greeks designed passive solar homes in response to shortages of wood for heating. Solar energy heated water in Roman public baths. Solar water heaters, stills and other devices have long contributed to human well-being. Our use of the sun's vast supplies of energy has taken many forms and has been of varying relative importance among other energy resources. As new ways to conserve energy and new alternative technologies are sought, solar power technologies can only become more important.

There are two basic kinds of solar technology – active and passive. An active solar energy system is one which captures the energy and transports it to be used somewhere else; active systems have mechanical parts. A solar water heater is an example of an active energy system. The water is heated by the sun, then goes to another area of the house for use. Passive solar systems are heat traps. For example, buildings or rooms are designed to function as passive solar energy systems by capturing the sun's heat. A greenhouse is an example. Passive systems generally do not have moving parts.

There are numerous methods of collecting solar energy for active use. Flat-plate collectors are the most common devices for heating water. These are the flat, dark, glass-covered boxes seen on roofs and in backyards. A flat-plate collector box acts as a heat trap. Heated water leaves the collector and is transferred to a storage tank or to a conventional water heater. The heated water can be used for such normal household purposes as bathing. In some systems, the water is used to heat the house and is stored in tanks in the basement until its heat is needed.



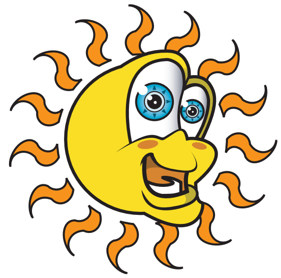
Solar *(photovoltaic)* cells, the electronic devices which convert light directly into electricity, are a special kind of active solar energy technology. They are commonly used in hand-held calculators. The wing-like structures on artificial satellites are panels of solar cells. In space, where there are neither clouds nor day/night cycles, solar cells provide an endless supply of electricity and are very efficient. A solar-powered ultra-light airplane, the Gossamer Penguin, has been successfully flown. Some solar electric cars have been built; General Motor Company's Sunraycer won a solar-powered auto race in Australia and toured the Eastern United States in the 1990s.

Although solar energy itself is "*free*," the present cost of arrays of solar cells large enough to provide power for a household is prohibitive, as is the cost of providing a solar electric-powered house with the necessary storage batteries. Nevertheless, the cost of solar cells has fallen about 90 percent in the last 10 years, making solar-produced electricity much more attractive. At the present time, the small solar cells available from scientific or electronic supply houses or catalogs may be used effectively for a variety of small-scale uses. Such uses include powering communication devices such as telephones, radios, and televisions. This is particularly important in developing countries.

Current uses of the sun's energy for producing large amounts of electricity require employing a modification of steam generation rather than photovoltaic cells. A solar furnace uses sunlight concentrated by mirrors to boil water and produce electricity from steam-powered turbogenerators. A huge array of mirrors on a slope focuses sunlight on the furnace's boiler. Solar furnaces are currently producing electricity in France and Arizona. A solar power tower is a variation of the solar furnace. A tower serves as the focal point for a circular array of mirrors on level ground around the tower. Water is heated to steam within the tower and electricity is produced by a turbogenerator. These kinds of generating facilities are most practical for desert areas because of the amount of groundspace they require, as well as the availability of maximum amounts of sunlight.

Passive solar technologies trap the sun's heat and employ only the properties of heated air or water in the energy's storage and use; mechanical devices do not assist in these processes. Passive solar building design, for example, has features which maximize solar heat gain in winter and minimize it in summer. The orientation of windows, the use of shading devices, and landscaping around the building may all play a part. Special features such as thermal masses *(e.g., brick or concrete walls or floors)* which absorb heat and release it slowly, greenhouses and Trombe walls may be included in passive solar designs. Trombe walls are hollow, vented, south-facing exterior walls which act as solar collectors. Air inside them heats up, rises, and exits through vents at the top of the wall to circulate through the room, drawing cool air into the vents at the bottom of the wall. Passive systems are generally considered energy conservation measures.

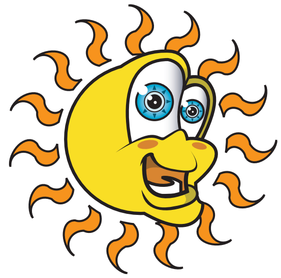
The passive use of solar energy can be done on a very small scale. One example is solar ovens. They are easy to build and use free fuel. Parabolic reflectors are commercially available and are designed to focus the sun's rays on a small area; used with a grill or spit, they make it possible to cook meat as well as other foods with



solar energy. While cooking with such ovens is not always practical, the use of solar ovens to dry food can be very convenient. Solar energy can be used to prepare some foods without using a solar cooker or dehydrator. Making *"sun tea"* is a popular method of preparing iced tea; the heat of the sun is trapped inside the closed jar, and tea is brewed slowly as the water heats up.

Our current standard of living requires an inexpensive, dependable supply of energy. Conventional energy resources may not always be available or affordable. The price of fossil fuels will increase as supplies dwindle; nuclear power is stymied by regulation and adverse environmental effects; and hydroelectric power is available only in certain areas. The sun is a source of environmentally safe, readily available, free energy. Although solar energy cannot totally replace conventional sources, it can help lessen our dependence on nonrenewable fuels (*foreign and domestic)*, while giving us more individual independence and direct control in meeting our energy needs.

GLOSSARY



alcohols: a class of compounds containing a hydrocarbon group and one or more hydroxyl (*OH*) groups; important in many different usages, including use as clean-burning, renewable fuels.

anaerobic digestion: the process by which microorganisms decompose organic material in the absence of oxygen; for example, in landfills bacteria break down wastes buried there; one product is methane.

anemometer: a device that measures wind speed or force.

bioconversion: the changing of materials or energy from one form to another by the action of living things.

biomass: a general term for plant materials (*in any form, from algae to wood*) and animal waste materials; important as an alternative energy resource.

biophotolysis: a process by which plants use light energy to break down compounds; a possible futuristic use of solar energy to produce hydrogen for use as a fuel.

British thermal unit (Btu): unit measuring heat energy; the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit.

calorie: the unit of energy used to express quantities of heat; when spelled with a lower case "*c*," refers to the amount of heat needed to raise the temperature of one gram of water one degree Celsius at one atmosphere pressure; when spelled with a capital "*C*," it means 1,000 calories or one kilocalorie *(food energy content in nutrition is always expressed in Calories)*.

convert: to change from one form to another; to transform.

depletable: describes resources that may be used up or exhausted.

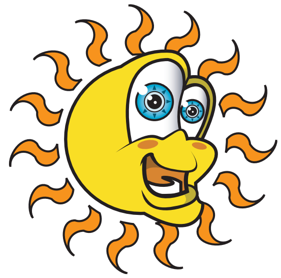
derivative: something taken from another source; not original in form; an extract of something.

digester: a device in which microorganisms produce methane from organic wastes.

distill: to separate substances from the mixture or material in which they are found by vaporization and condensation.

distillate: a liquid substance separated from another substance by vaporization and condensation.

distillation: the process by which a substance is vaporized, condensed, and then collected as a liquid.



dri-gas: a term for a group of manufactured products, which, when added to gasoline, claim to remove water; most of these products contain a high percentage of alcohol.

end-use: the final form in which energy is used directly for work, such as heating or other purposes.

environment: the physical and biological surroundings of an organism.

ethanol: an alcohol having the formula C_2H_5OH *(structurally* CH_3CH_2OH*);* formed by the fermentation or decomposition of sugars or starches; widely used in many products, alcoholic beverages, medicines, and gasohol; also known as ethyl or grain alcohol.

feasible: capable of being done or carried out.

fermentation: a process by which complex organic compounds are broken down into simpler compounds; especially, the production of alcohol from sugar by yeast.

fossil fuel: a hydrocarbon fuel formed from the remains of ancient plants and animals; coal, oil, and/or natural gas.

garbage: refuse consisting of food wastes.

gasohol: a mixture of 90 percent gasoline and 10 percent ethanol.

geothermal: describes heat energy from within the earth.

grain alcohol: ethanol produced from the fermentation of grain.

hydrocarbons: a large class of chemical compounds containing only hydrogen and carbon.

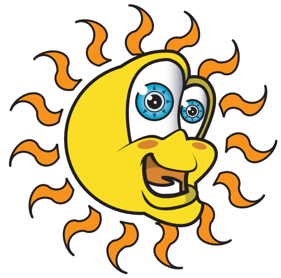
hydroelectricity: electricity produced by generators powered by the energy of falling water.

incineration: controlled high-temperature burning of wastes.

intermittent: describes something that stops and starts again from time to time.

landfill: a place where community waste is layered and buried under shallow layers of soil.

leeward: describes the side of an object that is opposite the side against which the wind blows; that is, the side sheltered from the wind; see *windward*.



liquefaction: a chemical process by which solid or gaseous materials are converted to liquids.

magnetohydrodynamics (MHD): the study of electricity-conducting fluids in electric or magnetic fields; magnetohydrodynamic generation is a proposed technology for burning coal more cleanly and efficiently.

methane: a colorless, odorless, flammable, gaseous hydrocarbon that is a product of the anaerobic decomposition of organic matter; can be burned as a fuel.

methanol: an alcohol having the formula CH_3OH; can be formed by the destructive distillation of wood; also known as methyl or wood alcohol; used in a variety of products such as antifreeze, solvents and cleaners and fuel.

nondepletable: describes resources that cannot be used up or exhausted.

nonrenewable: describes resources that cannot be restored, replenished, regrown, or replaced once they are used.

organic: describes chemical compounds based on the element carbon; most of the substances making up and produced by living things are organic compounds, used to mean any material from a living or once-living source.

paraffin: a waxy, solid hydrocarbon mixture produced as a by-product in the refining of oil; used to make candles, lubricants, sealants, and other products.

petrochemicals: chemicals derived from petroleum or natural gas.

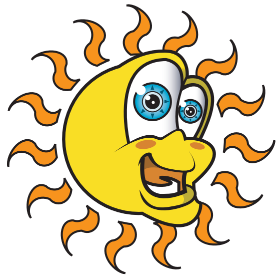
photochemical: describes chemical reactions produced by the radiant energy of light.

photoelectrolysis: a process using the radiant energy of light – as opposed to electrical energy – to produce a chemical change *(particularly decomposition)* in certain kinds of substances; a possible futuristic use of solar energy to produce hydrogen for use as a fuel.

production (of energy): a term used to indicate the amount of fuel made available for use during a specified time.

renewable: describes resources that may be restored, replenished, regrown or replaced as they are used.

reserves: identified deposits of a fuel or mineral that are profitably obtainable under present conditions, using current technology, and that are likely to be so in the future.



throw-away lifestyle: a way of living characterized by a high level of product consumption and discarding, especially if the products are designed for one-time usage.

tidal power: electricity produced by generators powered by the regular rising and falling of ocean water levels along coastal areas.

trash: a term used for wastes that do not include food wastes but may include other organic materials, such as plant trimmings.

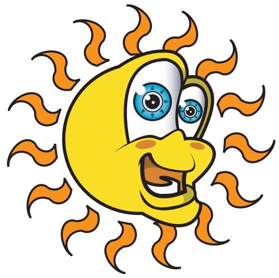
viable: workable; practicable.

waste: anything that is discarded, useless, or unwanted.

wind power: electricity produced by generators powered by the energy of moving air.

windward: of or on the side *(of an object)* that faces the wind; see *leeward*.

EDUCATORS' WEB SITES



Alliance to Save Energy Lesson Plans
URL: http://www.ase.org/educators/lessons/

Ask ERIC Lesson Plans
URL: http://www.askeric.org/Virtual/Lessons/

CEC Lesson Plans
URL: http://www.col-ed.org/cur/

Connections t-Science: Solar Energy
URL: http://www.mcrel.org/resources/plus/science/solar.asp

ENC: Web Links: Student/Classroom: Lesson...
URL: http://www.enc.org/weblinks/classroom/lessonplans/science...

Earth's Energy System
URL: http://www.wested.org./werc/earthsystems/energy/lpenergy.html

Education – Alternative Energy Sources
URL: http://www.leeric.lsu.edu/educat/lesson3.htm

Environmental Education Lesson Plans
URL: http://tess.uis.edu/www/environmentaled/framelinks/LESSON...

The Lesson Plans Page
URL: http://www.lessonplanspage.com/

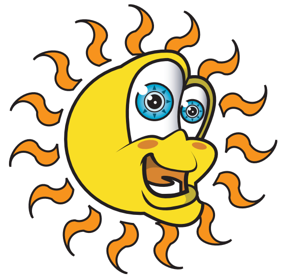
Lesson Plans and Other Links
URL: http://www.mcps.k12.md.us/departments/sert/lesson-plans.htm

Oregon Solwest Renewable Energy LINKS
URL: http://www.solwest.org/links.htm

Pro Teacher! Physical Science lesson plans...
URL: http://www.proteacher.com/110015.shtml

RReDC Kidzlinks
URL: http://rredc.nrel.gov/kidzlinks.html

Renewable Energy Education Framework
URL: http://www.solarnow.org/renenergyfr.htm



Renewable Energy Lesson Plans
URL: http://www.infinitepower.org/lessonplans.htm

STEDII FMP Lesson Plans
URL: http://nesen.unl.edu/stedii/fmpplans.html

SOLAR Center Lesson Plans
URL: http://solar-center.stanford.edu/teachers/lessons.html

Teacher's Room
URL: http://whyfiles.org/004antarctic/teacher4/index.html

Using Solar Energy
URL: http://www.eecs.umich.edu/~coalitn/sciedoutreach/funexperime...

What Can I Do?
URL: http://www.infinitepower.org/whatcanido.htm