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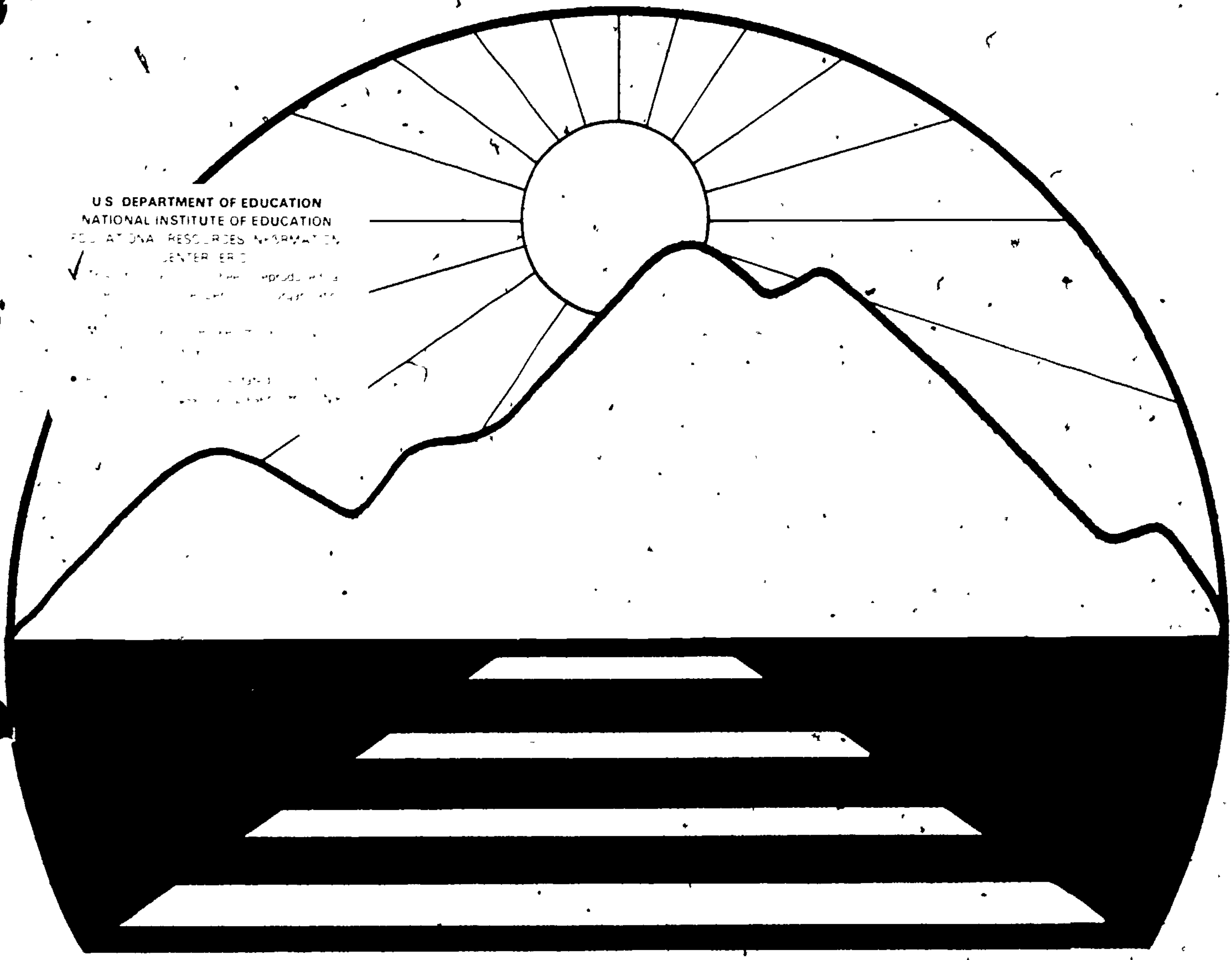
ABSTRACT

Following an introduction to solar technology which reviews solar heating and cooling, passive solar systems (direct gain systems, thermal storage walls, sun spaces, roof ponds, and convection loops), active solar systems, solar electricity (photovoltaic and solar thermal conversion systems), wind energy, and biomass, activities to introduce solar energy into the elementary school curriculum are presented in four sections: (1) sun and seasons - an introduction to properties of sunlight and relationship of sun and earth; (2) role of solar energy and conservation, how solar energy fits into the energy mix, and importance of conservation; (3) solar experiments, designed to foster an understanding of solar energy, its collection, and use; and (4) wind experiments. Each activity includes context (grade level and subject area), time required, overview, materials needed, advanced preparation, student outcomes, and extension activities. A selected list of resources, glossary of key vocabulary words, and student questionnaire for evaluating the activities are included. (JN)

SOLAR SPOTS



ACTIVITIES TO INTRODUCE SOLAR ENERGY INTO THE K-8 CURRICULA

Energy Administration
Michigan Department of Commerce

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As the name "Solar Spots" implies, this packet is a series of activities designed to help teachers infuse the study of solar energy into the existing curriculum. While many of the activities can be used alone, we urge you to use them as a supplement to further a total understanding of the sun and the wind.

By providing you with these solar energy activities, we have attempted to help introduce the concepts of solar energy into the classroom at an early age. We feel an understanding of four general objectives is a desirable outcome of this packet:

1. Solar energy is not a new "exotic" energy source; in fact, it is the basis of all life and energy on earth and has been used for centuries.

2. Solar energy is not <u>the</u> answer but it can make a great contribution to meeting our energy needs; no one energy source will return us to the days of cheap, abundant fuel and a diversification of our energy portfolio is necessary.

3. A strong conservation ethic and plan is a prerequisite to the efficient use of solar energy and any other energy source.

4. We are in an unprecedented state of energy transition. Reserves of fossil fuels are becoming dangerously low. The availability of fuel is inversely related to price; that is to say, as energy is less available (i.e, decreases), price increases. The question remains: How much of our disposable income can we devote to energy production, and consequently take away from other activities? Nonrenewable fossil fuels will become less available (more expensive) so we must shift to renewable sustaining energy sources. It is also important to remember that alternative energy prices are directly related to oil and gas prices, i.e., it takes petroleum to build solar collectors and windmills.

Many of the activities in this packet are adaptations of <u>A Solar Energy Curriculum for Elementary Schools, K-6, U.S. Department of Energy.</u> Other sources we found useful were:

- <u>Connections</u>, Joan Melcher, National Center for Appropriate Technology (from which the solar models are taken)

- <u>Solar 80's: A Teacher Handbook for Solar Energy Education</u>, David E. LaHart, Florida Solar Energy Center

- <u>Energy Challenge</u>, Department of Energy

- Solar Dwelling Design Concepts, U.S. Department of Housing and Urban Development.

- Science Activities in Energy: Wind Energy and Solar Energy, Oak Ridge Associated Universities

The activities are separated into four sections:

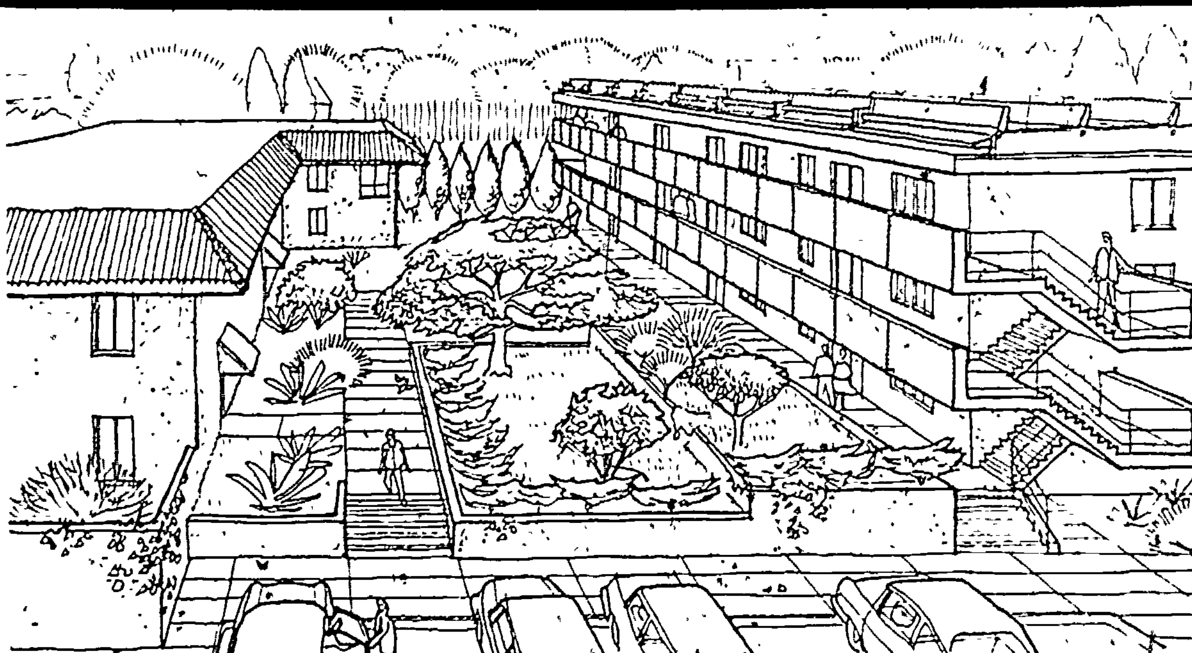
1) Sun and seasons; an introduction to the properties of sunlight and the relationship of the sun and the earth.

2) Role of solar energy and conservation; how solar energy fits into the energy mix, and the importance of conservation.

3) Solar experiments; activities to allow students to gain an understanding of solar energy, its collection and use.

4) Wind experiments; activities involving students in discovering this age-old energy source.

The final page of this packet is an Evaluation Form for these activities. Please let us know about any activities you have tried along with your reactions and that of your students.



Solar Heated and Cooled
Balcony-Access Apartments**

SOLAR TECHNOLOGY: AN OVERVIEW*

The idea of harnessing solar radiation for direct use by humans is not new. Xenophon, a Greek writer, described solar architecture in 400 B.C., and legend claims Archimedes won a naval battle with a solar weapon in 213 B.C. The sun is the ideal energy source, one that is abundant and non-polluting. But there are some problems. Although solar resources are abundant, they are diffuse and require large areas to gather enough energy to be useful. Solar energy collectors cost money and energy--for raw materials, to build, to install and to maintain. Another problem is that sunshine is intermittent. Phasing energy needs to match this available insolation is difficult. The number of sunlight hours and availability of solar resources fluctuate depending on variables like weather, season and location.

SOLAR HEATING AND COOLING

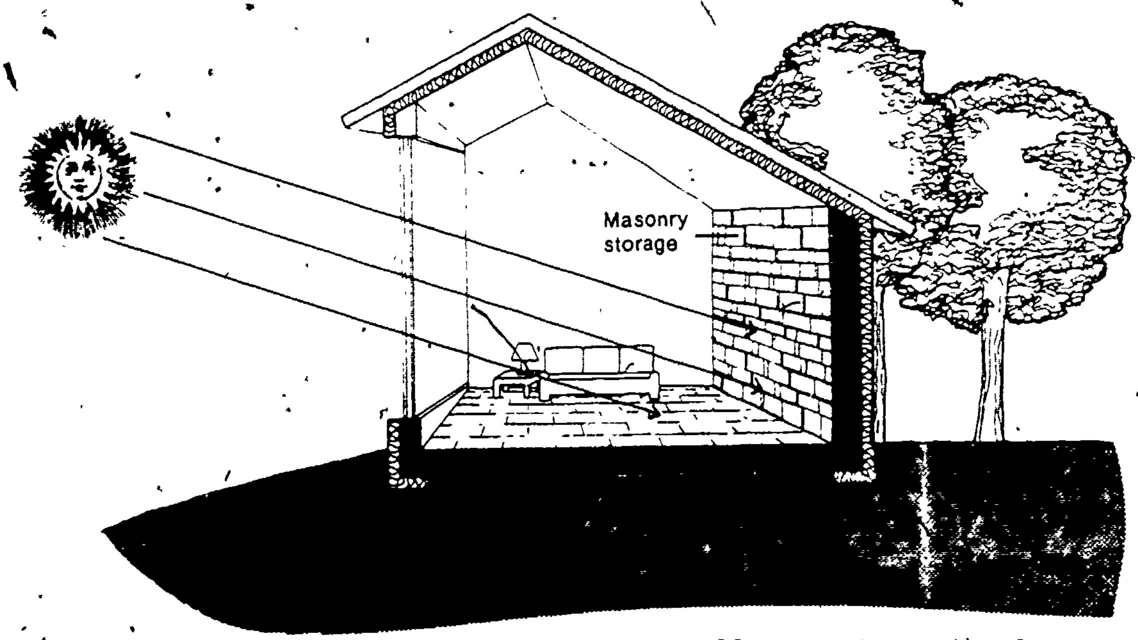
Solar heating and cooling are areas where applied solar technology is making a significant impact on energy consumption. This is especially true of solar water and space heating. Two distinct but complementary styles are used to convert sunlight and thermal energy: (1) active systems generally use mechanical power such as pumps or fans to collect, store and distribute energy, and (2) passive systems use natural energy flows produced by conduction, convection and radiation to store and transport thermal energy within a structure. Designs frequently combine both types of systems, resulting in a hybrid system. Adequate insulation is one of the most cost-effective ways to save energy in a new or used home, and it is vital for any house that incorporates a solar system.

PASSIVE SOLAR SYSTEMS:

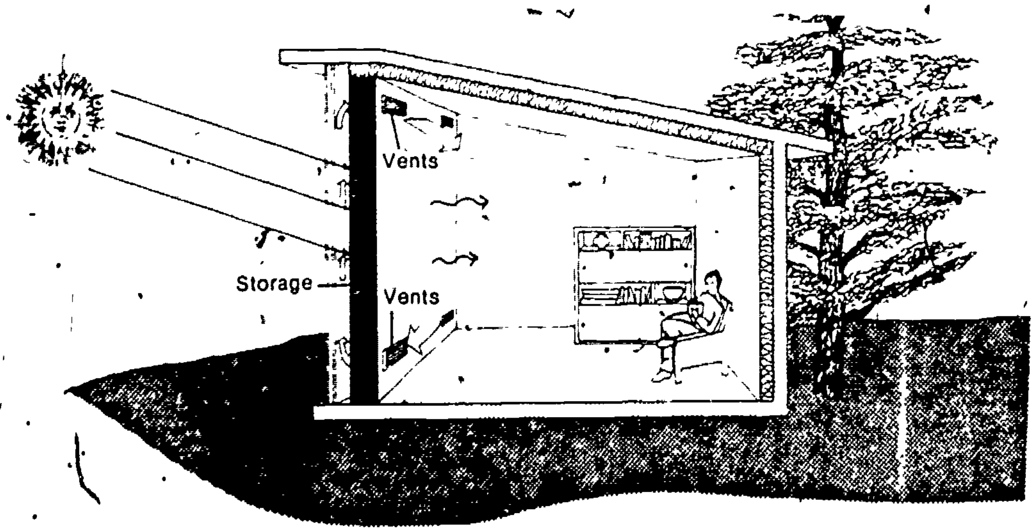
Passive systems are generally part of the overall design of a structure and can be the most cost-effective, natural way to provide part of your heating and cooling needs. Passive systems are usually characterized by the use of abundant heavy building materials such as concrete, brick and water. The approaches to passive design fit five basic groups:

1. <u>Direct Gain Systems</u>--Such systems incorporate south-facing windows (often called solar windows) to admit sunlight into the living space. When the

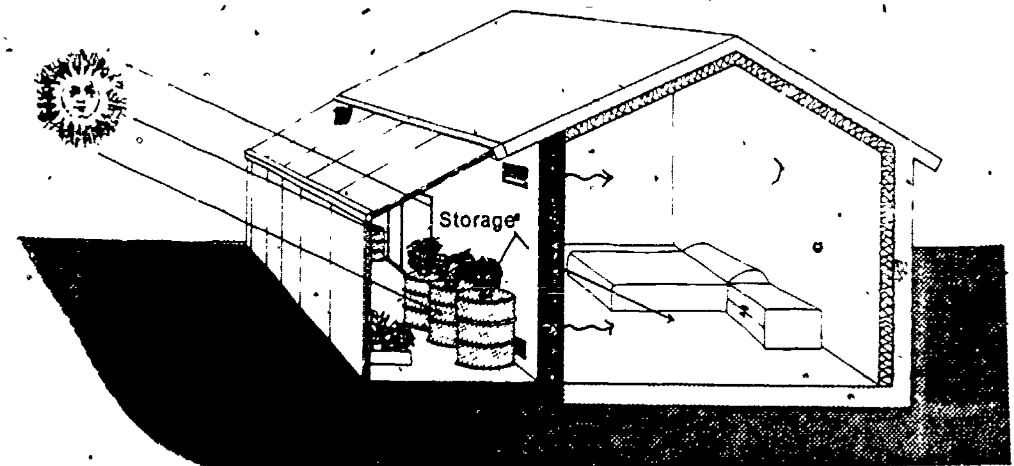
sunlight strikes interior surfaces of the building it changes from shortwave light energy to longwave heat energy. This energy, which does not readily pass through glass, is "trapped" in the building's walls, floors and ceilings (thermal mass) and is available for use later (at night) when heat is needed to maintain comfort. Excessive heat gains during the day, and losses at night or on cloudy days, are often controlled by movable window insulation or "thermal drapes."



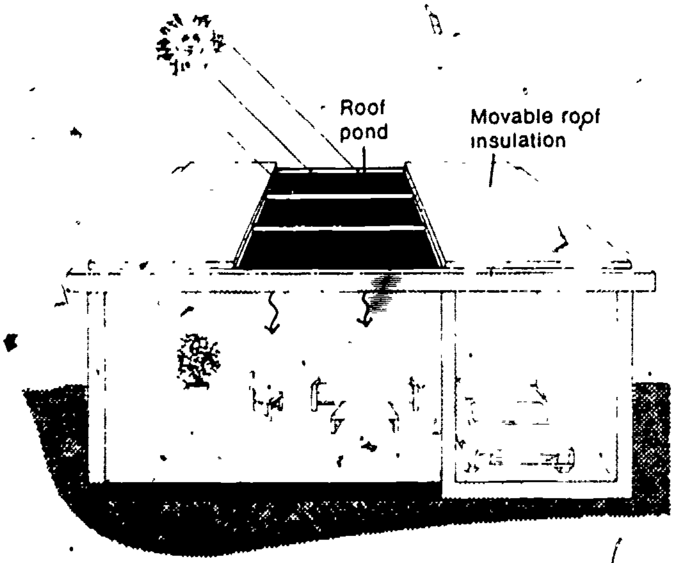
2. <u>Thermal Storage Wall</u>--Thermal storage walls operate on the same principles as do direct gain systems except that the massive storage material is placed between the solar windows and the living space. Thus, sunlight does not enter the living space of the building directly; instead, heat energy enters the living space by traveling through the thermal storage wall. For this reason, thermal storage walls sometimes are called "indirect gain" systems. Two widely used thermal storage walls are the "Trombe wall" and the "water wall."



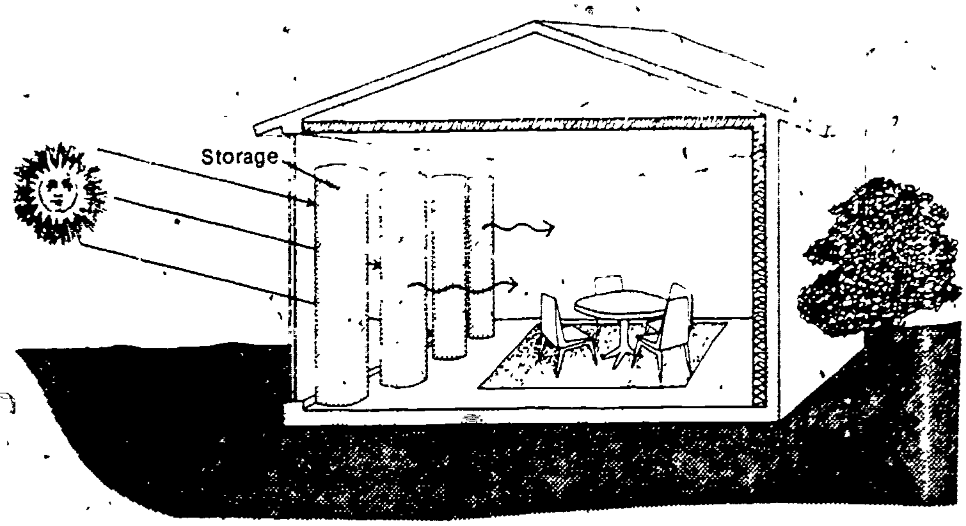
3. Sun Spaces--Sun spaces are similar to the thermal storage wall, the major difference being that the distance between the solar windows and the storage wall is increased to allow the interim space to be usable either as a greenhouse, atrium, entry foyer, sun room, or simply as a buffer zone. When used as a greenhouse, the sun space can provide valuable humidity, oxygen, food and plants for the home occupants.



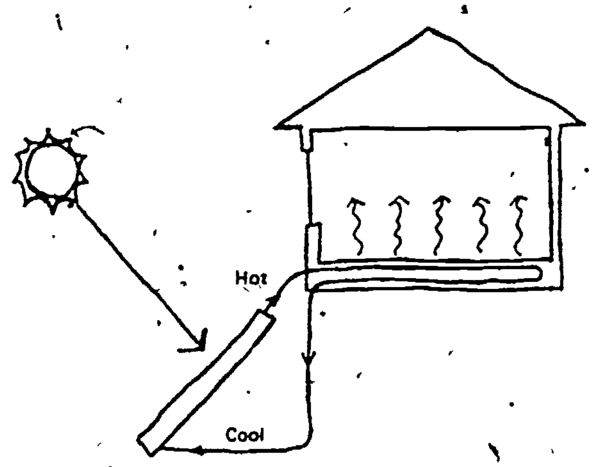
4. Roof Ponds--A roof pond also resembles a thermal storage wall. The storage medium, however is horizontal (in the roof) rather than vertical and is liquid rather than solid. Water is stored in containers and is warmed by the sun during sunny periods and insulated at night and on cloudy days with movable roof insulation. For cooling, the pond is used in reverse, with the insulation being used during sunny periods and removed during cool night periods.



5. Convective Loop--The convective loop is based on the natural thermodynamic tendencies of fluids (either liquid or gas). When a fluid is heated it tends to rise, leaving behind a void or low-pressure zone, and other, cooler fluids rush in to fill that space. Thus, if a container of fluid (a house filled with air or a drum filled with water) is heated on one side only the fluid will tend to circulate.

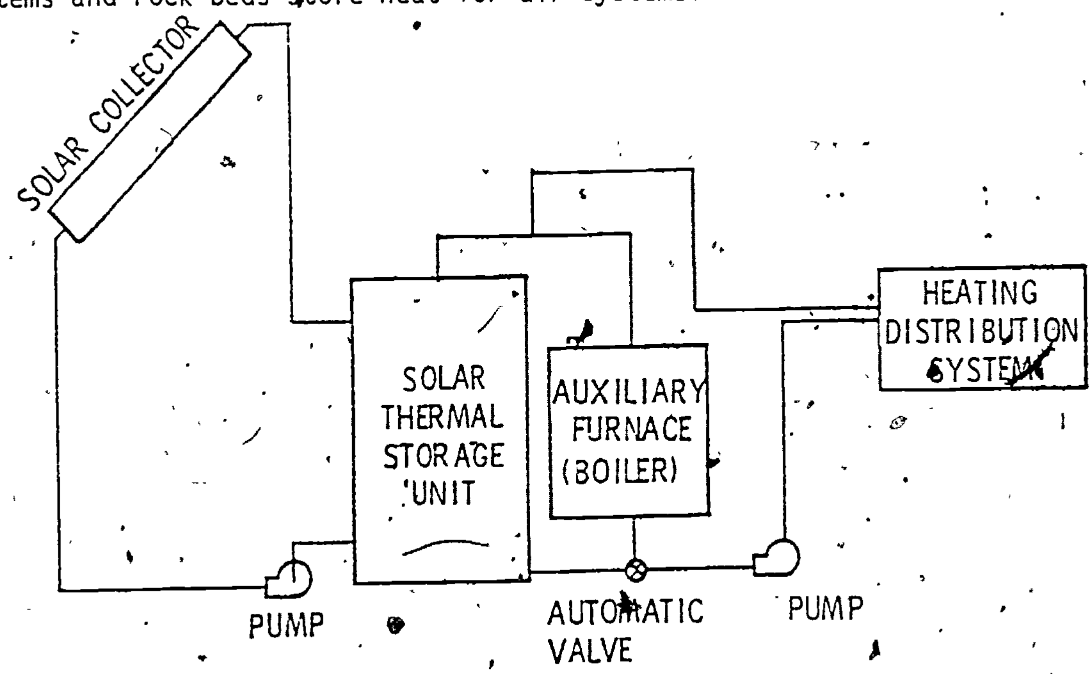


The heat which is generated at one area of the container is transferred to another area (usually the highest point in the container). In solar heating, this principle results in what is commonly called the thermosiphon system, where a storage medium is located higher than the collector or solar window, allowing natural convection to move and transfer the thermal energy from the collector to the storage medium.



ACTIVE SOLAR SYSTEMS:

Active solar systems are characterized by the use of a pump or a fan to power the system. They generally use a collector with an absorber plate that transfers the sun's heat to a working fluid (either liquid or air) and a translucent cover plate (glazing) that prevents reradiation of heat to the environment. Insulation at the back of the collector also reduces energy losses. Storage is required if the thermal energy collected during sunlight hours is to be used at night and when the sky is overcast. Water is usually used as the storage medium for liquid systems and rock beds store heat for air systems.



Cooling is handled by absorption chillers similar to those in gas refrigerators. The economics of solar cooling devices generally are not competitive except in commerical sizes. Higher working temperatures need more expensive components than those required for space heating.

The economics of solar heating and cooling should be considered by using the value of the energy saved over the life of the system. Purchasing a solar heating system is not unlike paying all your heating bills for the next several years at one time. Because of solar's relatively high initial cost, life cycle costing is useful in determining the projected costs when comparing solar with conventional systems. Life cycle costing is a measure of what something will cost totally, not only to buy but also to operate over its lifespan.

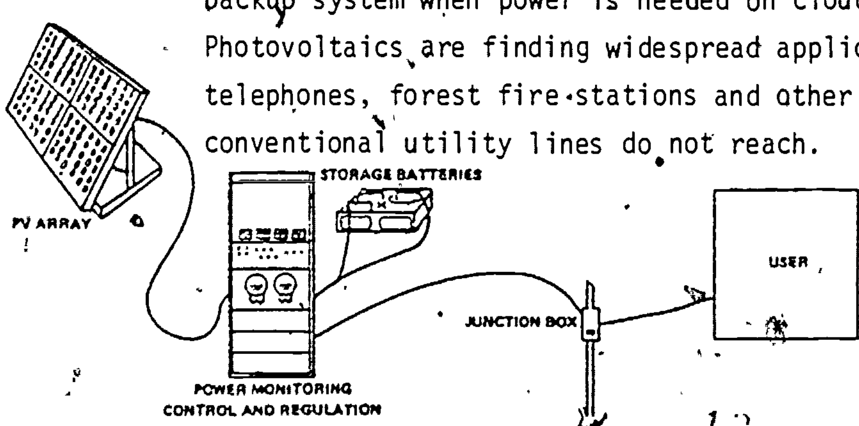
Solar energy is technically feasible and economically viable for heating domestic hot water and swimming pools. Where energy rates are high and winters are harsh, solar space heating is becoming economically attractive. Active, passive and hybrid systems hold promise for the future when conventional fossil fuel pricing and availability are considered.

SOLAR ELECTRICITY

Solar electricity technologies include photovoltaics (solar cells) and solar thermal energy conversion. Solar cells convert sunlight directly to electricity. Solar thermal conversion uses specially designed solar collectors to generate steam, which drives a turbine and generator to produce electricity. Only the solar heating of the boiler distinguishes this electrical system from that of a fossil-fueled electric plant. Because existing power-generating technology can be used, solar thermal power systems are being studied for many commerical applications.

1. <u>Photovoltaic Systems</u>--Conventional collectors convert solar radiation to heat; photovoltaic cells convert sunlight directly to electricity. This simple solid-state device holds the promise of a long operating life with little need for servicing. Since electricity is our most convenient form of energy, solar cells could be used for a wide variety of electrical applications.

   Solar cells are interconnected and are usually placed into sealed units called modules. Any number of these modules, each of which might deliver 12 watts, are then put into frames or arrays designed to meet specific electrical demands. Since solar cells only produce power during daylight hours, they require a storage system or backup system when power is needed on cloudy days or at night. Photovoltaics are finding widespread applications for roadside telephones, forest fire stations and other remote situations where conventional utility lines do not reach.



Major Components of a Photovoltaic System

The technology of photovoltaic conversion is well developed, but large-scale application is hampered by the high price of solar cells. Recently the manufacturing process has been improved, and the current goal is to reduce costs enough to make solar cells competitive with conventional electrical sources by the mid-1980s.

2. Solar Thermal Conversion Systems--The power tower or central receiver system has a large tower surrounded by a field of sun-tracking mirrors (heliostats) which concentrate the sun's rays onto a boiler located in the top of the tower. A 10,000 kilowatt plant of this type under construction in Barstow, California, has a 4.75-acre field of heliostats. Another system uses a field of sun-tracking parabolic troughs to concentrate the sun's rays into a thermal fluid at the focus of the parabola. The fluid moves to a receiver, where it produces steam to drive a turbine and generator.

Other solar electric technologies currently being studied include ocean thermal energy conversion (OTEC), where minor differences in ocean temperatures might be used to convert a low boiling point liquid to a gas to drive turbines. Solar power satellites (SPS) would use a combination of microwaves and photovoltaics to produce electrical energy.

WIND ENERGY

Wind energy is produced when solar radiation is converted into kinetic energy by the differential heating of the earth's surface. Wind-produced energy has long served people by providing power for transportation at sea and for many agriculture purposes. A windmill or wind turbine converts the kinetic energy of moving air into mechanical motion which in turn generates electricity or pumps water.

Estimates of available wind energy vary, but even the lowest estimate represents a substantial energy potential.

Wind power has been extensively used in the United States. Before rural electrification occurred, more than six million small windmills generated household and farm electricity and pumped water; only 150,000 are still in use. The largest wind machine built in the United States had a rotor diameter of 174 feet and generated 1250 kilowatts of electricity. It operated from 1941 to 1943, when the Vermont project was abandoned.

Modern plans to use wind power cover a wide range of sizes and technologies. Some new machines have blade spans larger than the wing span of a jumbo jet and weight many tons. Components of fiber-glass, steel, aluminum, plastics and other materials are used.

The construction of wind generators does not require any new technologies, and cost estimates in favorable regions are close to those of other energy sources. Unfortunately, to produce appreciable amounts of power, installations have to be large and are costly. Wind, like the sunshine that produces it, is a variable resource. Wind velocities decrease considerably at night and vary with the weather. For wind power, the problem of storing energy must be solved.

BIOMASS

Biomass is any material derived from growning organisms--such as wood, corncobs, seaweed or indirectly from garbage. Biomass is a form of solar energy and is produced by a natural process, photosynthesis. It has been a form of fuel for most of human existence. Wood provided 75 percent of this nation's energy just a hundred years ago--a quantity equal to about 3 percent of our current inflated energy appetite.

In many cases, residues from agriculture, forestry operations and municipal wastes form a near-term source of solar energy which can be collected and used now. Such residues might provide up to 5 percent of the nation's energy by 1985. When environmental costs and benefits are fitted into the resource recovery equation, the energy recovered represents only a small part of the savings. Bioconversion is the high-temperature heating of organic matter in the absence of oxygen that produces a dark liquid which can replace petroleum for many industrial uses. Biomass is attractive for making alchohol fuels.

Methanol, is derived from wood or municipal wastes, and ethanol comes from various grains and other agricultural products. In many ways, alcohols are superior to gasoline as a fuel; they increase octane and they can burn cleaner than gasoline. A problem in widespread use is the energy-intensive nature of its production. Mixtures of alcohol and gasoline produce the composite fuel "gasohol," which is commerically available in several states. Other uses of methanol or ethanol include substituting for natural gas and oil, animal feed and fertilizer.

Over-harvesting forests has created many deserts in the world; our greed for cropland helped produce the Dust Bowl of the 1930s. Mining land and water for energy could ultimately destroy the productivity of the earth. Biomass has the potential of being an ecologically attractive form of energy if sufficient care is taken to preserve the integrity and productivity of biological communities.

Solar energy is a rapidly growing field. This introduction serves as an overview of the technologies that are considered in Solar Spots. You may want to investigate this topic in greater detail.

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* adapted from Solar 80's: A Teacher Handbook for Solar Energy Education, David E. LaHart, Florida Solar Energy Center

** diagrams taken from:

- Solar Fact Sheet: Storing Solar Heat, National Solar Heating and Cooling Information Center
- Implementing Solar Energy Education, K-12, Mid-America Solar Energy Complex
- Photovoltaic Energy Conversion, U.S. Department of Energy, Conservation and Energy Division

A CORNY LOOK AT THE SUN

CONTEXT: K - 2
Science, Language Arts

TIME: 20 minutes

OVERVIEW: By pretending to be corn, students can gain an understanding that the sun is essential for growth and life on earth.

MATERIALS: Lamp or flashlight

ADVANCED PREPARATION: None

STUDENT OUTCOMES: STUDENTS SHOULD:
- understand the relationship between sun and growth.
- be able to observe this relationship in nature.
- be able to further develop gross and fine motor skills.

PROCEDURE:

1. Explain to students they are to pretend they are corn and they can only "grow" when the sun is shining on them.

2. Ask one student to pretend to be the sun by standing at the front of the room with the light.

3. After darkening the classroom the student shines the sun (flashlight) moving over the "corn field" which begins to grow slowly.

*note: This activity could involve more students in different roles by having children pretend to be clouds moving slowly and covering the sun. The important thing for students to recognize is the need for sunlight for plant growth.

4. Discuss how sunlight effects living things:

* *
* STUDENT RESPONSE: grows plants, keeps the earth warm, *
* helps us see, provides for all life on earth. . . *
* *

EXTENSION ACTIVITY: This exercise could be done in the spring to coincide with a plant-growing activity.

SUNLIGHT AND PLANT GROWTH

CONTEXT: K-3, 4-8
Science

*note: This experiment could be used as a demonstration for the primary grades.

TIME: 30 minutes
continuing 2 weeks

OVERVIEW: In this experiment, students will examine the effects of sunlight, or lack of it, on plant growth.

MATERIALS: For each group:
- 2 pots (think recyclable: milk cartons)
- 15-20 grass seeds per pot, 30-40 per group
- soil
- labels for each pot
- a box large enough to fit over one of the pots
- enough window space or lighting to accomodate all the plants

ADVANCED PREPARATION: Acquire materials

*note: Grass seed is suggested in this activity because of its rapid growth characteristics and easy obtainment, but any seed will suffice. It is important to provide adequate drainage, either by punching holes in the bottom of a makeshift pot or using a conventional pot. Either one requires a catch basin to hold the water and to keep the custodian's scream to a low decibel level.

STUDENT OUTCOMES: STUDENTS SHOULD:
- observe the requirements of sunlight for plant growth.
- be able to set up and carry out an experiment and evaluate the results.

PROCEDURE:
1. Discuss with students what the sun does for them (warms them, helps them see), and what the sun does for plants (helps them grow). "Let's see what happens to plants without sunlight."
2. Have each group plant an equal number of seeds in two pots.
3. To assure that other variables will not affect the outcome of the experiment, each group will have a pot in the sunlight (the control subject) and a pot in the dark (the experiment subject). Both pots will be treated exactly the same (equal amounts of water and tender loving care) except for light.

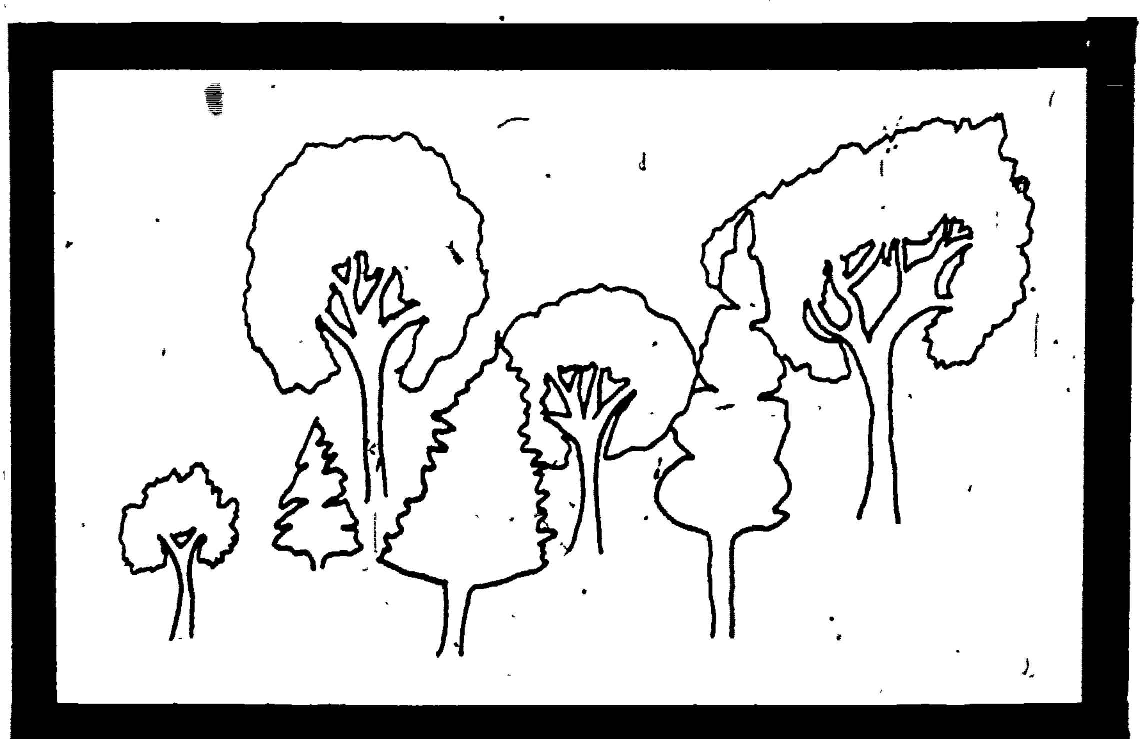
4. Have each group label their pots and place one in the window (or under a light) and the other in the box (or in a dark closet).

5. Make sure the pots are given the same amounts of water (or encouragement).

6. Check the pots daily and record observations at the end of a predesignated time period (suggested 2 weeks). Students can present the pots and their conclusions to the class, comparing their results with those of the rest of the class.

7. Bring one-half of plants back out to grow and observe the effects of sunlight on the experimental subjects.

EXTENSION ACTIVITY: To incorporate mathematic skills in this activity, have students graph the results of their experiment.



A HUMAN SUN-EARTH SYSTEM

CONTEXT: K-3
Science

TIME: 45 minutes

OVERVIEW: Students will explore the physical relationships between the earth and the sun such as rotation and revolution of the earth, by imagining themselves to be the sun and the earth.

MATERIALS:
- flashlights for every two students
- globe
- bare low wattage lamp

ADVANCED PREPARATION: None

STUDENT OUTCOMES: STUDENTS SHOULD:
- understand the physical relationship between the sun and the earth.
- be aware of the spaceship Earth spinning through space in an orbit around the sun.
- recognize the reason for day and night.
- be able to further develop gross motor skills.

PROCEDURE:

1. Take the class outside (or near a window with direct sunlight), have them stand in the sun and ask them how warm they feel. Move over to the shade and ask the same question. "Why is there a difference?"

2. Back inside the classroom, shade the window and turn the lights off. Have a student stand up with a flashlight, explaining that s/he is the sun (that will probably brighten her/his day).

3. Ask a second student to be the earth. The sun shines its light on the earth's front. "Is it day or night on the earth's front?" "What about the earth's back?"

4. Ask the earth to rotate (turn around) and discuss where it's day and night. Ask the earth to revolve around the sun while it is rotating (be sure to do this before lunch!). You may want to add the moon and discuss its relationship at the same time.

5. Ask the students to find a partner and act out what they have just seen with the sun and the earth.

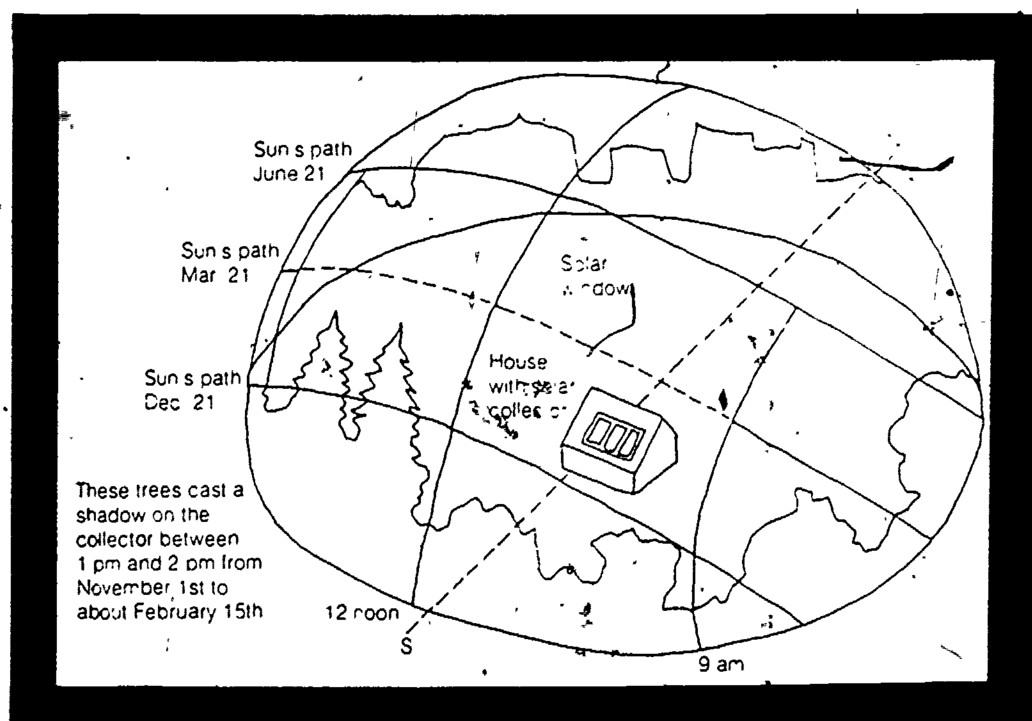
6. Using the globe and the lamp, a more accurate description of sun-earth interactions can be demonstrated. Follow the format discussed above, substituting the globe and lamp for the students and flashlight. It is important to make this transition to gain an understanding of the solar system.

EXTENSION ACTIVITY:

1. The students could draw the relationship just acted out.

2. As a class or small group project, the students could build a miniature solar system, perhaps even including the other planets.

3. A possible outdoor or gymnasium activity could be the "Solar System Dance." Two students back-to-back in the middle of the circle represent the sun and make movements to simulate the sun's activity (waving their arms, for example) and the other students can represent each of the other planets in the solar system, revolving around the sun in stratified or staggered orbits, at the same time rotating on their "axis". The effect will either be mass confusion and dizziness or an awareness of the relationship of the sun and planets in our solar system.



WHAT CAUSES RAINBOWS?

CONTEXT: Grades 4 - 8
Science

TIME: Approximately 60 minutes

OVERVIEW: The sun provides us with heat and light. This activity will provide an understanding of one of the characteristics of light.

MATERIALS: prism

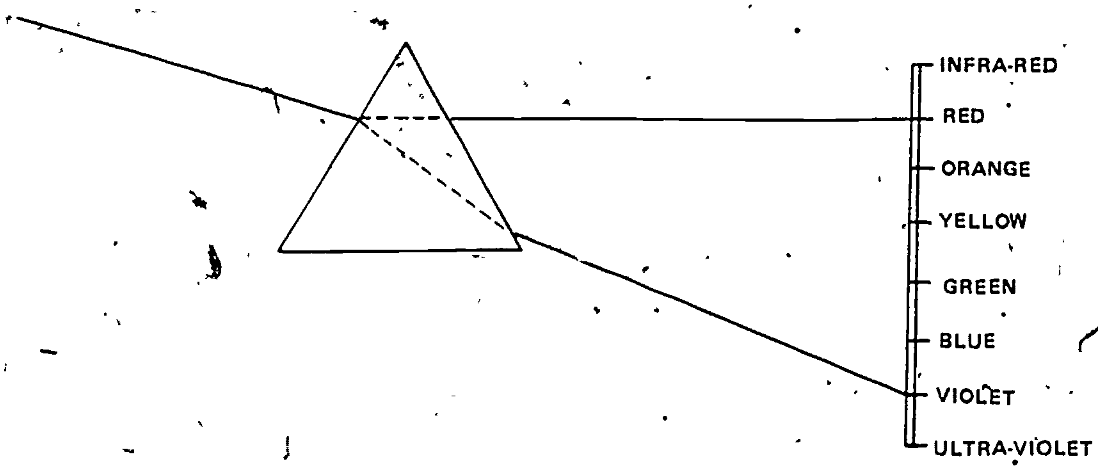
For each student:
- white poster board - 4" square
- compass
- 3½' of string or heavy thread
- crayons

ADVANCE PREPARATION: None

STUDENT OUTCOMES: STUDENTS SHOULD:
- recognize that light is composed of different colors.
- recognize that some colors of light bend more than others.

BACKGROUND INFORMATION: Rainbows are caused by the spreading of sunlight (as it passes through rain droplets) into different colors which reflect into our eyes. The separating of sunlight showing different colors is called a spectrum. A rainbow shows the spectrum of visible light. A prism spreads light into different colors of the visible spectrum. As light travels from one medium to another, such as from air to glass, it is bent. Some colors of light bend more than others and thus a spectrum of the different colors of visible light can be seen.

There is also a much wider spectrum of light that we cannot see. Infrared light, which lies above the red end of the spectrum, gives us heat. Ultra-violet light, which lies below the violet light, gives us tans (or sunburns, if we stay in the sun too long). A prism showing how light is bent into different colors is shown on the next page.



PROCEDURE:

1. Discuss rainbows students have seen. When did the rainbow appear? What caused the rainbow? (Refer to background information.)

2. Tell the students they are going to make a spectrum wheel to see how light is separated and blended together.

3. Directions for making a spectrum wheel.

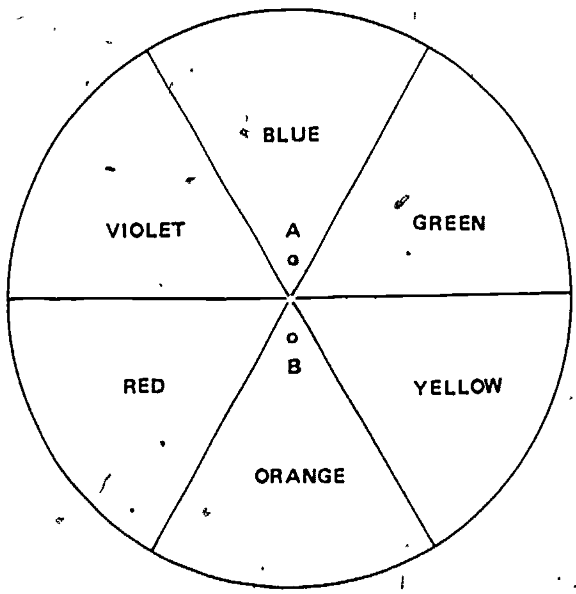
   a) Take a piece of white cardboard, and using a pencil compass, draw a circle about 3" in diameter.

   b) Divide the circle into 6 equal parts.

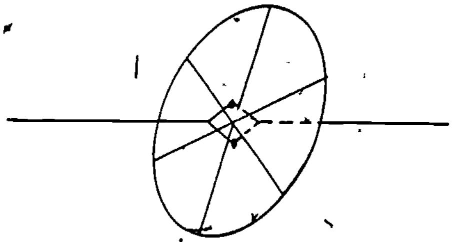
   c) Using a crayon, color the circle as shown.

   d) Now cut the disc out of the cardboard.

   e) Make two small holes near the center about ½" apart. (see point A and B on the following drawing.)



   f) Put the string or thread through the two holes and tie the ends together.



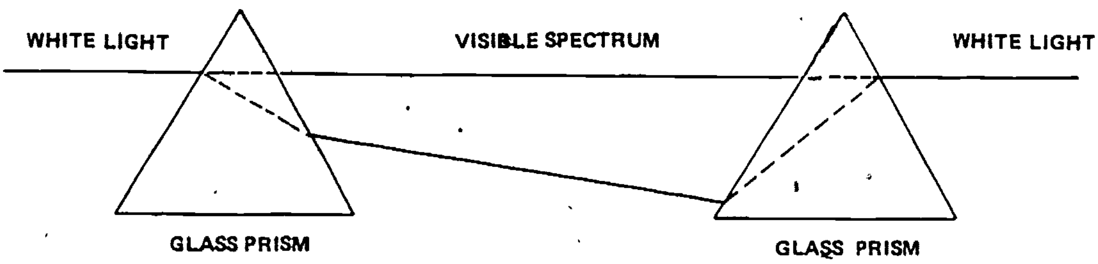
4. To work the color wheel, hold the string by the loops at each end and have someone slide the color disc to the center of the string. Whirl the disc around until the string is tightly twisted. Now gently pull the loops back and forth so that the disc spins quickly.

5. Have the students describe what they see as the disc spins. The colors should blend together, making the cardboard appear whitish. The colors should appear and disappear as the disc slows down or speeds up.

6. Using a prism and either sunlight or a beam of light from a slide projector develop a color spectrum against a wall or piece of cardboard.

7. Have the students color the spectrum they see and indicate the location of infrared and ultraviolet light in the spectrum.

EXTENSION ACTIVITY: A further adaptation of the prism experiment can be to use a second prism. Have the light of the first prism make the spectrum with the second prism close by, recombine the spectrum to form white light once again. This experiment was actually done by Issac Newton, 1672, when he proved that white light was the coalescence of many colors.



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ANGLE OF THE SUN

CONTEXT: 4 - 8
Science

TIME: 40 minutes

OVERVIEW: By simple experimentation using a flashlight and paper, students will learn why the earth is warmer in summer than in winter even though the earth is farthest from the sun in the summer. Using a bare small wattage lamp and a globe, students experiment to see the concept of night and day and the seasons. These factors need to be considered in the adaptations for collecting solar energy.

MATERIALS: For each group of 2 or 3 students:
- a small flashlight
- masking tape
- a piece of string 3' or 4' long
- ruler
- a large sheet of paper
- crayons

For the class:
- Sun-Earth Sheet
- a lamp with small lightbulb, without a shade
- a globe of the earth
- overhead projector

ADVANCED PREPARATION: Make transparency of Sun-Earth Sheet

STUDENT OUTCOMES: STUDENTS SHOULD:
- understand the reasons for summer and winter.
- understand the reasons for different climates in different areas.

BACKGROUND INFORMATION: The sun's rotation on its axis causes day and night, and the angle of the axis in relation to the sun causes seasons. There are two reasons for seasons: 1) in the summertime, the days are longer which gives the sun more time to warm the earth; and 2) the angle of sunlight is more direct and intense. Since we have no control or way to use the length of days, solar designs take advantage of the angle of insolation. (See informational sheet on sun and seasons.)

The same amount of incoming sunlight (insolation) over a large area results in less concentration of light per unit. The effect will be less heat and light when the sun is at a greater angle to the earth (winter).

PROCEDURE: Using the Sun-Earth transparency discuss: Why the earth has day and night (rotation of the earth), and when the earth is closest to the sun (winter).

Why are we warmer during the summer instead of winter?

Explain to the students that we will now conduct an experiment to determine an answer to this question.

*note: This experiment can be done as a demonstration.

1. Tape sheet of paper to the floor, tie one end of the string to the flashlight close to the lighted end, and tape or tack the other end of the string to the center of the piece of paper.

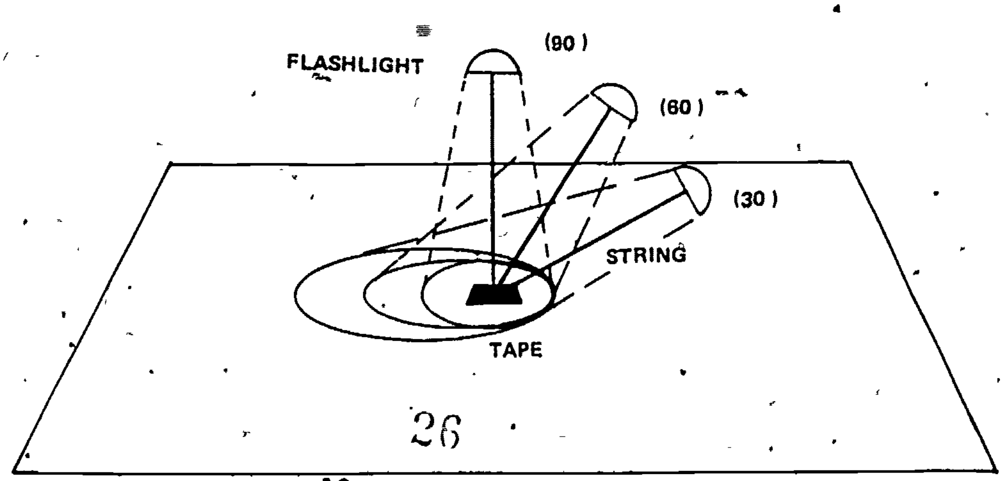
*note: A comfortable length for the string would be about waist height so the exact length will depend on the height of the students.

2. Hold flashlight directly over the paper, pulling string taut. Another student can draw with a crayon a rough outline of the lighted circle on the paper.

3. Move the flashlight 2 or 3 feet from the vertical position with the string taut to assure equal distance, and outline the circle in a different color crayon.

4. Move the flashlight still farther from the vertical position, and outline with a third color crayon.

5. Measure the dimensions of the spots, compare them with position of the flashlight and record on the experiment paper. At the same time, compare the brightness of the different spots in relation to their size.



"Since the amount of light coming from the flashlight was the same in all positions, what can we say about the amount of light that strikes a given area at the different positions?

* *
* STUDENT RESPONSE: The larger the circle, the less *
* light (and heat) per unit area. *
* *

Using the globe and the lamp, a more accurate description of the sun-earth interactions can be demonstrated. Using the format discussed below, the transition can be made from the flashlight and paper to the sun and earth to gain a greater understanding of the solar system.

1. Place the lamp with a low wattage bulb on a table and place the globe several feet away.

2. Darken the room and observe how the light shines on the globe -- Where is it night? Where is it day?

3. Position the globe so that the North Pole points to the light. What season is it here (your city)? Why? What season is it in the Southern Hemisphere? Why?

4. Try different positions of the globe in relation to the light source and identify seasons in each case.

EXTENSION ACTIVITY: Holding the flashlight in a horizontial position, take a 3" x 5" card first in a flat position (so that the light shines on the edge of the card), then slowly rotate the card towards the light. Observe the differential brightness on the card. This explains why solar collectors are tilted up on the roofs and toward the south (some even follow the sun's track) so that they can obtain the maximum insolation.

SUN AND SEASONS INFORMATION SHEET

This a brief overview of the relationship between the sun and the earth and its meaning for the collection and use of solar energy.

The sun is the basis of all life on earth: it powers the processes of photosynthesis and the hydrologic (water) cycle. The fossil fuels from which we have built our industrial society also orginate from the sun.

For millions of years, humans have relied on the indirect use of the sun's energy by burning wood and other organic matter for heating and cooking. Now we are beginning to directly harness the sun's energy. An understanding of how the earth interacts with the sun is essential for the maximum use of this vast, renewable energy source.

The earth revolves around the sun in an elliptical (oval) path at a distance averaging 93 million miles (149.5 million kilometers). Interestingly, the earth is closer to the sun in the winter (91.5 million miles, 147 million kilometers) than in the summer (94.5 million miles, 152 million kilometers). Distance from sun therefore is not a determinant of seasons.

Seasons are caused by what could be considered a quirk of nature: the earth's axis (the imaginary line from the north pole to south pole on which the earth spins) is tilted 23½o. As can be seen in the Sun-Earth sheet*, the effect of this tilt is that the sun is directly overhead at different places at different times of the year.

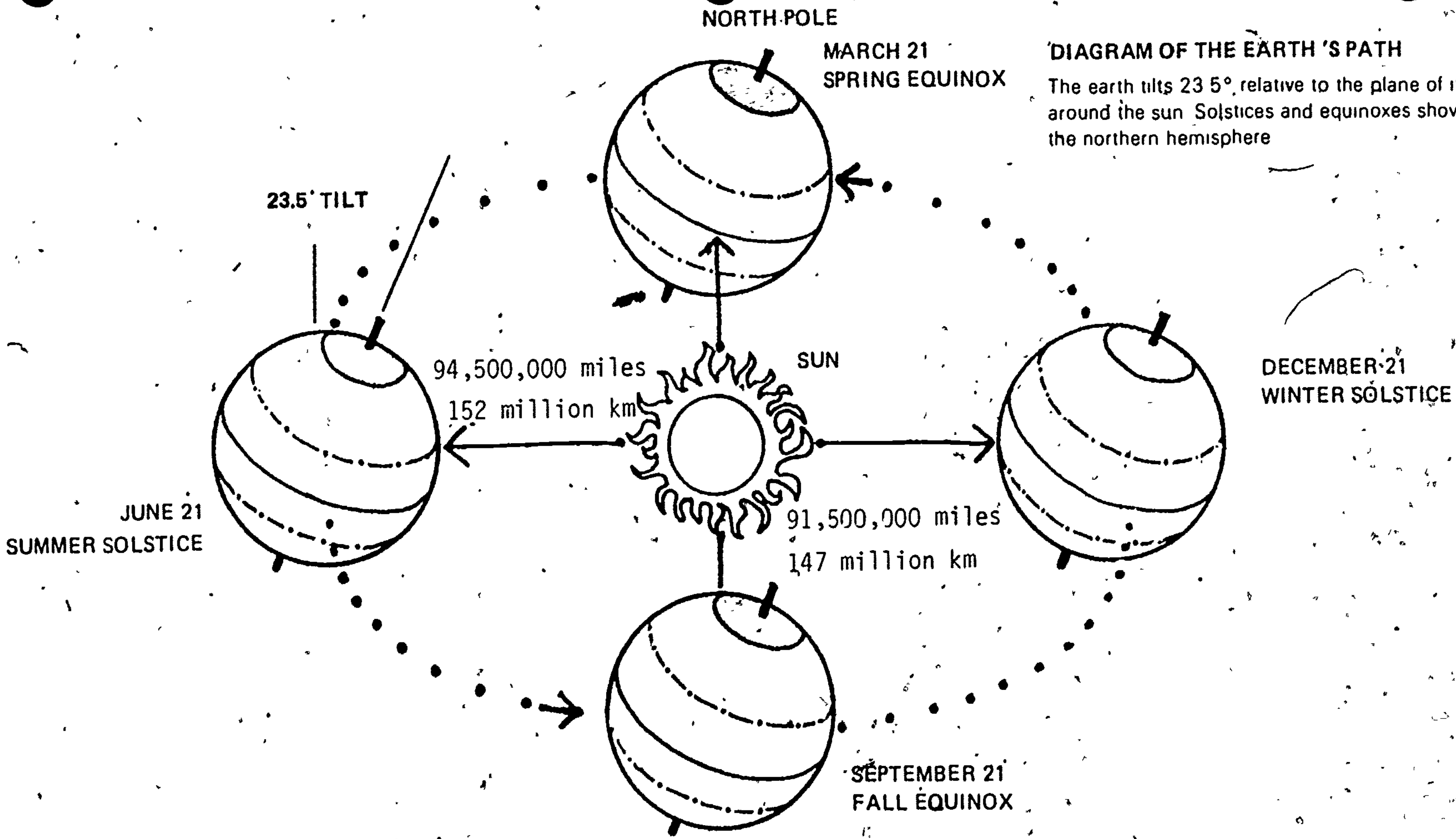
There are two determinants of seasons: 1) during the summer months, the northern hemisphere is exposed to the sun longer (i.e., longer days) which has an overall warming effect on our hemisphere; and 2) the angle of insolation (incoming sunlight) is greater in the summer than in winter. The effect of the angle of insolation is similar to the difference between the noon sun and evening sun; the former, being much warmer because of the greater angle to the earth's surface. This second reason for seasons is the basis for most solar energy collection adaptations. There are certain strategies for taking advantage of the sun's angle, such as the location and tilt of collectors and the use of overhangs or awnings to let the winter sun in and block the summer sun. This information is show on the Characteristics of Sunlight sheet.*

* <u>Solar Dwelling Design Concepts</u>, U.S. Department of Housing and Urban Development, Office of Policy Development and Research, 1976.

SUN-EARTH SHEET

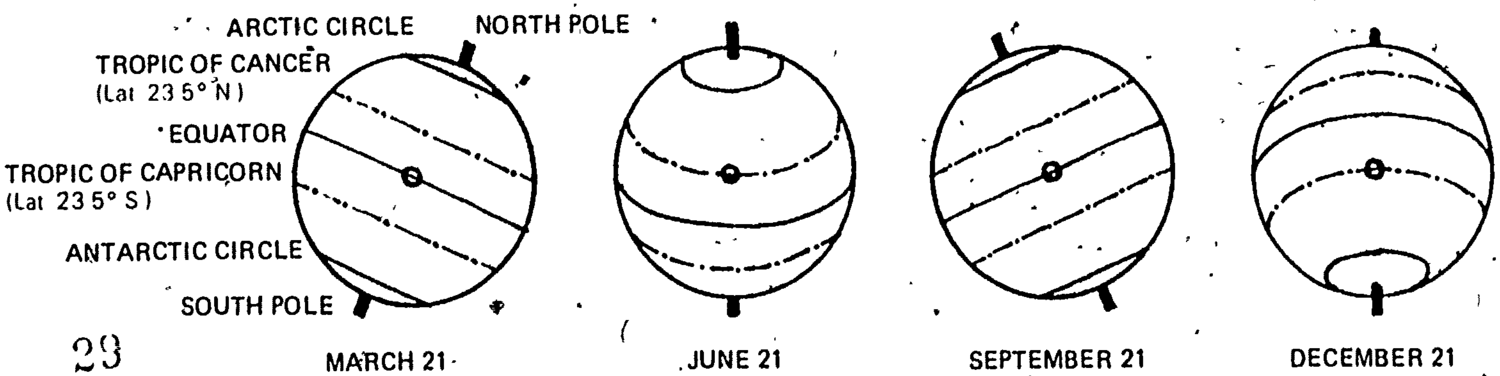
DIAGRAM OF THE EARTH'S PATH

The earth tilts 23.5° relative to the plane of its orbit around the sun. Solstices and equinoxes shown are for the northern hemisphere.

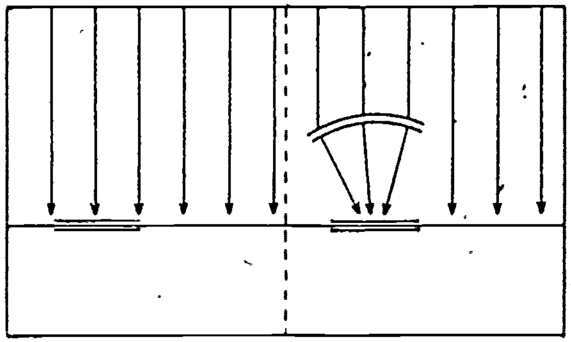


WHAT THE SUN 'SEES'

The o shows the latitude at which the sun would be directly overhead.



CHARACTERISTICS OF SUNLIGHT

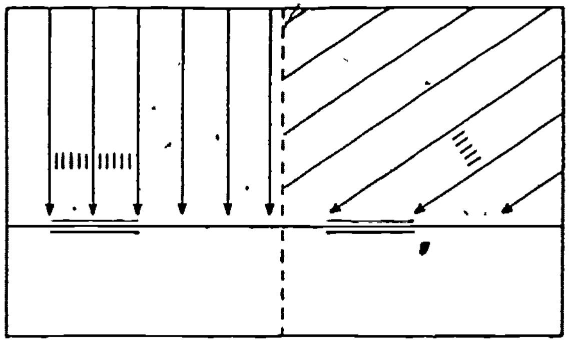


1. SOLAR CONSTANT

THERE IS A NEARLY CONSTANT AMOUNT OF SOLAR ENERGY STRIKING THE OUTER ATMOSPHERE — 429 BTU PER S F PER HOUR — AND THIS QUANTITY IS KNOWN AS THE SOLAR CONSTANT

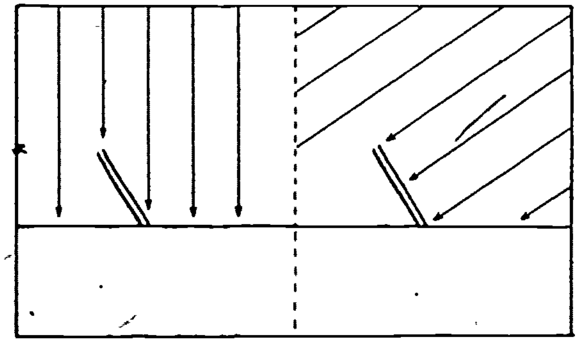
NOTE

You cannot increase the amount of solar energy striking a collector of a given size by focusing You may increase the collector's efficiency or the temperature of the working fluid



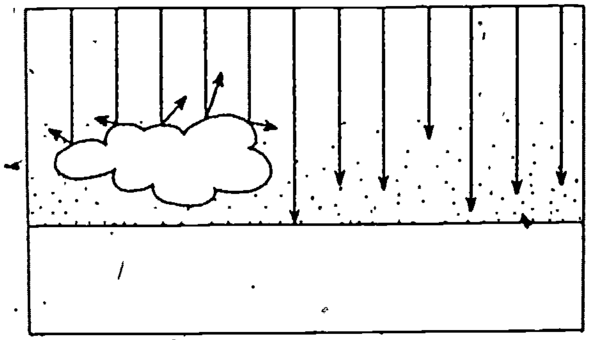
2. COSINE LAW — HORIZONTAL SURFACE

LESS SOLAR RADIATION STRIKES A GIVEN HORIZONTAL AREA AS THE SUN GETS LOWER IN THE SKY THE AMOUNT CHANGES BY THE COSINE OF THE ANGLE MEASURED FROM DIRECTLY OVERHEAD



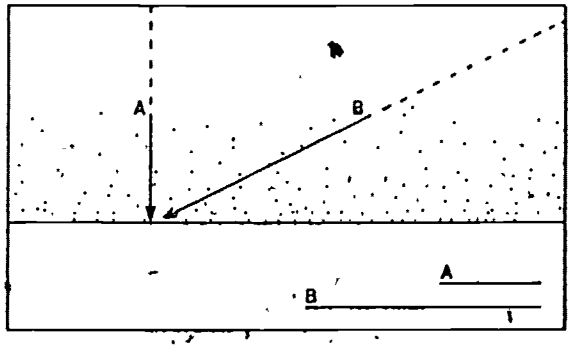
3. COSINE LAW — TILTED SURFACE

THE SAME LAW APPLIES TO A TILTED SURFACE SUCH AS A SOLAR COLLECTOR BY TILTING THE COLLECTOR SO THAT IT IS MORE NEARLY PERPENDICULAR TO THE SUN MORE ENERGY STRIKES ITS SURFACE



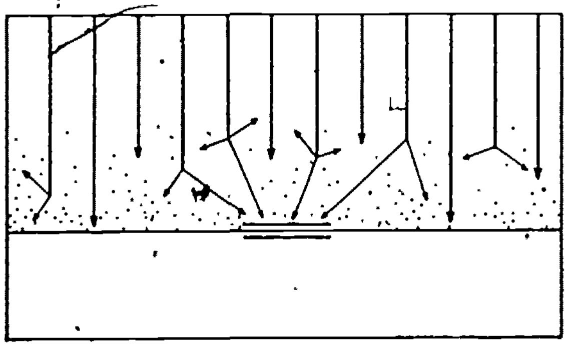
4. ABSORPTION AND REFLECTION

NEARLY HALF THE SOLAR RADIATION ENTERING THE EARTH S ATMOSPHERE IS LOST THROUGH ABSORPTION BY MATERIAL IN THE ATMOSPHERE, OR BY REFLECTION FROM CLOUDS



5. LENGTH OF TRAVEL THROUGH THE ATMOSPHERE

MORE SOLAR RADIATION IS LOST BY ABSORPTION AT LOW SUN ANGLES BECAUSE THE LENGTH OF TRAVEL THROUGH THE ATMOSPHERE IS GREATLY INCREASED (THAT IS WHY YOU CAN LOOK DIRECTLY AT THE SUN AT SUNSET) HIGH ALTITUDES HAVE MORE SOLAR RADIATION FOR THE SAME REASON



6. DIFFUSE RADIATION

CLOUDS AND PARTICLES IN THE ATMOSPHERE NOT ONLY REFLECT AND ABSORB SOLAR ENERGY BUT SCATTER IT IN ALL DIRECTIONS BECAUSE OF THIS. SOLAR ENERGY IS RECEIVED FROM *ALL PARTS* OF THE SKY — MORE SO ON HAZY DAYS THAN ON CLEAR DAYS SUCH RADIATION IS CALLED *DIFFUSE* AS OPPOSED TO THE NORMAL *DIRECT* RADIATION

TURN ON TO ENERGY

CONTEXT: K - 3
Social Studies

TIME: 30 minutes (on-going)

OVERVIEW: Through the use of an on-off switch at each desk, students will become accustomed to energy conservation behavior.

MATERIALS: For each student:
- two small pieces of heavy construction paper or posterboard, one 1" x 4" and one 4" x 4"
- a brass spreading brad
- crayons
- tape

ADVANCED PREPARATION: Prepare materials

STUDENT OUTCOMES: STUDENTS SHOULD:
- understand the necessity of conservation.
- demonstrate energy conserving behaviors by using the switch on each desk.
- demonstrate conservation behavior in other aspects of their lives.
- increase their ability to follow oral directions.

PROCEDURE:

1. Discuss with class why we need to save energy:

* *
* STUDENT RESPONSE: to have energy in the future, to allow others to use energy, to save money, to decrease pollution, to expand range of energy choices, to reduce dependance on imports. . .
* *

2. Discuss with class ways they can save energy:

* *
* STUDENT RESPONSE: walk or ride a bike to school; turn off lights, T.V., stereo, etc., when not being used; close doors quickly during the cold months; wear a sweater so that the thermostat can be kept dialed down. . .
* *

3. Tell the students that they will begin to practice how to save energy by putting an energy conservation switch on each desk.

4. Directions for making the energy conservation switch:

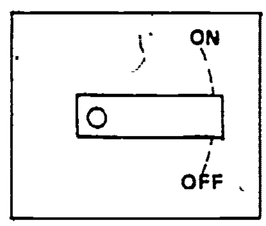
a) Distribute the two pieces of paper to each student.

b) Have the students print the word "ON" in the upper right hand corner of the 4" x 4" paper and the word "OFF" in the lower right hand corner.

c) Punch a hole along the left hand side of the 4" x 4" paper, approximately 1 inch from the edge and in the middle.

d) Punch a hole approximately 1 inch from the end of the small strip.

e) Attach the small strips to the larger paper by putting the brad through both holes.



*note: For younger students you may want to make the energy conservation switches for them.

5. When the students get up and leave their desks, they should turn their switches "off" since the desks are not being used. When they return to their seat, they should turn their switches "on". This encourages students to get in the "habit" of turning things off when not in use.

EXTENSION ACTIVITY: Have the students become energy managers. Each day discuss the need for reliance on electrical energy (e.g., the need for lights) or the possibility of relying on solar energy. Assign an energy monitor to carry out the class decision (e.g., turn off lights, open drapes, etc.). Ask students to carry out some of these same activities at home with their families.

MODUS OPERANDI

CONTEXT: 4-8
Social Studies, Language Arts, Science

TIME: 40 minutes

OVERVIEW: Because we often do activities in the same manner, we fail to consider alternative strategies to accomplish these tasks. This exercise is designed to promote divergent thinking among students by listing as many possible options to daily activities in which they participate.

This activity can be used as an introduction to a unit to start students thinking about the energy we use, or as a conclusion to an energy unit to wrap-up concepts and to emphasize the effects of student action on energy usage.

MATERIALS: Method of Operation Worksheet

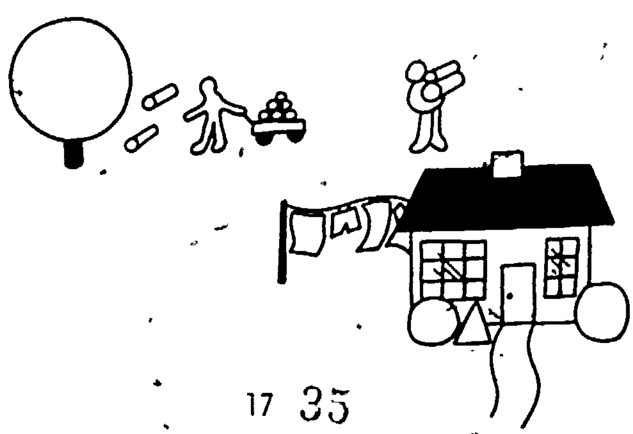
ADVANCED PREPARATION: Duplicate worksheets for each student

STUDENT OUTCOMES: STUDENTS SHOULD:

- recognize that all activity requires energy.
- recognize the sun as the ultimate source of all energy.
- become aware of alternatives for accomplishing tasks.
- understand the energy required by the various alternatives.
- recognize their own preferences for the alternatives and the energy involved.
- develop divergent thinking skills.

PROCEDURE:

1. Conduct a discussion (brain-storming session) about activities that students do that involve energy.
2. As the students begin to realize that all activity requires energy, lead the discussion toward different ways for doing that same activity and the amount and source of energy required.



3. Prepare the students for completing the Method of Operations worksheet by working through an example on the chalkboard.

    a) Identify a common task (i.e., obtaining clothing).
    b) Identify ways of obtaining clothing.
    c) Complete the "source of energy" boxes by listing all the energy required for the task and the origin of that energy. Stress the importance of considering all energy required; i.e., materials, transportation, processing, use and the source of that energy.
    d) Have the students rank from 1-4 their preferences for ways to accomplish the task.
    e) Then, rank from 1-4 (from least to most) the amount of energy required for each alternative.

	buying polyester knits at the mall		buying cotton pants downtown		getting hand-me-downs		ordering from a catalogue	
getting a pair of pants	SOURCES OF ENERGY petroleum for polyester gasoline for car energy for making auto energy for heating and lighting mall		SOURCES OF ENERGY petroleum fertilizer for cotton gasoline for car or bus energy to make car or bus and to run store		SOURCES OF ENERGY original energy for getting pants saving energy compared getting new pants		SOURCES OF ENERGY gasoline for delivery energy for warehouse operations energy to make and send catalogue	
	MY PREFERENCE	ENERGY REQUIRED	MY PREFERENCE	ENERGY REQUIRED	MY PREFERENCE	ENERGY REQUIRED	MY PREFERENCE	ENERGY REQUIRED
	2	4	1	3	4	1	3	2

4. Distribute the worksheet and have the students complete it either individually or in small groups.

5. After some time has been given for students to complete the worksheet, bring the class together to discuss their findings.

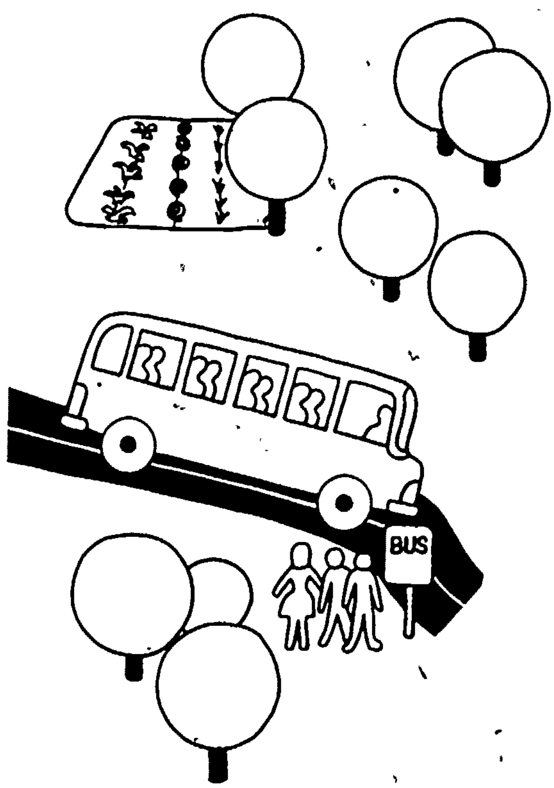
   Be sure to include:
   - as many alternatives as possible,
   - all the energy required and its origin,
   - the matching of preferences and energy use.

*note: It is expected that there will not be complete agreement among the students regarding energy requirements and energy usage. A discussion of these differences will help students recognize the importance of finding many alternatives to the energy situation.

EXTENSION ACTIVITY:

1. After the worksheet has been completed, a scenario could be developed where one or more of the energy sources are not available (i.e., an oil embargo diverts all available petroleum to agriculture and national defense). Have students discuss or write about the implications of this action and what alternatives would be possible.

2. Ask students to pick a task (i.e. getting to school) and do one of the less energy-intensive alternatives for a week then discuss their reactions with the class.



METHODS OF OPERATION

OPERATION				
	SOURCE OF ENERGY my preference / energy required	SOURCE OF ENERGY my preference / energy required	SOURCE OF ENERGY my preference / energy required	SOURCE OF ENERGY my preference / energy required
	SOURCE OF ENERGY my preference / energy required	SOURCE OF ENERGY my preference / energy required	SOURCE OF ENERGY my preference / energy required	SOURCE OF ENERGY my preference / energy required
	SOURCE OF ENERGY my preference / energy required	SOURCE OF ENERGY my preference / energy required	SOURCE OF ENERGY my preference / energy required	SOURCE OF ENERGY my preference / energy required

	PRODUCTION	USE	RENEWABLE?	ADVANTAGES	DISADVANTAGES
CONSERVATION	Human effort	To save all types of energy	YES	- low cost - buys time to develop alternatives - improves economy	- needs commitment and effort of people
COAL	Mined from deep in the earth or scooped from shallow mines near the surface	Burned for electricity in power plants for steam heat and heat for homes	NO	- abundant domestic reserves - proven technology	- dangerous mining - environmentally harmful strip mining - pollutes when burned - transportation problems
PETROLEUM	Pumped from deep wells on land or off seacoasts	Transported to refineries to be made into fuel oil for heat or electricity, gasoline and petrochemicals such as plastic and polyester	NO	- easy to transport and store - most effective fuel for transportation	- short supplies becoming expensive - refineries pollute - pollutes when burned - oil spills harmful to environment
NATURAL GAS	Pumped from deep wells on land and off seacoasts. Only 20% is found with petroleum	Burned for space heating, cooking, and hot water	NO	- clean burning and most efficient fossil fuel	- short supplies becoming expensive

	PRODUCTION	USE	RENEWABLE?	ADVANTAGES	DISADVANTAGES
HYDRO-ELECTRIC POWER	The energy of falling water over a dam turns a turbine	Turbine generates electricity for use in homes and industry	Yes, but new sites are becoming scare	- no air pollution - proven technology	- not located near cities - destroys river habitats and floods large areas - few new sities available
WOOD ENERGY	Trees cut in forest	Burned in stoves for heat and cooking	YES	- easily obtained by individuals to produce own heat - used extensively in the past	- not available everywhere - needs storage space - pollutes the air when burned - efficient woodstoves are expensive - cost of wood is increasing
SOLAR ENERGY	Energy from the sun collected for use	Space heating and cooling, hot water heating and generating electricity	YES	- little pollution - individual control - free after collector is obtained - unlimited supply	- not a constant source, needs storage and/or back-up systems - collectors are expensive
NUCLEAR FISSION	The nuclei of atoms of uranium are split apart in a reactor to produce steam to turn a turbine	Turbine generates electricity for use in homes and industry	NO	- small amount of fuel produces a tremendous amount of energy - no gaseous or particle pollution in the air	- wastes are dangerous, difficult to handle and contain, and will remain radioactive for a long time - plant malfunction may result in widespread damages - fuel could be stolen and made into atomic weapons

	PRODUCTION	USE	RENEWABLE?	ADVANTAGES	DISADVANTAGES
OIL SHALE	Petroleum can be extracted from special rock formation	Substitute for petroleum	NO	- large reserves concentrated area - could be used as a transition from fossil fuel	- waste disposal - mining environmentally harmful - needs much water in a water-short area
GEOTHERMAL ENERGY	Slow decay of radioactive rock in Earth's core heats water to steam	Could be directly used as a heat source or to generate electricity	YES	- unlimited supply - little pollution - proven technology	- unevenly distributed - chemical pollution of surface water
BIOMASS	Methane gas can be produced by the breakdown of organic matter like plants	Heating and cooking, generating electricity, transportation fuel	YES	- recycling waste material - abundant supply	- may not be a large source of power - may be a problem in urban areas
WIND ENERGY	The sun heats the earth unevenly which causes the movement of air	Wind turns blades which turn a turbine that generates electricity	YES	- little pollution - individual control - free after collection system is obtained - unlimited supply	- not a constant source, needs storage and/or back-up system - windmills are expensive - danger of blades falling off - distorts TV reception - problem in urban areas

	PRODUCTION	USE	RENEWABLE?	ADVANTAGES	DISADVANTAGES
NUCLEAR FUSION	The joining, or fusion of hydrogen atoms to produce energy (similar to the process of the sun)	Generates electricity	No, but hydrogen is from water, an abundant but finite resource	- abundant source - less dangerous than conventional fission plants	- unproven technology the reaction is difficult to contain - requires large amount of electricity - needs a lot of cooling water
OCEAN THERMAL ENERGY CONVERSION (OTEC)	Producing energy from the difference between warm surface water and cold water from the ocean depths	Generates electricity for coastal areas could be used to desalinate ocean water	YES	- could provide electricity - could help meet fresh water shortages	- expensive and unsure technology - unsure environmental impact - large mixing of ocean water
SYNTHETIC FUEL (SYNFUEL)	Coal is converted by gasification (into synthetic natural gas) or liquification (into synthetic oil)	Could be used to replace natural gas and petroleum	NO	- uses coal, an abundant domestic energy source to replace scarce petroleum and natural gas	- water-intensive in a water-short area - high environmental impact - may not produce net energy - high cost
TIDAL/WAVE POWER	Dammed water during high tide is released during low tide and generates electricity, much the same as hydroelectric power-wave action revolves a mechanical shaft to produce electricity	Generates electricity	YES	- doesn't pollute the air and water	- unsightly plants in coastal area - may have great environmental impact in delicate coastal zone

ENERGY QUESTIONS

CONTEXT: 4-8
Language Arts, Science

TIME: 20 minutes

OVERVIEW: Students will learn more about energy sources by playing an adaptation of the game Twenty Questions.

MATERIALS: Energy Resource Information Sheets

ADVANCED PREPARATION: Prepare Energy Source Information Cards from Energy Resource Information Sheets.

STUDENTS OUTCOMES: STUDENTS SHOULD:

- be able to identify energy sources.
- be able to classify energy sources as renewable or non-renewable.
- be able to determine the advantages and disadvantages of different energy sources.
- improve listening skills.
- improve memory skills.

PROCEDURE:

1. Prepare the students for the game by reviewing energy sources.

2. Divide the class into two teams.

3. A person from Team One draws an energy source information card. By asking questions that can be answered yes or no Team Two attempts to identify the energy source on the card. If the energy source is identified in 10 or less questions the team earns a point. The game continues for a pre-determined length of time or number of rounds. The winning team is the one with the most points.

Sample questions:

1. Is it renewable?

2. Does it require water?

3. Is there a waste problem associated with its use?

*note: As the students become more proficient the rules for the game can be adjusted (i.e., the cards can have the name of an energy source but no information; the source must be guessed in five or less questions....)

PROBLEMS/SOLUTIONS

CONTEXT: 4-8
Science, Social Science, Language Arts

TIME: 45 minutes

OVERVIEW: Any of the alternative technologies may help to supply our energy requirements but may at the same time present some new problems to consider. This worksheet is designed to assist students in identifying energy issues and the advantages and disadvantages of particular energy sources relating to those issues.

MATERIALS: Problems/Solutions worksheet

ADVANCED PREPRATION: Duplicate worksheet for each student.

STUDENT OUTCOMES: STUDENTS SHOULD:
- be able to identify which energy issues are avenues to solutions to our energy situation and which are problems.
- identify the relationship between energy issues and energy alternatives.
- exhibit divergent thinking skills.

PROCEDURE:

1. Review with the class the different energy sources discussed previously.

2. Introduce the worksheet by emphasizing that no one energy source will be able to meet our energy needs, and all sources have problems associated with their use. Conversely, their use can help solve certain problems.

3. Distribute worksheet and explain directions.

4. After students have had ample time to complete the worksheet (either individually or in groups), bring the class together and discuss the results.

* note: Because problems are definitional, some students may identify problems that others may not. Therefore the answers given here are flexible. This is where discussion will be an important tool in assessing student values and attitudes.

EXTENSION ACTIVITY: Choose one of the energy sources from the worksheet. Discuss the implication of the aggressive development of that source to the relative exclusion of other energy source development on different sectors and facets of American and international life. It is suggested that one energy source be chosen and examined thoroughly. Remember that decisions regarding energy often have far-reaching and hidden effects not readily recognized. Below are some examples of topics, but they are certainly not restrictive.

<u>Economics</u> -- solar development could result in more investment on the part of individuals rather than as stockholders investing through corporations, shifting the economic structure.

<u>Social patterns</u> -- domestic oil development could result in a large influx of people to oil-concentrated areas, putting a strain on municipal facilities.

<u>International relations</u> -- coal development and burning could result in an acid rain problem, causing concern in neighboring countries.

<u>Land use</u> -- nuclear development could require the acquisition of prime agricultural land for power plant sites and transmission line rights of way.

<u>Environment</u> -- wood development could result in forest abuse from mismanaged cutting practices.

<u>Transportation</u> -- coal development could necessitate a massive upgrading of the rail system.

<u>Employment</u> -- solar development could result in a change in employment patterns.

<u>Resource allocation</u> -- synfuel development in water-short western states could result in a diversion of water from other uses, such as agricultural irrigation.

* The Problems/Solutions worksheet is adapted from <u>Energy Challenge</u>, U.S. Department of Energy (formerly Federal Energy Administration).

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PROBLEMS / SOLUTIONS

The use of any one of these energy sources may help to supply our energy requirements but may at the same time present us with new problems to consider. In the lefthand column of this page are some of these issues--some are problems, some are solutions. Mark each statement S (for solution) or P (for problem). Place a checkmark in every energy source column on the right to which a statement applies.

IF THIS ENERGY SOURCE IS USED, IT...	SOLAR	NUCLEAR	WIND	GEO-THERMAL	SYNFUEL	WOOD	OIL SHALE	BIOMASS
______ WOULD HELP SOLVE THE PROBLEM OF SOLID WASTE DISPOSAL.								
______ COULD POLLUTE WATER.								
______ WOULD CONSERVE THE DWINDLING RESERVES OF FOSSIL FUELS.								
______ COULD DAMAGE WILDLIFE OR THEIR HABITAT.								
______ WOULD BE DIFFICULT TO STORE AND TRANSPORT.								
______ WOULD NOT POLLUTE THE ATMOSPHERE.								
______ WOULD DISRUPT THE NATURAL USE OF LAND SURFACES.								
______ WOULD NOT BE ABLE TO SUPPLY ENERGY ALL THE TIME.								
______ WOULD HAVE TO WAIT UNTIL THE TECHNOLOGY IS DEVELOPED.								
______ WOULD USE LOTS OF WATER TO PROCESS.								
______ WILL DECREASE THE NEED FOR OIL IMPORTS.								
______ PRODUCES UNUSABLE WASTE MATERIAL.								
______ WILL MAKE USE OF THIS COUNTRY'S MOST ABUNDANT FOSSIL FUEL.								

RUN FOR ENERGY RELAY

CONTEXT: 4-8
Science, Language Arts

TIME: 20 minutes

OVERVIEW: By participating in a relay, students can reinforce their knowledge of energy sources.

MATERIALS:
- chalk
- chalkboard

ADVANCED PREPARATION: None

STUDENT OUTCOMES: STUDENTS SHOULD:
- be able to identify energy sources.
- be able to classify energy sources as renewable or non-renewable.

PROCEDURE:

1. Prepare the students for the relay by reviewing energy sources.

2. Divide the class into teams of 5 or 6. The teams should be in lines facing the chalkboard.

3. At a signal, the first member of each team goes to the board and writes an energy source, returns and gives the chalk to the second person who writes a <u>different</u> source on the board. The relay ends when each person has had a turn <u>or</u> when a pre-determined number of energy sources have been identified.

*note: The relay can be played at various levels of difficulty:
a. List energy sources.
b. List energy sources and identify as renewable or non-renewable.
c. The first person lists an energy source, the second person identifies the source as renewable or non-renewable, then adds another source.
d. Require that the name of the energy source be spelled correctly.

HISTORY OF SOLAR ENERGY

CONTEXT: K-8
Social Studies, Language Arts, Science

TIME: Variable

OVERVIEW: The following activities are familiar formats adapted to studying the history of solar energy and the differences in lifestyles between the eras before, during and after fossil fuels.

MATERIALS: Variable

STUDENT OUTCOMES: STUDENTS SHOULD:
- understand solar energy has been used for thousands of years and is not a new "exotic" energy source.
- understand how lifestyle is affected by energy use.

ACTIVITY:

1. Have students imagine they are back in George Washington's day (when cherry trees made great false teeth!). Have them act out how they might accomplish certain tasks like getting to school, keeping warm, cooking. . . Any time period and activity could be used; i.e., crossing the United States in a covered wagon, procuring food as a pioneer (hunting with clubs, knives, guns, etc., and cooking over a fire).

2. Set up an old-fashioned school day and recreate a day in the life of Ivan Student, wear old-fashioned clothes, use slates instead of paper, and anything practical to represent a school day as it was. Students could prepare their lunches like pioneers (not only no twinkies, but also no bananas or oranges -- only locally available food).

3. Investigate the sun as an object of worship in different cultures. The following are some suggestions for leads:
   - Ancient Egyptians and the sun god RA
   - Aztec Indians of Mexico
   - Inca Indians of Peru
   - Akhenaton concept of a single supreme sun god (see National Geographic, November, 1970)
   - Hindu Vedic hymns and thought
   - Ciwiltkonia, a sun ceremony of the Papage Indian in southwestern United States

- Kwakiutl Indians (Pacific Northwest)
  "Prayer at Sunrise"
  "Welcome, Great Chief, Father, as you come and show yourself this morning. Let nothing evil befall on me this day which you have fashioned according to your wishes, Great One, Walker-Across-The-World, Chief."
- The yoga Sun Exercise or Soorya Namaskar is a combination of postures (asanas) and breathing practiced early in the morning facing the sun. The sun is considered to be the deity for health and long life. This could be a good morning stretching activity. A further explanation of Soorya Namaskar and other Yogic asanas can be found in a Yoga book in your school or public library.
- Art is an expression of culture. Investigate artists' representation of the sun throughout history.

4. Visit a senior citizens center or home or invite a senior citizen to visit the classroom and conduct an interview, using class developed questions, emphasizing how certain chores were done (cleaning clothes, cooking, keeping warm) and how they contrast with present methods.

5. Divide the class into sections for time periods.
   1. Prehistoric to 1599
   2. 1600-1799
   3. 1800-1899
   4. 1900-present

   Students could research their respective periods and either draw a mural or cut out pictures for a collage to represent energy usage during that time period.

6. a) Investigate the use of solar energy in architecture throughout history, such as Pueblo Indian homes, Roman structures, and the color of early American barns (the red paint was skim milk mixed with iron rust coloring an lime, which absorbed sunlight).

   b) Further discussion could include the differences in architecture caused by the prevailing energy source of that era and available materals; i.e., contrasting Indians tipis or log cabins with the Renaissance Center in Detroit.

7. Study the earlier forms of mass transit: Viking Ships; gondolas; the Nina, Pinta and Santa Maria; Pilgrim ships; covered wagons; stage coaches, etc. How did these modes of travel reflect a use of solar energy?

MORE

The following are activities which can further develop the concepts presented in this unit. Most are familiar projects adopted to the topic of energy generally and in particular energy sources.

1. Make a collage using either pictures depicting an energy source or words describing one, and have students identify the source to which the collage refers.

2. Using poetry, stories or riddles, have students write about an energy source.

3. Make a mobile with either pictures of the different energy sources or the steps involved in the use of those sources (i.e., mining, processing, transportation, generation, transmission and use).

4. Do library research on any of the sources and report the findings to the class.

5. In cooperation with other teachers, develop energy source rooms, each room depicting a different energy source by displays, presentations by students, etc.

6. Draw where an energy source comes from (coal--mined in earth's crust, oil--from wells on land and offshore, solar--sun).

7. Make a booklet with annotated pictures throughout the year while studying energy.

8. Make a display or bulletin board (either teacher or student developed) showing energy source origins, processing and use along with side effects of each (i.e., coal--increased air pollution and strip mining).

SOLAR JUICE COLLECTORS

CONTEXT: K-8
Science

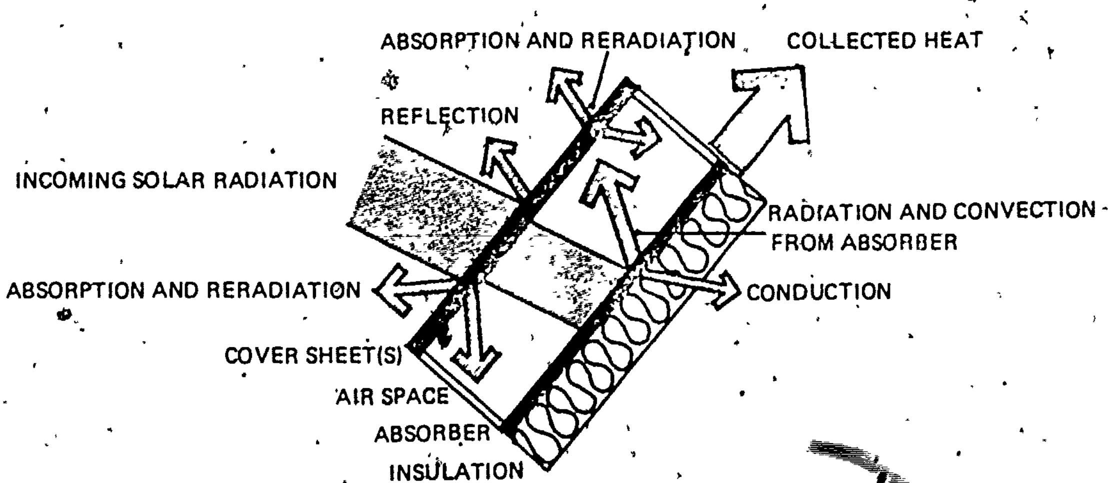
OVERVIEW: This unit is concerned with solar energy collection systems and their efficiencies. By using empty juice bottles, the following concepts will be introduced for collecting the sun's rays: 1) color, 2) insulation, and 3) thermal mass.

The activities are suggested to be used as a unit since all these factors have an effect on the efficiency of a collection system. Two worksheets are provided to graph the circumstances and temperatures of the various bottles: one to chart each separate activity and another to incorporate all the concepts.

We suggest that at the end of each experiment students transfer their data from the individual data sheet to the total data sheet, so that the first can serve as a "rough" copy (in case the students spill their solar-heated water on the sheet), and the second can be left in the classroom and used as a "final" copy.

The activities are written for Grades 4-8 but many of the experiments and ideas can be adapted or used as demonstrations for the primary grades.

Although these experiments are simple, students need to recognize that they actually demonstrate the technology of collecting solar energy.



COLOR

TIME: 30 minutes materials preparation
Five 10-minute intervals throughout the day.

MATERIALS: For each group:
- 3 juice bottles
- black paint
- white paint
- data sheets
- thermometer

*note: Measurement accuracy will be increased by providing one thermometer per bottle.

ADVANCED PREPARATION:
- Reproduce individual experiment data sheet and total data sheet
- collect materials

STUDENT OUTCOMES: STUDENTS SHOULD:
- become familiar with concepts of solar energy collection systems.
- understand the importance of achieving maximum efficiency of the collection system.
- increase their ability to obtain accurate measurement.
- discover solar absorption capacities of different colors.

PROCEDURE: Discussion:

"How is the sun's energy useful to people?"

* *
* STUDENT RESPONSE: By growing food; by keeping us warm; *
* by providing all life on earth. . . *
* *

"How can the sun keep us warm?"

* *
* STUDENT RESPONSE: By providing heat to warm us, to *
* heat our homes, to heat our water. . . *
* *

"Today we are going to set up an experiment in which we will discover how color helps gather (collect) the sun's energy, by using juice bottles which are painted different colors.

Materials Preparation:

1. Distribute 3 juice bottles to each group along with containers of black and white paint.

2. Leaving one bottle clear, paint one white and the other black.

*note: This should be done on the day preceeding the experiment day.

Experiment:

1. Fill each bottle with water, take the temperature and record on the individual experiment data sheet, then set outside in a sunny area that will not be shaded at any time throughout the day.

2. At intervals during the day the temperature in the bottle should be taken and recorded.

3. At the end of the day, students should transfer their data to the total data sheet.

Ask: "If we build a solar collector, what color should we paint it?"

*note: It is assumed that through this experiment students will discover that black has the highest solar absorption capacity. (If they discover otherwise, it is suggested that you send us these students via UPS and we will deal with them swiftly and effectively!!)

EXTENSION ACTIVITY:

1. Compile the class results by taking the data gathered and making a mathematical problem to find the average (or mean) temperature, and then post on a "master data sheet."

2. Repeat the experiment using different colors and combinations of colors on the bottles.

INSULATION

TIME: 30 minutes materials preparation
Five 10-minutes intervals throughout the day.

MATERIALS: For each group:
- 3 "cut-in-half" milk cartons or small boxes
- 3 test tubes or juice bottles
- thermometer
- warm water
- variety of insulating materials (cotton balls, styrofoam chips, fiberglass insulation, newspaper...)
- data sheet

ADVANCED PREPARATION: Collect materials

STUDENT OUTCOMES: STUDENTS SHOULD:
- become familiar with the concepts of solar energy collection systems.
- understand the importance of achieving maximum efficiency of the collection system.
- increase their ability to obtain accurate measurement.
- discover the difference between the insulating values of three materials.
- correlate the importance of insulation and conservation to solar energy collection systems.

BACKGROUND INFORMATION: Conservation plays a very important role in the efficiency of solar energy, as with any energy source. Without a well insulated home, solar energy space heating is not practical.

PROCEDURE: *note: This activity can be used in conjunction with the previous solar energy collection system. By using solar heated water, the correlation between insulation and insolation can be more readily recognized.

1. Each group prepares boxes using insulating materials of their choice, by placing the bottle or test tube in the middle and placing the material around it.

*note: Do not pack--insulation needs air space to be effective.

2. Pour the warm water into the container so that it's half-full (or half-empty), take the temperature and record immediately. Point out the origin of the energy source used for warming: natural gas, coal, oil, nuclear, solar.

3. At intervals throughout the day, record the temperature of each container.

4. At the end of the day students post their results on the total data sheet. Then bring all students together to share their results and draw conclusions on the most effective insulating material.

5. Hypothesize what will happen overnight and measure the next morning.

6. Ask the students to imagine that the bottles are their houses. "Would you put insulation in your house and if so what kind? Is it important to have insulation in a solar home? Why?"

EXTENSION ACTIVITY:

1. Invite a local insulation contractor to come to class to discuss various types of home insulation.

2. Compare difference of insulating capacity by placing material in one box and packing it in another.

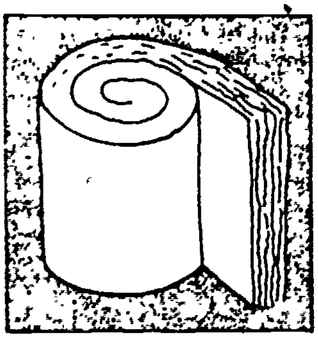
INSULATION: WHAT'S AVAILABLE

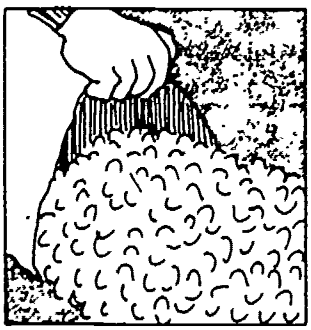
BATTS AND BLANKETS.
Fiberglass or mineral wool (R-3.1).
Suitable for use in unfinished areas. Made in standard thicknesses (generally yielding total R-values of 11, 13, 19, and 22), and in widths meant to fit between wall studs and floor joists. Available with or without vapor barrier. Presents very remote fire hazard.

LOOSE-FILL.
Cellulose (R-3.7), mineral wool (R-3.1), perlite, (R-2.8), fiberglass (R-2.3), and vermiculite (R-2.1).
Suitable for use in both finished and unfinished areas. Can be poured into place between exposed floor joists or blown into finished wall or floor cavities Any loose-fill material may settle in time, thus lowering its R-value. Except for cellulose the risk of fire from loose-fill is remote.

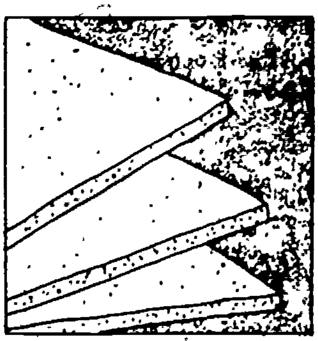
FOAM.
Urea-formaldehyde (R-4.8).
Suitable for use in finished walls. High temperature and humidity can cause the foam to deteriorate and can cause a formaldehyde odor to linger after installation. The foam also deteriorates when exposed to light or open air. Some studies indicate that the foam shrinks for several months after installation, drastically reducing its effectiveness as an insulator. The material will burn, but presents very little risk of fire inside wall cavities. Proper installation is essential, components of the foam must be mixed correctly, injected at the proper pressure, and injection holes must be left open to allow water to evaporate and the foam to cure. Foam-insulation contractors must be chosen with special care.

PLASTIC FOAM BOARDS.
Urethane (R-5.9), polystyrene (R-4.5), and beadboard (R-3.6).
Suitable for use as exterior sheathing, or to cover finished walls. To insulate finished walls, panels of material are attached to an existing wall, then covered with a vapor barrier and, for fire protection, gypsum board at least ½-inch thick. Plastic boards don't shrink or settle, but they are combustible. They *must* be covered with a fire-retardant material, as specified by your local building code.


BATTS AND BLANKETS


LOOSE-FILL


FOAM


PLASTIC FOAM BOARDS

THERMAL MASS

TIME: 30 minutes materials preparation
Five 10-minute intervals throughout the day

MATERIALS: For each group:
- 3 juice bottles
- data sheet
- sand
- water
- thermometer

ADVANCED PREPARATION: Prepare materials

STUDENT OUTCOMES: STUDENTS SHOULD:
- become familiar with the concepts of a solar energy collection system.
- understand the importance of achieving maximum efficiency of the collection system.
- increase their ability to obtain accurate measurement.
- be introduced to the concept of thermal mass and its relation to energy storage.

BACKGROUND INFORMATION: Indians and pioneers understood the concept of thermal mass when they heated rocks in the fire and buried them underneath their beds to eminate heat throughout the night. Matter with more mass holds heat longer than matter with less mass, although it takes more heat to raise the high mass material to optimal temperature.

In most solar homes, great attention and detail is given to thermal mass. During the day, when insolation enters a home, the mass absorbs and stores the energy, keeping the room cool. In the evening when the sun goes down, the mass reradiates the heat back into the room.

PROCEDURE: Materials Preparation:
Prepare three juice bottles by painting them black on the day preceding the experiment. (Bottles used in the previous experiments could be used to conserve resources.)

Experiment:
1. Fill one bottle with air (!?!), a second with water and a third with sand. With the students, determine which is the heaviest.

*note: Although weight and mass are different concepts, they have a direct correlation (mass is determined for a given body by dividing the weight of the body by the acceleration due to gravity).

2. Take the initial temperature of each bottle, record and set all 3 bottles outside where they will receive sunlight for the full day.

3. At various intervals throughout the day the temperature should be taken and recorded.

4. Bring in the bottles, record their temperature at the end of the day, leave them overnight and then be sure and check the temperature again in the morning. This will better demonstrate the concept of thermal mass and storage.

5. Record all the groups' findings on the master class data sheet and compare the results.

*note: It is important that students understand the answers to the following questions:

"Which of the bottles warmed the fastest?"

"Which stayed warm longer?"

"Which is more efficient? Why?"

"What does this mean when solar homes are being built?"

"What materials would be used for thermal mass in a home?"

CONCLUSION: Draw together all the concepts: 1) color of collector; 2) insulation; and 3) thermal mass by asking the class "If you were going to build a solar home, what would you do?

* *
* STUDENT RESPONSE: Paint the collectors black, insulate *
* with ________________ and build in lots of thermal mass *
* like concrete walls and floors. *
* *

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DATA SHEET

TIME	TYPE OF BOTTLE ________	________	________
________	________ F ________ C	________ ________	________ ________
________	________ ________	________ ________	________ ________
________	________ ________	________ ________	________ ________
________	________ ________	________ ________	________ ________
________	________ ________	________ ________	________ ________

TOTAL DATA SHEET

TIME	COLOR EXPERMENT			INSULATION EXPERIMENT			THERMAL MASS EXPERIMENT		
	F C								

A PASSIVE SOLAR HOUSE

CONTEXT: 4-8
Science, Social Studies

TIME: 2 sessions, 60 minutes each

OVERVIEW: By making a model home, students will understand passive solar energy and its use in their lives.

MATERIALS: For each student group of 2 (or 3):

- a cardboard box (up to 12" x 12" x 12")
- a flat piece of cardboard larger than the bottom of the box
- a small piece of posterboard - 2" x 4"
- tree sheet
- a flashlight to simulate the sun
- string - 2' to 3'

* note: You may want students to bring flashlights from home.

ADVANCED PREPARATION:

- Collect materials
- Duplicate tree sheet for each student group

STUDENT OUTCOMES: STUDENTS SHOULD:

- understand the basic features required in a simple passive solar design.
- understand the importance of geographic, climatic and solar factors in relation to design and placement of a house.
- apply the knowledge of physical factors and design features to build a model passive solar house.

BACKGROUND INFORMATION: Passive use of solar energy involves using the sun's energy to heat and cool a structure or substance, without the need for any other energy source such as electricity to power fans or pumps to accomplish this energy transfer.

The underlying principles involved in using passive solar energy for heating and cooling combine various structural patterns with landscaping to have the maximum use of the sun during the cold weather and minimum use of the sun during warm weather. To accomplish these ends, an overall site plan for a building lot must be devised based on some knowledge of the sun's position at various times during the year. Specific features on or near a building lot must be studied to account for their effect on the sun's availability at various times of a day or year. Hills, large trees, and other structures are some of the factors that can directly affect the availability of sunlight for a given locale.

For a new building, certain structural design features will make passive solar heating and cooling attainable. Windows should be maximized on the south side of the building and minimized on other sides. All windows should be double glazed and have thermal shades or shutters. An overhang should be built on any windows exposed to the sun. This cuts out sunlight during the summer and early fall and allows the sun to penetrate during the fall, winter and early spring.

Measures can also be taken in existing buildings to utilize passive solar energy. The house should be properly insulated and weatherstripped to avoid infiltration and conduction heat losses as much as possible. The windows on the sun side of the house should be covered at night with insulating drapes or thermal shutters to keep the warm house air from conducting through cooler windows. Overhangs should be installed.

The landscaping of a building can also contribute to the best use of the sun's energy. Deciduous trees should be located on the sun side of the building. These trees will shade the house in the summer and allow the sun to strike the building during fall and winter.

Coniferous trees should be located on the wind side of the building since wind usually increases infiltration heat losses. Conifers provide very good wind breaks for the prevailing winds in an area, thereby reducing these heat losses.

PROCEDURE: Session I

Review with students the results of their Angle of the Sun experiment.

Concepts include;
- angle of the sun and intensity
- reasons for seasons (earth's axial tilt, length of days and rotation)

2. These concepts will now be applied by building a model passive solar home.

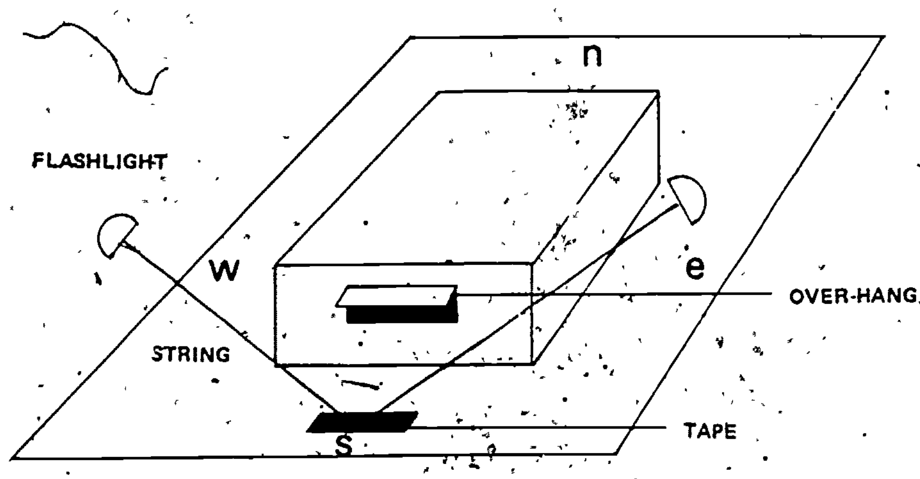
3. On the large piece of cardboard, print North, South, East and West on the appropriate sides. The large piece should be at least 6" larger on each side than the box.

4. Cut an opening to scale to represent a window and place the box on the cardboard.

5. At this point, students will experiment to find the best placement of windows to take advantage of the sun's energy.

6. Tie string to the flashlight, close the lighted end, and tape the other end to the "south" side of the cardboard.

7. Begin by pointing the window side to the north, turn on the flashlight and position it to approximate the sun's position at noon in the winter months (i.e., at a low angle on the south side).



8. Observe how much light is shining into the box, and draw some conclusions about north-facing windows. (Along with the fact that little direct sunlight is available to the north side, windows also represent a greater heat loss than do walls.)

*Note: If this exercise is being done in the wintertime it may be useful to have the student touch a window and an external wall and compare the temperature difference. Windows feel like they let the cold in, but since heat always flows from a warmer space or object to a colder one (a process called conduction), actually the windows let the heat out. The warmth from the student's hand flows to the window.

9. Turn the house so the window now faces south and repeat step 7 and 8 to affirm the southern placement of windows.

Session II

1. During the winter, the maximum sunlight exposure is desired with a minimum of heat loss, but during the summer minimum sunlight exposure is desirable. Therefore, in this session, students will experiment with different ways to shield sunlight from the interior along with landscaping techniques to assist in the heating and cooling of the house.

2. In summertime, the sun's track is higher in the sky resulting in a sharper angle of the insolation than in the winter. An overhang can be used to block the sun's rays in the summer and still allow the rays to enter in winter. Have students cut a piece of posterboard approximately 3/4 of the size of the window, crease the top quarter and tape the overhang over the window. Place the house so the window is facing south.

3. Turn on the flashlight and approximate the sun's position at noon in the summertime (it will still have an angle). Observe the sunlight infiltration. Now move the flashlight down toward the floor to simulate winter noon and observe the sunlight infiltration.

4. "What ways can we block out summer sunlight?"

* *
* POSSIBLE STUDENT RESPONSE: Close drapes during the day, install awnings and/or overhangs, thermal shutters for the windows. . .
* *

5. "What about planting trees? What kind of trees will block out the sun in the summer but let it through in the winter?"

* *
* STUDENT RESPONSE: The kind that lose their leaves in the fall -- deciduous.
* *

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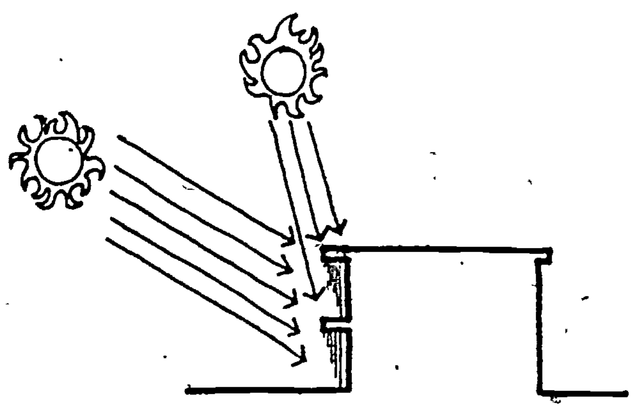
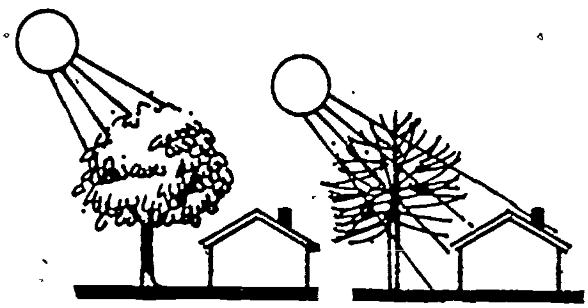
"What kind of trees will block out the wind throughout the year?"

* *
* STUDENT RESPONSE: The kind that never lose their leaves --*
* coniferous. *
* *



WINDOWS USED AS COLLECTORS SHOULD BE SHADED IN THE SUMMER



DECIDUOUS TREES CAN BE USED FOR SUMMER SUN SHADING OF THE DWELLING AND YET ALLOW WINTER SUN PENETRATION THROUGH THEIR BARE BRANCHES FOR SOLAR COLLECTION.

6. Distribute the tree sheet, have the students cut out each tree, and use flashlight (as in Session I, steps 6, 7, and 8) to experiment with the optimal landscaping design.

7. Bring the class together to discuss their findings. "If you were going to build a house, what would you do to provide for passive solar energy?"

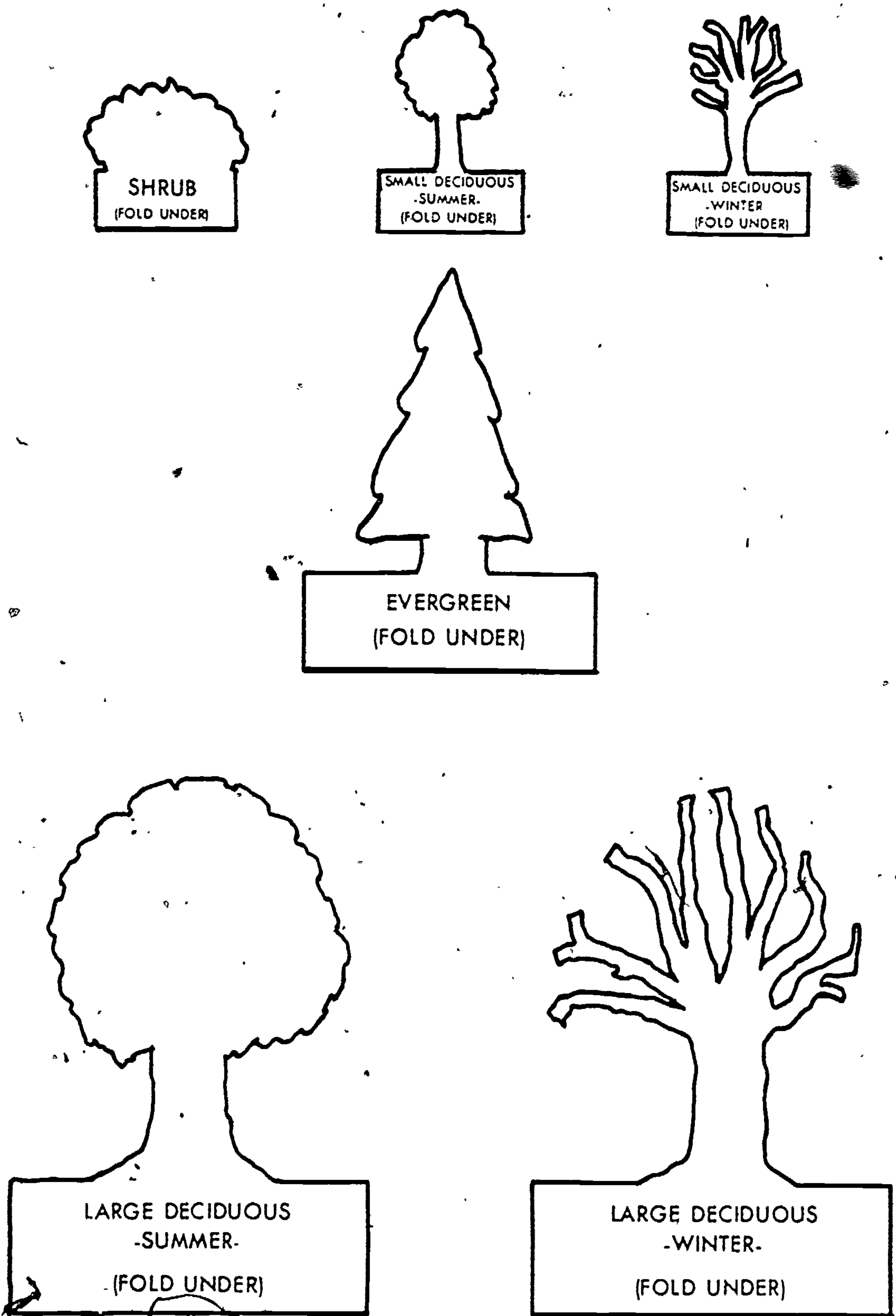
* *
* STUDENT RESPONSE: Put in windows on the south side with as *
* few as possible on the north side; have drapes, thermal *
* shutters, overhangs and/or awnings; plant deciduous trees on *
* the south and coniferous trees on the north. . . *
* *

EXTENSION ACTIVITY:

1. Using the concepts in this activity, students may design their own house with more detail, or perhaps design a solar city as a group or class project.

2. Students could check their own homes or the school for passive solar design and report back to class.

TREE SHEET


SHRUB
(FOLD UNDER)
SMALL DECIDUOUS
-SUMMER-
(FOLD UNDER)
SMALL DECIDUOUS
-WINTER
(FOLD UNDER)
EVERGREEN
(FOLD UNDER)
LARGE DECIDUOUS
-SUMMER-
(FOLD UNDER)
LARGE DECIDUOUS
-WINTER-
(FOLD UNDER)

SUNNY SIDE OF THE STREET

CONTEXT: 4 - 8
Social Studies, Science

TIME: Session I - 50 minutes
Session II - 40 minutes

OVERVIEW: By drawing an outline students will determine the passive solar features of their own house.

MATERIALS: For each student:
- drawing compass
- paper

ADVANCED PREPARATION: NONE

STUDENT OUTCOMES: STUDENTS SHOULD:
- determine where the sun rises and sets in relation to their own house.
- recognize passive solar features of the school.
- recognize passive solar features of their own house.

BACKGROUND: We recommend that students complete the "Passive Solar House" activity before attempting this activity. If this has not been done, be sure the students understand the concepts presented in that activity.

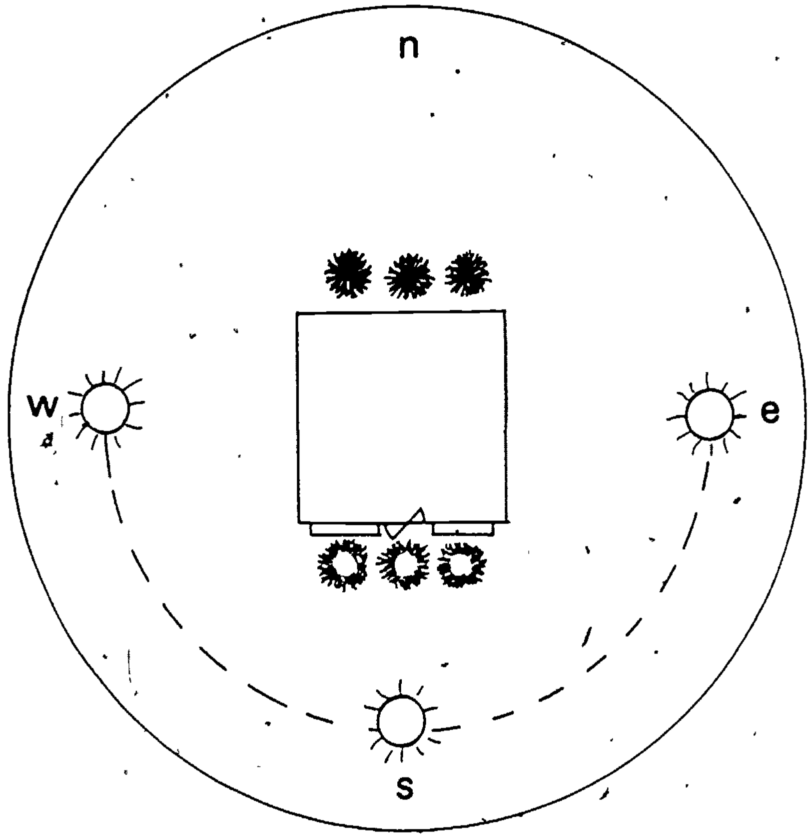
PROCEDURE: Session I

1. Review the concepts necessary for a passive solar home. Tell the students they are to determine if their own house has any passive solar features.

2. In preparation for the activity, use the school as a laboratory. Walk around the building, determine the direction it faces, the classrooms directly benefiting from solar energy, the location and types of trees and any other passive solar features.

3. Return to the classroom and draw what has been observed. Do this step by step, drawing first on the chalkboard and then assisting individual students in drawing their own outlines.

   a) Draw a large circle and label to represent the directions.



b) Inside the circle, draw the following:
- an outline of the school showing the direction it faces, including doors and windows.
- trees on the property, coniferous and deciduous
- the path of the sun

*note: Step 3 could be completed at another time.

4. In order to complete Session II students should walk around their own house determining the passive solar features just like they did the school. If they are uncertain about the direction the house faces, they should ask their parents or use a compass.

Session II

1. Have the student repeat step 3 of Session I using their own house.

2. When the drawings are completed discuss the results. Include such questions as:
   - Can any of the houses be considered to be passive solar houses?
   - Which houses have good passive solar features?
   - Could passive solar features be added (trees, awnings, overhangs...)?
   - Have any of the houses added solar collectors?
   - What conservation measures have been taken (caulking, weatherstripping, dialing down...)?

EXTENSION ACTIVITY:

1. Using the same procedure draw a floor plan for an "ideal" passive solar house.

2. Use this activity in conjunction with a unit on mapping.

BUILD A SOLAR BROCCOLI COOKER

CONTEXT: 4-8
Science, Social Studies

TIME: Variable

OVERVIEW: Solar models are valuable for students to build in order to gain first-hand experience in concepts of solar energy systems.

MATERIALS: Description included in each model

ADVANCED PREPARATION: Before deciding on which model to use, determine the concepts desired and then examine the materials list carefully, basing choice on cheap, local, available materials.

STUDENT OUTCOMES: STUDENTS SHOULD:
- be able to apply solar energy collection concepts to construct their own models.
- be able to test and modify models to meet their own needs and the environmental factors.
- exhibit skills in following directions and constructing models.

PROCEDURE:

1. Review with students the concepts and uses of solar energy collection.

2. After deciding on a solar model, the following steps might be taken:

   a) Decide on how materials will be acquired (be sure to emphasize renewable or recycled materials).

   b) Decide on format, whether individual, small group or class project.

   c) Find resource persons inside or out of school who have had experience with solar energy collection systems to be "technical advisors" to the projects.

   d) After the models have been constructed, hold a solar energy demonstration on the school grounds for other classes to come and observe the projects.

3. These projects are valuable hands on activities, but they need to be incorporated with other solar energy activities for students to understand the nature, the potential, and the problems of solar energy.

* The following instructions for solar models were taken directly from Connections by the National Center for Appropriate Technology (NCAT).

How the Solar Models Work

Solar Water Heater:

A metal container for water is painted black and placed in the focal point of a triangular reflective box. The open side of the box is covered with clear plastic. The sun shines through the plastic and is absorbed by the black can, heating the water. The silver sides of the box reflect the sun's rays to the container in the center of the box, further contributing to the heating of the water.

Solar Cooker:

A rotisserie-like half cylinder, lined with aluminum, is angled toward the sun. The cylinder reflects solar heat to the center, where a wire is mounted like a spit on a rotisserie.

Solar Dryer:

A box painted black absorbs the sun's heat. An opening in the box is slanted for better exposure to the sun. Plastic is placed over the opening to keep the heat in. Holes are cut in the bottom and top of the box to draw cool air in and circulate the hot air out. The cool air is drawn in at the base and the hot air moves out the top, carrying with it the moisture released from the drying foods. The screens suspend the food so air can easily circulate and the drying process is accomplished rapidly. Legs under the box allow air to circulate underneath.

Solar Air Heater:

Air is heated and circulated through this cardboard model of a window heater. A cardboard box (about 3 inches in depth) is painted black on the inside surface and taped to the inside of a sunny window (south-facing is best). If no window is available it is covered with saran wrap or vinyl or polyethylene to simulate the glass surface of the window. The black surface of the box faces outside, absorbing heat from the sun. A system of air ducts cut into the back of the box allows cool air to be drawn in from the room at the base, heated, and circulated out the top back into the room. Plastic flaps act as backdraft dampers to keep the box from cooling air, rather than heating it, when the sun goes down.

Tips for Successful Solar Models

Preparation: The model building goes much faster and is much easier if the painting is done ahead of time. The shellac can be diluted. It is used to seal the cardboard to prevent infiltration of the paint. The black paint is applied after the shellac has had a few hours to dry.

The Correct Aim: The models should be directly aimed at the sun at all times. You'll find adjustment in aim will be needed at least every half hour to be directly in line with the sun's rays. With the solar cooker you should be sure to aim the half-cylinder directly at the sun. A good way to check if you are directly aligned with the sun's rays is to check for shadows in the inside corners of the model boxes. If there is any shadow, it should be equal on both sides of the box. Another good indicator is to insert a nail, or other thin, long object, directly in the front and center of the various models (you'll have to locate an appropriate spot for each model). When your model is aimed correctly, the nail will cast its shadow straight back. Another method for aligning the solar cooker is to stand in front of the cooker and focus the glare from the reflectors on the rotisserie spit.

Keep Clean and Tight: Keep the reflector area and plastic covering of the various models clean and tightly attached. Dust will prevent full reflection and a loose plastic covering will hinder sun absorption as well as reflection.

Results

The models were made by a sixth grade class in Butte and tested in the classroom as well as at NCAT Through trial and error we found success with each model. We'd like to share some of the results of our tests and provide the intrepid teacher with practical suggestions to make his or her course a little smoother than the course we pursued.

The Solar Cooker:

This model is popular as an elementary school project because it is simple to make and hot dogs are a popular food item with youngsters. However, since other lessons in the curriculum stress the nutritional value of food in its original form, we tried to find other foods that would cook as well, if not better, than the hot dog.

It took up to 45 minutes to cook a hot dog on an 18" solar cooker in Butte on a hot summer day (about 80°). We placed a polyethelene cover over the rotisserie and were able to cook a hot dog in about 20 to 30 minutes. The polyethelene was taped to the back of the cooker and around the sides.

We also experimented with marshmallows, pieces of vegetables, corn on the cob and a whole apple We found surprising success with the apple and recommend it as the most nutritious, tasty, cookable food for the cooker. Using the cover, we baked an apple in about 1 hour. Its appearance was similar to that of an apple baked in an electric oven and it tasted better! If you let it cook until it is quite soft (another 15 to 20 minutes), you can peel it and mash it for apple sauce.

Virtually anything will cook, if placed properly on the rotisserie. Use your imagination to come up with a new food idea. One thing to remember is that the darker the color of the food, the faster and more efficiently it will cook. Marshmallows reflect the sun and cook slower than hot dogs. We had thought corn would be an ideal food, but found the light yellow color a deterrent to cooking. We also skewered an unhusked ear of corn on the cooker and found the corn would cook in 45 minutes to an hour, but somehow the flavor of freshly steamed corn was lost in the slow process.

The spit of the rotisserie should be strong enough to hold without bending whatever you want to cook; if not, the spit will bend and the food to be cooked will not be in the focal center of the cooker. Make sure you keep the holes for the spit small, so it will fit tightly and hold in place when the food is rotated.

The larger the cooker, the faster the food will cook. Our model is about 18 inches. If you are able to secure larger pieces of cardboard, we heartily recommend building a larger cooker. You'll find your cooking time dropping in direct proportion to the size of your cooker. Using a plastic or polyethelene covering is recommended; it will speed up the process considerably.

The Solar Water Heater:

The water heater may be the most effective demonstration project suggested here. Make sure the plastic covering used is tight around the box and the heater is aimed directly toward the sun and you'll find sure success. Of course, a sunny, clear day is the best time for testing any of the models, but our experiments showed that the water heater will perform under relatively adverse conditions.

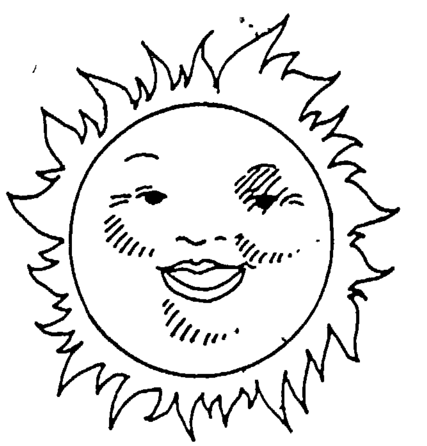
First, we tested on a clear, warm day (about 85°) in Butte We began with very cold water from the tap. In less than an hour the water was face-washing warm; in two hours, it was beginning to steam and good for making tea; in three hours it was too hot to touch. On a cloudy, cooler summer day (about 70°) in Butte the water heated to face-washing temperature in four hours.

The Solar Dryer:

We found the most success with apple slices in this solar model. An apple was cored and peeled and sliced in 1/4" sections. The sections were placed on the screen in the dryer, spaced so they did not touch In about 6 hours they had dried to tasty tidbits that could rival any product found on the store shelf We also tried apricots. They took two days to dry (we put them out for two days for about 7 hours each day) and were good, but not as good as the apple slices. If placed in a sunny location, the solar dryer will work well inside. If you are worried about browning of the fruit, soak the sections in a salt water solution (1 teaspoon salt to 1 gallon water) and rinse well before drying We did not soak our apples and had no trouble with browning.

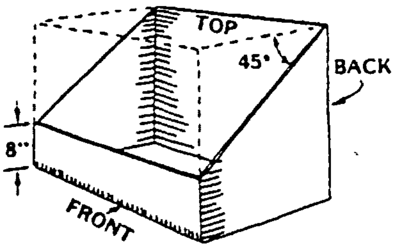
Things to Remember:

Various factors will determine the degree of success you will find with the models. We tested in Butte, elevation 5500 feet, where the temperature rarely reaches above 80 degrees and the growing season is rarely longer than 70 days. However, we tested usually on clear, sunny days, some of the warmest days of the year We would suggest you try the models on the clearest days possible It is easiest to experiment with them outside on a warm, sunny day, but if you can find a room with good south and west exposure you can angle the models so they are exposed to the sun and your results should be similar to outside experiments. Be sure to have the models angled directly to the sun and stress the importance of the focal point being in direct alignment.



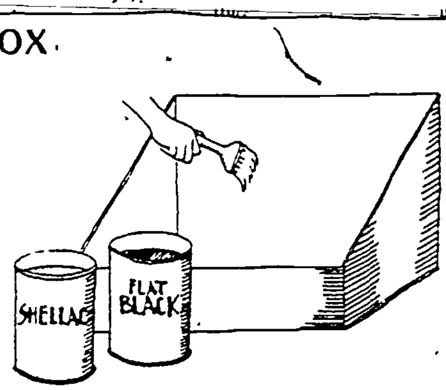
HOW TO MAKE A SOLAR FRUIT DRYER

Find a box with dimensions that will leave about 8" in front when a 45 degree angle is made from the top corner.



1 FIND THE RIGHT BOX.

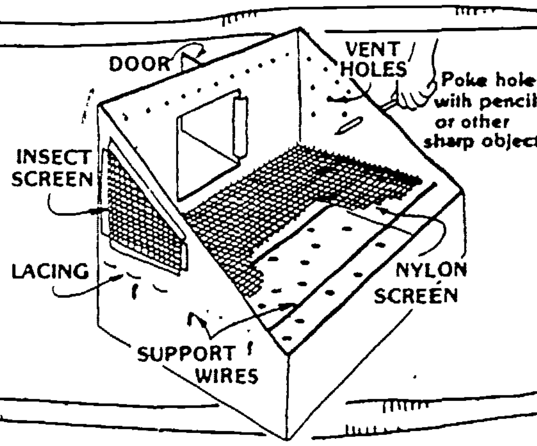
Cut a section out of the box as shown.
The entire inside of the box needs to be black. You can either glue black construction paper to the inside with "Elmers" glue, or you can paint it.
If you choose to paint, first brush on a coat of shellac, let dry for 5-7 hours, then paint with a flat black enamel or latex paint.



2 PREPARE THE BOX

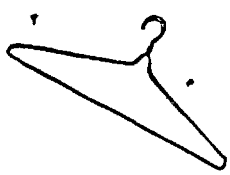
Next, cut a door in the back of the box large enough to let your hand through, plus whatever you will be putting in to dry. Reinforce the uncut, hinging part of the door with a piece of duct tape.

Poke holes in the bottom and sides as shown with a sharp pencil. (about 30 holes).

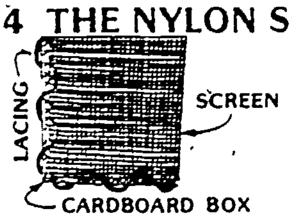


3

Make 3 or 4 screen support wires out of a thick wire such as a coat hanger wire, and stick them through the box near the bottom as shown and bend down the ends.



4 THE NYLON SCREEN



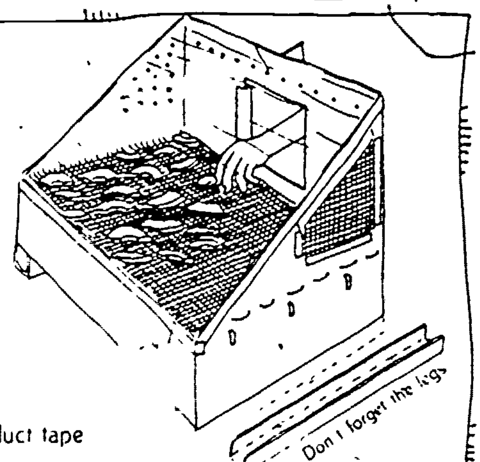
Get some nylon flyscreen material and cut it larger than the bottom of the box, so that the edges can be turned up and laced to the sides of the box.

5 GLAZING THE DRYER BOX

Use "Saran Wrap" or clear vinyl to cover the open top of the box.

Fasten the edges down with silver duct tape

Make 2 legs out of cardboard and fasten them to the bottom with duct tape as shown



INSECTS?

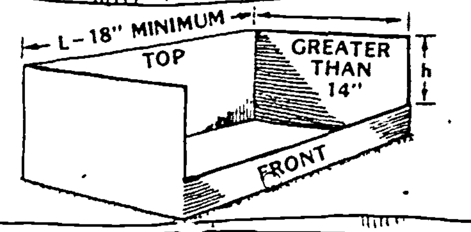
If so, cover the vent holes with more of the nylon screen and fasten it with duct tape

HOW TO MAKE A SOLAR COOKER

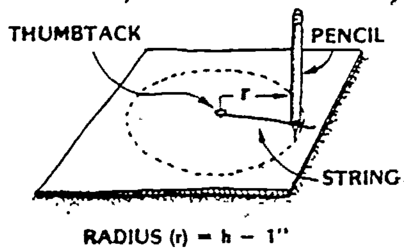
1 Begin with the Frame

You'll need a cardboard box that is strong and in good condition. A long, rectangular box will work better than a short, square one.

Cut the top and front out of the box as shown. The size of this box will determine the size of your cooker.

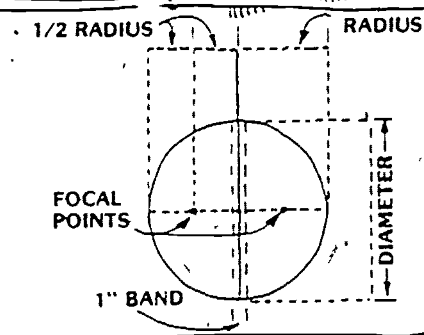


2 Next, the Semi-Circular Ends

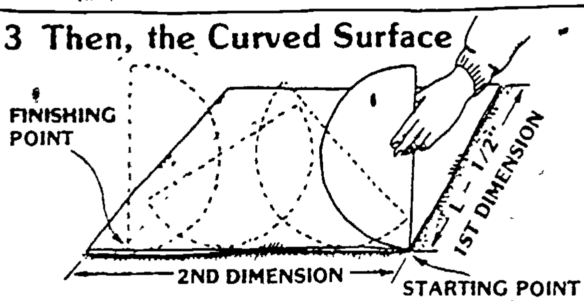


Cut a circle out of cardboard with a radius that is 1" less than the height of the front opening (h) of the frame box.

Locate the focal points as shown and cut out a 1" band, centered along the diameter.



3 Then, the Curved Surface



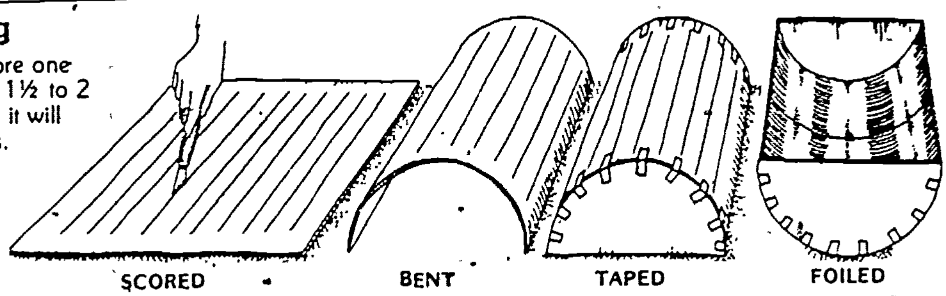
You'll need another piece of cardboard for this part.

The first dimension you need is about 1/2" shorter than the length of the frame (L).

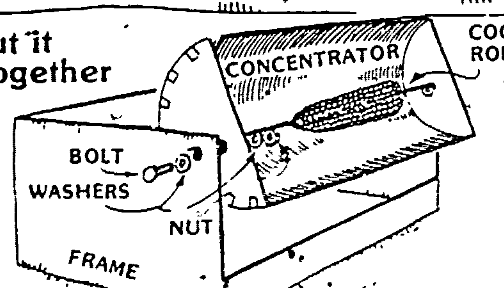
The second dimension is a little more difficult. Start the point of the semi-circular end piece as shown and roll the curved edge along the other unmeasured edge of the cardboard. Be careful not to slip or scoot it. Mark where the other point ends (and maybe add about 1/2"). This distance is your second dimension.

4 Scoring and Taping

After cutting this piece to size, score one side (but don't cut through) every 1½ to 2 inches with lines as shown so that it will bend easily around the end pieces. Tape the end pieces to the curved piece and cover the inside with aluminum foil. Rubber cement works well for htis, just be sure to read directions.



5 Put it Together

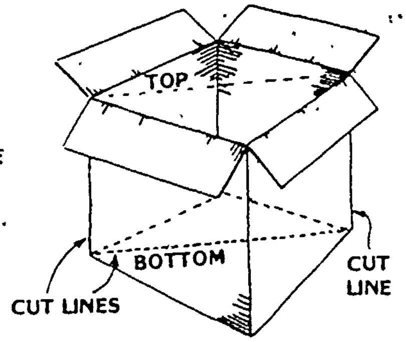


Take an unpainted thick wire and hold over a flame to burn off any excess oily substance, then push wire through the focal points of the curved concentrator to make the cooking rod.

Connect the concentrator to the frame with bolts, nuts and washers as shown.

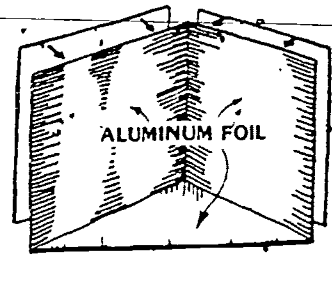
HOW TO MAKE A SOLAR WATER HEATER

1 Cut a Cardboard Box in Half Diagonally:



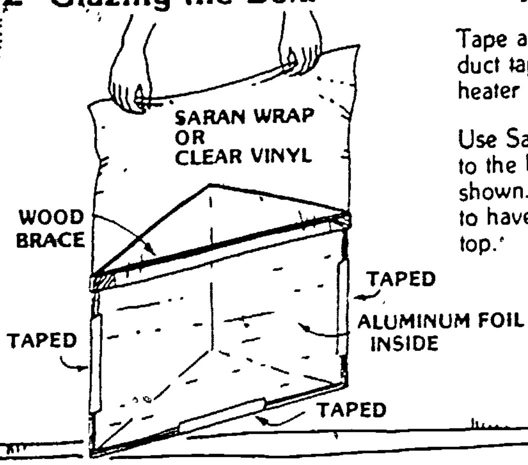
Cut the box in half along the diagonal as shown, leaving a triangular shaped top & bottom. Then cut of the top triangle

The left-over piece has two sides that can be cut out to fit flat onto the sides of the remaining half-box. Glue alumninum foil to these two pieces with Rubber cement (be sure to read the directions on the label), then tape them to the sides of the half-box. These side pieces will add some thickness to the walls & help keep heat inside.



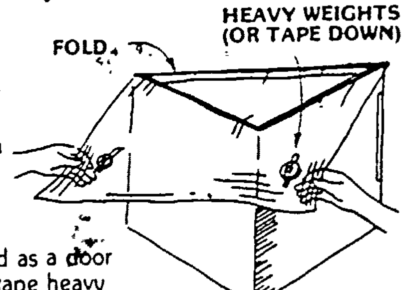
Cover the bottom with alumninum foil in the same manner.

2 Glazing the Box:



Tape a small stick of wood with silver duct tape across the top corners of the heater box as a brace.

Use Saran Wrap or clear vinyl & tape it to the bottom & sides of the box as shown. Make sure it is cut long enough to have some left over to fold over the top.



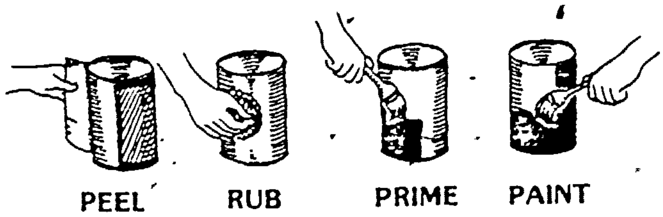
The fold-over flap can be used as a door to get into the box. You can tape heavy weights to the corners for holding it shut or just use tape for as long as it sticks.

3 The Water Can

Use any can, about 1 quart size & without leaks.

Peel off any labels & rub the can with steel wool or fine sandpaper to dull the shiny finish.

Brush the can with a metal primer, let it dry completely, then paint it with a flat black enamel or latex paint



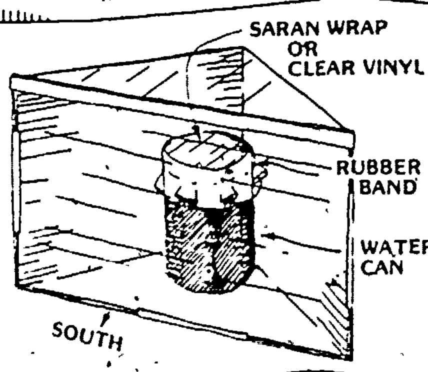
4 Set Up the Water Heater

Open the top of the heater box.

Fill the water can, cover the top of it with Saran Wrap or clear vinyl, & wrap a rubber band around the top of the can to seal it.

- Place the filled can on the bottom of the heater box & close the top flap. Be sure it is well-sealed.

Face the front of the box to the south & 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 water cans and jars

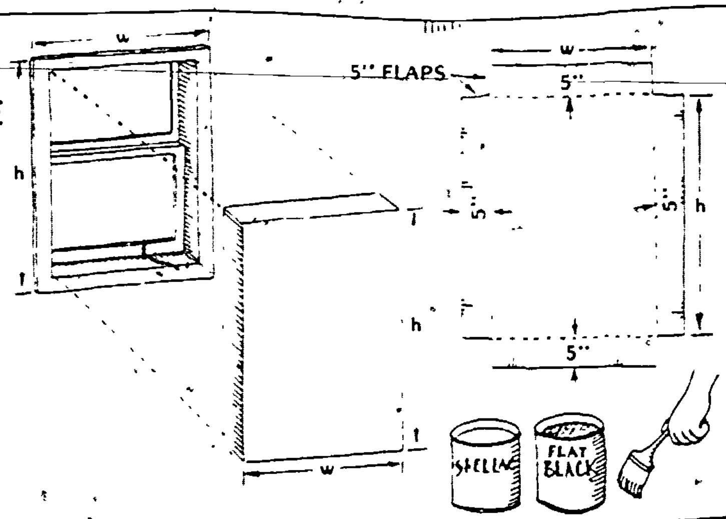


HOW TO MAKE A SOLAR AIR HEATER

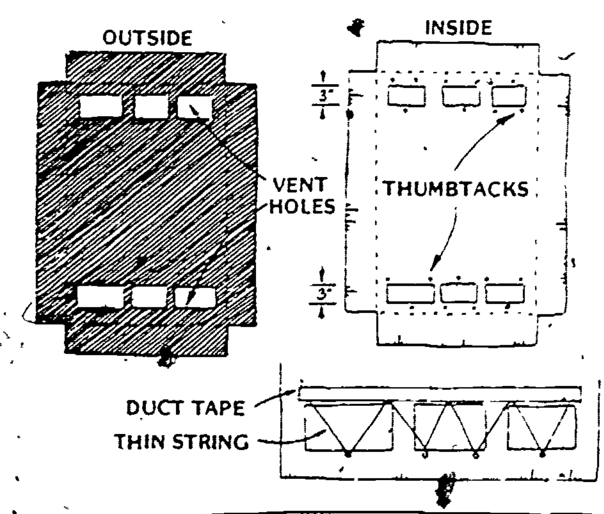
1 MEASURE A SOUTH-FACING WINDOW TO BE USED AND FIND A LARGE ENOUGH PIECE OF CARDBOARD

Cut the cardboard to fit snugly inside the window frame.

Brush one side with shellac, then after drying for 5-7 hours, paint it with flat black enamel or latex paint



2 THEN MAKE THE VENT HOLES



Cut them near the top and bottom at least 3" high

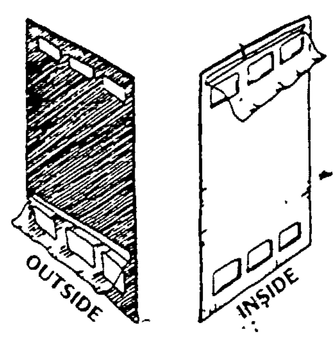
Push thumbtacks into the cardboard around the vent holes as shown.

Weave some thin string around the thumbtacks and across the vent holes

Cover up the thumbtacks with silver duct tape to keep them from falling out.

Get some thin plastic film (like food wrap — but not wax paper) and cut it large enough to cover the vent holes.

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



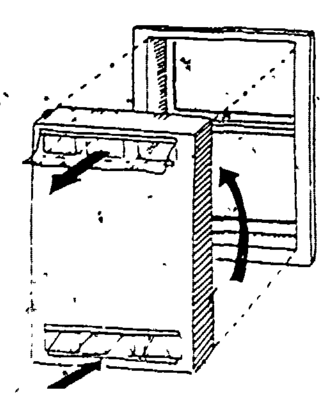
3 NOW YOU CAN INSTALL THE HEATER

Place the cardboard, black side facing the window, top vents up, (so that the plastic flaps hang down over the vent holes), then tape it to the window frame with masking tape.

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

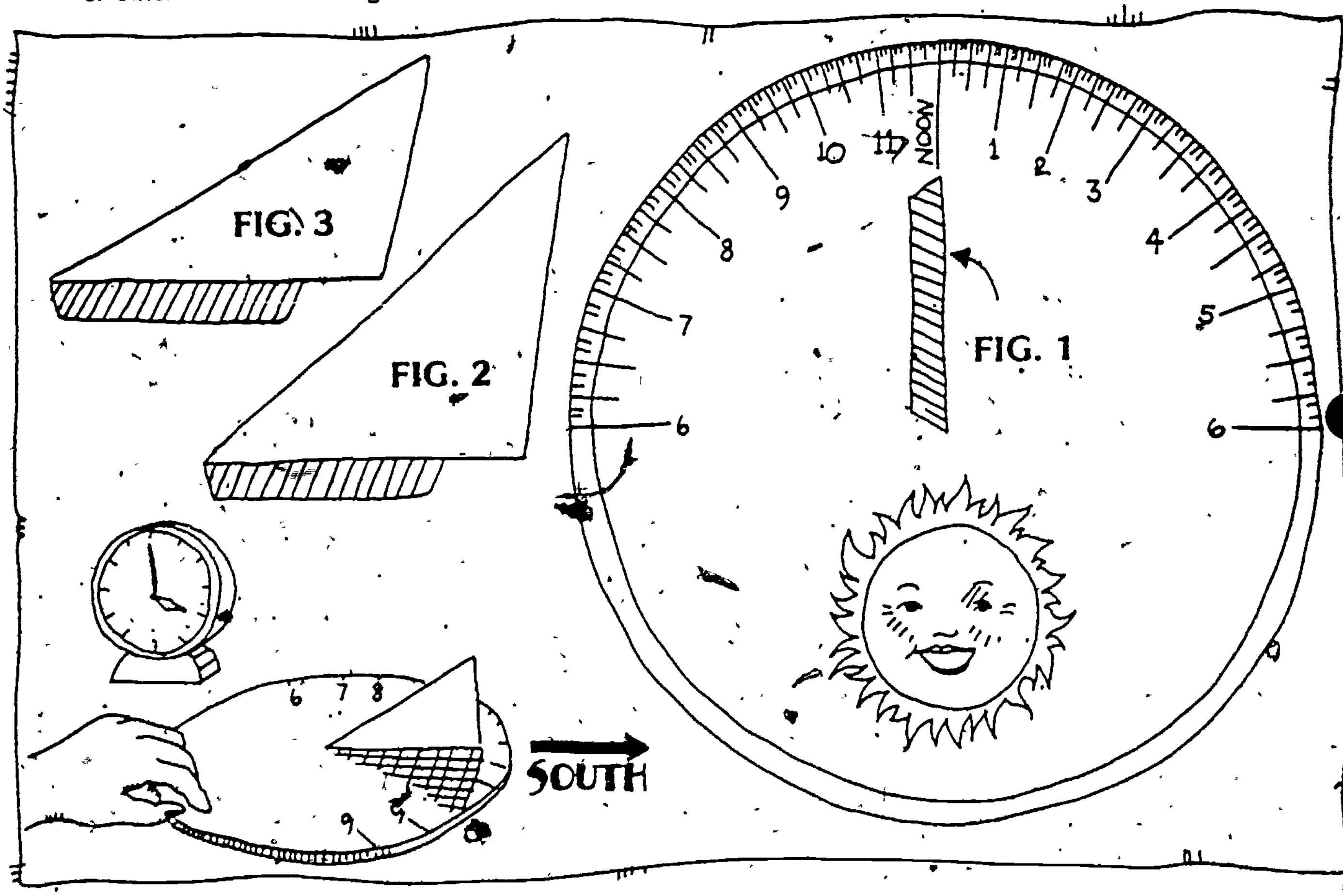
Don't leave the masking tape on the window frame too many days, or it may pull the paint off with it.

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



HOW TO MAKE A SUN DIAL

If you live in the North cut out figures 1 and 2; if you live in the South cut out figures 1 and 3. Use rubber cement to glue the paper figures to a piece of cardboard; cut along the lines through the paper and the cardboard. Use a sharp knife or other tool to cut through the cardboard circle where shown. Insert the base of the triangle (gnomon) through the circle (dial) so it stands at a right angle with the gnomon aligned directly along the noon axis. Bend and glue the gnomon to the back of the dial.



Be sure the dial is kept directly aligned along the noon axis. Otherwise the shadow cast by the gnomon will be off. To determine true North point the sun dial in a northerly direction; look at the time and position the dial so the correct hour shows on the dial. **Remember**: The sun knows no daylight savings time. If you are using an adjusted time frame, base your time of day on standard time and set the dial to North accordingly. Pick a place for the dial that you know will receive sun throughout the day. Be sure your dial is secure and won't be moved by wind, weather or living things. Check the dial at different times of the day to see if it is keeping good time.

There are a few factors that could throw your sun dial off slightly. We all live in time zones; your location in the zone could effect in a small way the time the sun dial gives you. Also, the angle of your gnomon may not be precisely correct for your latitude. The gnomon cut-outs are angles that reflect the number of degrees of latitude for average U.S. North and South locations. (North: 45 degress; South: 30 degrees). If your latitude varies far from either of these angles you might want to measure another angle that precisely reflects your latitude and cut the gnomon to that size.

DANCE WITH THE WIND

CONTEXT: K - 3
Social Studies, Language Arts, Science, Art

TIME: 30 minutes

OVERVIEW: Through sensory discovery students will develop an awareness of the relationship between solar energy and the wind.

MATERIALS: For each student:
- paper
- crayons

ADVANCED PREPARATION: None

STUDENT OUTCOMES: STUDENTS SHOULD:
- understand the relationship between solar energy and the wind.
- further develop sensory awareness.
- further develop gross motor skills.

BACKGROUND INFORMATION: Wind is a form of solar energy. It is created as the sun heats the earth unevenly which causes the movement of air. (Hot air rises and cool air moves in to take its place.)

PROCEDURE:

1. Take the students outside and have them find some evidence of the wind. They should not tell anyone what they have found.

2. Have individual students or pairs of students act out what they have found. The rest of the class should guess what evidence of wind the students are demonstrating.

*note: To emphasize the variability of the wind speed and why it is so difficult to use, this part of the activity should be repeated on a windy day.

3. Discuss with the class:
   a. What causes the wind?

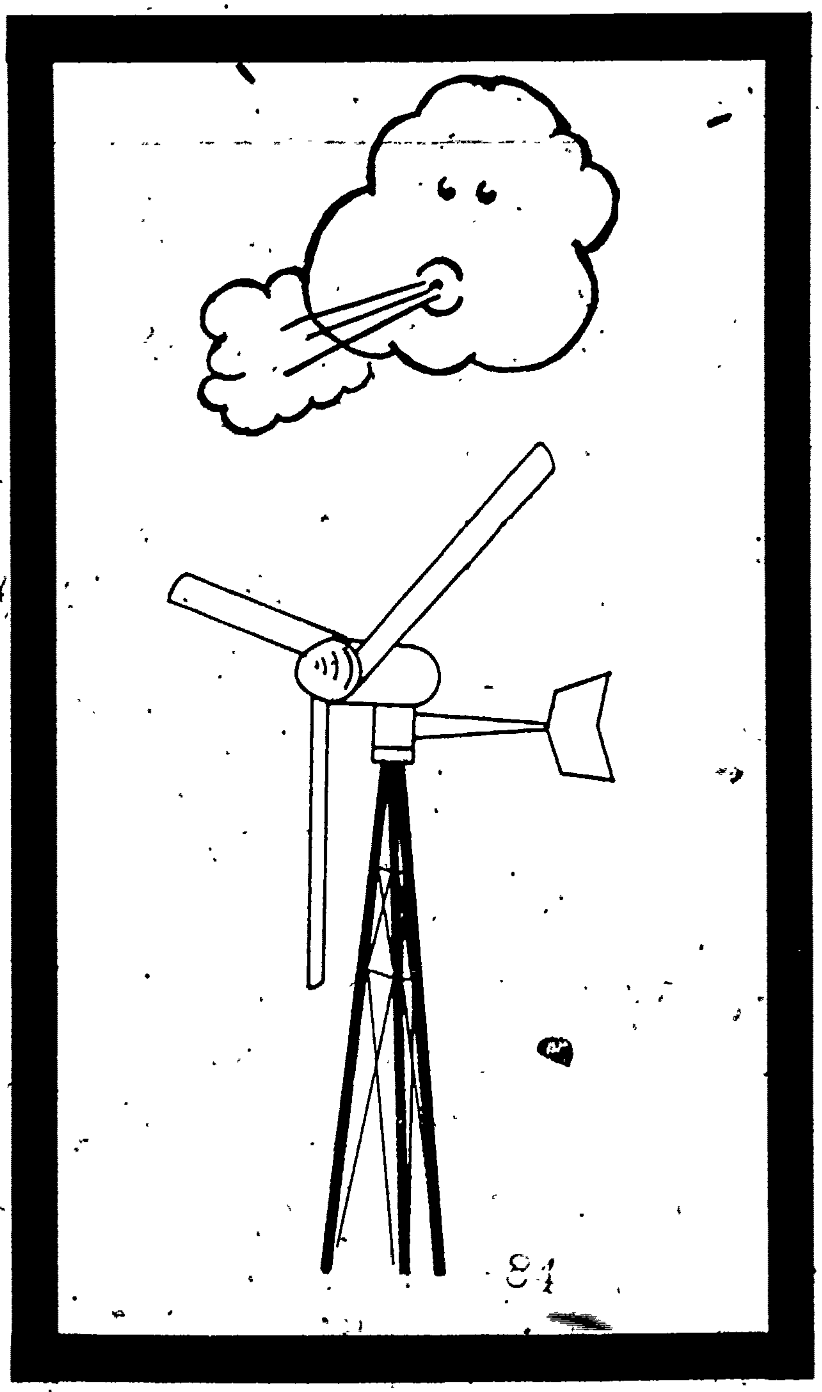
*note: At this level it is enough for the students to recognize that the wind is a form of energy that comes from the sun.

b. How can wind power be used?

* *
* STUDENT RESPONSE: dry clothes, move seeds, sail ships, *
* fly gliders, kites, planes, turn windmills. . . *
* *

4. Have the students draw a picture of a way we use the wind.

EXTENSION ACTIVITY: Have the students create a dance (repeat the movements they were doing during the outside activity) which shows how the energy of the wind moves things. This dance could be put to music.



RISE AND SHINE

CONTEXT: K - 8
Science

TIME: 40 minutes

OVERVIEW: Through demonstration or experimentation students will develop an understanding of the relationship between solar energy and wind energy.

MATERIALS:
balloon
small mouth bottle
2 pans
hot plate
punk stick or frayed rope
matches

ADVANCE PREPARATION: Determine if the activity will be a demonstration or student experiment and collect appropriate materials.

STUDENT OUTCOMES: STUDENTS SHOULD:
- understand the characteristics of air movement such as hot air rises and cold air moves in to take its place.
- relate this understanding to weather and wind.
- postulate how this wind energy might be harnessed.
- increase experimentation skills.

BACKGROUND INFORMATION: Wind is a form of solar energy. It is created as the sun heats the earth unevenly which causes the movement of air. (Hot air rises and cool air moves in to take its place.) It is important for students to conceptualize this idea. Thus, we urge you to actually have the students do an experiment to prove that hot air rises. There are many experiments designed to do this. We have included one version. Check your science text for other examples.

PROCEDURE:
1. Place a balloon over the top of a small mouth bottle. Ask the children what is in the bottle? (air)

2. Before doing each step of the demonstration or experiment ask the students what they think will happen and why and then proceed to determine if their prediction (hypothesis) is correct.
   a) Place the bottle in a pan of hot water. (The balloon will inflate as the air expands.)
   b) Heat the pan of hot water. (The balloon will get larger.)

c) Place the bottle in a pan of cold water. (The balloon will collapse as the air cools and contracts.)

d) Place the bottle back in the pan of hot water. After the balloon has inflated, remove it and hold a smoking punk stick or piece of smoking frayed rope over the open bottle. (The smoke will rise at it is carried by the warm air.)

*note: For the primary grades this part of the experiment could be done as a demonstration.

3. Discuss what the students have learned and relate it to the characteristics of wind. In general terms, the air over land heats and rises and colder air moves in to take its place creating wind.

4. Ask "What factors influence the movement of air?"

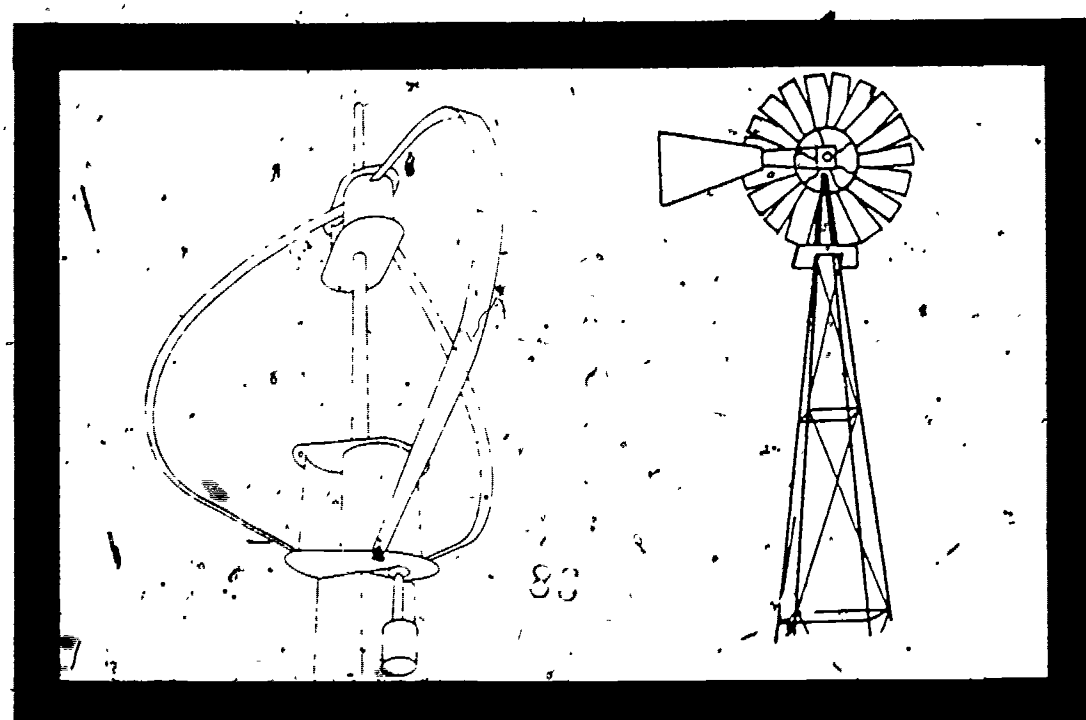
* *
* STUDENT RESPONSE: atmospheric conditions, obstructions, *
* (i.e., mountains, or high buildings); surface, (i.e, *
* land, water, asphalt). . . *
* *

5. Ask "How can we use this natural phenomenon?"

EXTENSION ACTIVITY:

1. Have the students measure the temperature in the classroom at various levels starting with the floor and in various locations in the classroom. Before beginning have then predict what they think will happen.

2. Do the same activity outdoors.



EVERYONE KNOWS IT'S WINDY

CONTEXT: 4 - 8
Science

OVERVIEW: Through observations and/or experimentation students will recognize some of the wind patterns in their area.

MATERIALS: For experiment:
- protractor
- string or fishline
- ping-pong ball or other type of weight

For observation and experiment:
- Wind Speed Record Sheet

ADVANCE PREPARATION: Duplicate record sheet

STUDENT OUTCOMES: STUDENT SHOULD:
- recognize the variability of the wind.
- improve their skills of observation.
- improve their record keeping ability.

BACKGROUND INFORMATION: Although wind can be harnessed to generate electricity certain drawbacks need to be recognized. Winds must constantly remain over 8 - 10 miles per hour. Storage mechanisms such as batteries must be used. If this source of electricity is used with a backup system of the local utility company special arrangements need to be made. This activity will help students recognize the need of a thorough investigation before a windmill is built.

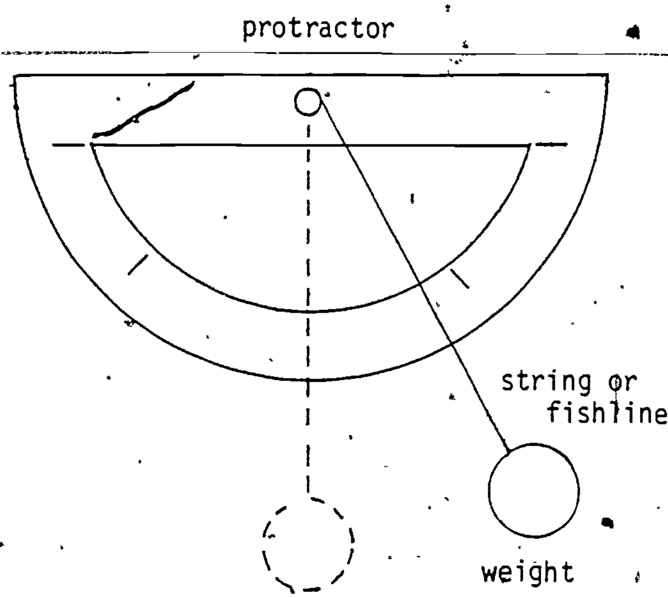
PROCEDURE: Observation

1. Over a period of several days, and several times each day, have the students use the Beaufort Wind Scale, (included) to estimate the speed of the wind in several locations on the school ground. Record the observations.

Experiment

1. Build a device to measure the wind by attaching a weight such as a ping-pong ball or anything with a large surface area, to catch the wind to a protractor with light string or monofilament fishing line.

2. Use this device to calibrate the wind speed. Follow the strategy outlined for the observation and use the device with the wind speed calibration chart.



* note: This activity could be completed by having the students work in pairs, one to complete the observation and one to complete the experiment.

Discussion
When the observations and experiments have been completed discuss the results.

- Are wind speeds the same everywhere on the school grounds?

- Are wind speeds the same throughout the day?

- How can the wind speeds be described (i.e. steady, gusty...)?

- Would it be practical to have a wind mill to generate electricity for the school?

EXTENSION ACTIVITY:

1. Wind speed can be measured by using an anemometer. Check your science text book for directions.

2. Include the activity as part of a unit about weather, emphasize the wind speeds associated with different kinds of clouds.

WIND SPEED CALIBRATION SCALE

angle	mph*
90	0
85	5.8
80	8.2
75	10.1
70	11.8
65	13.4
60	14.9
55	16.4
50	18.0
45	19.6
40	21.4
35	23.4
30	25.8
25	28.7
20	32.5

*miles per hour

BEAUFORT WIND SCALE

* mph = miles per hour

Beaufort number	Description*	Observation
0	calm (0-1 mph)	smoke rises vertically
1	light air (2-3 mph)	smoke drifts slowly
2	slight breeze (4-7 mph)	leaves rustle; windvane moves
3	gentle breeze (8-12 mph)	twigs move; flags extended
4	moderate breeze (13-18 mph)	branches move; dust and paper rise
5	fresh breeze (19-24 mph)	small trees sway
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 KABOOM!

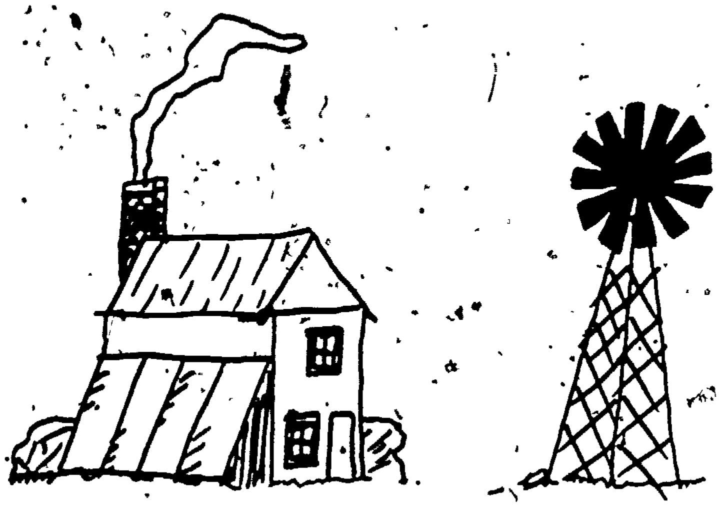
WIND SPEED RECORD SHEET

location										
date	time	speed								

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

SUN
GAS
WIND
LIGHT
SOLAR

WOOD
COAL
BTU
OIL
ENERGY



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

PHOTOSYNTHESIS
SOLAR
CONSERVATION
OIL
INSOLATION
SPECTRUM
IMPORTS
KILOWATT
GAS
HYDROELECTRIC
LIGHT
WOOD
GEOTHERMAL
BIOMASS
BTU
WIND
FOSSIL FUELS
SUN
ENERGY
BARREL
COLLECTOR
SYNFUEL
COAL

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

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

RESOURCES

This is the place where voluminous lists of organizations and materials are usually found. Sorry to disappoint you, but numerous bibliographies and resource searches have been done and need not be repeated here. Inclusion or exclusion does not constitute endorsement by the Michigan Energy Administration.

Listed below are some resources available for solar energy information. Those marked with an asterisk (*) can be obtained by calling the Energy Administration Clearinghouse toll-free hotline (1-800-292-4704).

*1980 Solar Energy Information Locator
Solar Energy Research Institute
1617 Cole Boulevard
Golden, CO 80401
1-303-231-1415

This is a resource for finding information about solar energy. It includes government, private and citizen organizations along with periodicals (does not include a bibliography).

Solar Energy Education Bibliography, Beth Wagner
Center for Renewable Resources
1001 Connecticut Avenue N.W., Suite 510
Washington, D.C. 20036
1-202-466-6350

Separated into elementary, secondary, and college levels, this is a comprehensive listing of books, periodicals and audio-visuals dealing with solar energy. The current cost is $3.25 + 15% postage and can be ordered directly from the Center for Renewable Resources.

*Solar Bibliographies and Fact Sheets
National Solar Heating and Cooling Information Center
P.O. Box 1607
Rockville, MD 20850
1-800-523-2929

Operated by the Franklin Research Center for the U.S. Department of Housing and Urban Development and Department of Energy, the Center has published a number of bibliographies and fact sheets dealing with solar retrofit, greenhouses, economics and other specialized topics.

<u>Connections</u>, Joan Melcher
National Center for Appropriate Technology
P.O. Box 3838
Butte, MT 59701
1-406-494-4572

This curriculum unit, appropriate for grades 5 and above, serves as an introduction to the concepts of appropriate technology (including solar energy) and is the material from which we took the solar models.

Cooperative Extension Service

Bulletin Office
Michigan State University
Box 231
East Lansing, MI. 48823
517/355-2308

The Bulletin Office has numerous publications on energy topics, many dealing with solar energy including wood.

Agriculture and Natural Resources Education Institute (ANREI)
Michigan State University
410 Agriculture Hall
East Lansing, MI. 48823
517/355-6580

ANREI has books and audio-visuals (slide-tapes and films) dealing with solar energy on a loan basis for a nominal charge.

Local Utility Company

Most utilities have an education and information division which have materials for educators.

Local Community Colleges and Universities

Many colleges have individuals who are working on solar energy projects and can identify other sources of information.

Jordan College
360 W. Pine Street
Cedar Springs, MI. 49319

Jordan College puts on workshops, provides classes and has information dealing in solar energy.

GLOSSARY

ACTIVE SOLAR ENERGY SYSTEMS (see SOLAR ENERGY SYSTEMS -- ACTIVE)

ABSORBER OR ABSORBER PLATE -- A sheet of materials, usually copper, aluminum, or steel, which absorbs solar heat and conducts it to the transfer medium. In some systems, this function is performed by the side of the building or by interior masonry elements like floors and walls.

BARREL -- Although seldom put in actual "barrels," crude oil is measured in a unit called the barrel, equal to 42 U.S. gallons. One barrel of crude oil has the same energy as 350 pounds of coal.

BIOCONVERSION -- A general term describing the conversion of one form of energy into another (fuel) by plants, algae, municipal wastes, etc. It usually refers to the conversion of solar energy by photosynthesis. It may also refer to conversion of organic wastes into usable fuels like methane.)

BIOMASS -- Material that was recently part of a living system--such as garbage, agricultural wastes, or specially-grown crops--from which energy may be derived.

BREEDER REACTOR (see NUCLEAR ENERGY -- BREEDER REACTOR)

BRITISH THERMAL UNIT (BTU) -- An engineering unit of heat; the quantity of heat necessary to raise the temperature of one pound of water one degree Fahrenheit, about one-quarter of a Calorie.

CALORIE -- A metric unit of heat energy--the amount of heat needed to raise the temperature of one gram of water one degree Centigrade.

CHEMICAL ENERGY (see ENERGY -- CHEMICAL)

COAL -- A solid fuel, mostly carbon, formed from the fossils of plants living hundreds of millions of years ago.

COLLECTOR -- A device to trap the sun's radiation and convert it to usable heat. A well-designed building with south-facing windows may be considered a collector in the broad sense of the term. In its most common usage, collector refers to a panel made up of an absorber plate and glazing (a glass or plastic surface), surrounded by an insulated frame. (see also ABSORBER PLATE)

CONCENTRATOR -- In solar terminology, a reflector or lens designed to focus a large amount of sunshine into a small area, thus increasing the temperature. (In wind terminology, a device or structure that increases the speed of the wind.)

CONDUCTION -- The transfer of heat energy from molecule to molecule within a substance such as heat transferred from a hand to a cold surface.

CONSERVATION -- Planned management of natural resources to prevent exploitation, destruction or neglect; the use of natural resources in a way that assures their continuing availability to future generations.

CONVECTION -- The transfer of heat energy by moving masses of matter, such as liquid or gas circulation. Convection is demonstrated in the natural upward movement of warm air and its replacement with cool air.

CRUDE OIL -- Liquid fuels formed from the fossils of animals and plants at the bottom of ancient seas; raw materials from which most refined petroleum products are made.

DEGREE-DAY -- A unit which describes the severeness of a particular climate. The number of degree-days for a particular day equals 65°F minus the average outdoor temperature for that day.

ELECTRICAL ENERGY -- (see ENERGY -- ELECTRICAL)

ENERGY -- 1. Strength of expression. 2. Potential forces; inherent power; capacity for vigorous action. 3. The capacity for doing work and overcoming resistance.

ATOMIC ENERGY -- The energy released during reactions of atomic nuclei (see also NUCLEAR ENERGY).

CHEMICAL ENERGY -- A form of energy stored in the structure of atoms and molecules, which can be released by a chemical reaction.

ELECTRICAL ENERGY -- The energy associated with electric charges and their movements; measured in kilowatt-hours.

GRAVITATIONAL ENERGY -- The force by which every mass or particle of matter attracts and is attracted by every other mass or particle of matter.

HEAT ENERGY -- Energy that flows from one body to another because of a temperature difference between them. The effect of heat resulting from the motion of molecules; measured in Calories or BTU's.

MECHANICAL ENERGY -- Energy of motion of material bodies and the phenomena of the action of forces on bodies.

RADIANT ENERGY -- Energy that travels in waves especially electromagnetic radiation, as light, x-rays, gamma rays, etc.

ENTROPY -- A measure of the degree of disorder in a substance or system: entropy always increases and available energy diminishes (see also SECOND LAW OF THERMODYNAMICS).

ENVIRONMENT -- The sum of all external conditions and influences affecting the life, development, and ultimately the survival of an organism.

ENVIRONMENTAL IMPACT -- The effect any given technology or strategy to save or produce energy has upon the environment.

FISSION (see NUCLEAR ENERGY -- FISSION)

FOSSIL FUELS -- Coal, petroleum, natural gas; this term applies to any fuels formed from the fossil remains of organic materials (plants and animals) that have been buried for millions of years. The ultimate source of energy for those plants and animals was the sun.

FUEL -- A substance used to produce heat energy by burning, chemical energy by combustion, or nuclear energy by fission.

FUSION (see NUCLEAR ENERGY -- FUSION)

GENERATOR -- A device that converts heat or mechanical energy into electrical energy.

GEOTHERMAL ENERGY -- The heat energy available in the earth's subsurface, believed to have been produced by natural radioactivity; the temperature increases by about 1°F for each 100 feet of depth.

GRAVITATIONAL ENERGY (see ENERGY -- GRAVITATIONAL)

GREENHOUSE EFFECT -- The trapping of infrared radiation (from the sun and normally bounced, or reradiated, back into space by the earth) by carbon dioxide and water vapor built up in the earth's atmosphere, similar to the process inside a greenhouse.

HEAT ENERGY (see ENERGY -- HEAT)

HYDROELECTRIC POWER -- Energy released in the form of electricity when water falling to a lower level is caused to turn a turbogenerator.

CONVENTIONAL HYDROELECTRIC PLANT -- A power plant that utilizes stream flow only once as the water passes downstream.

PUMP STORAGE HYDROELECTRIC PLANT -- An energy storage system in which reversible pump turbines are used to pump water uphill into a storage reservoir. The water can then be used to turn the turbines when it runs downhill.

INSOLATION -- The amount of solar radiation (direct, diffused, or reflected) striking a surface exposed to the sky; measured in watts per square meter or BTU's per square foot per hour.

INSULATION -- A material with high resistance (R-value) that retards the passage of electricity, heat and sound. Examples of some materials used as insulation are fiberglass, cellulose and mineral wool.

INTENSITY -- The amount of energy of heat and light per unit area.

KINETIC ENERGY -- The energy of motion. The ability of an object to do work because of its motion.

KILOWATT(KW) -- A unit of power equal to 1,000 watts, 3,410 BTU's, or 1.341 horsepower.

LEAD TIME -- The time that elapses between the inception of an energy-producing or -conserving idea, process, etc., and the implementation of it to actually produce or conserve energy.

MECHANICAL ENERGY - (see ENERGY -- MECHANICAL)

NONRENEWABLE ENERGY SOURCE -- A mineral energy source which is in limited supply, such as fossil (gas, oil, and coal) and nuclear fuels.

NUCLEAR ENERGY -- The harnessing of energy in the nuclei of atoms either by splitting heavy atoms (fission) or joining light atoms (fusion) to generate electricity.

BREEDER REACTOR -- A nuclear reactor so designed that it produces more fuel than it uses. Uranium 238 (92 U-238) or thorium 232 (90 TH-238) can be converted to the fissile fuel, plutonium 239 (94 PU-239) or uranium 233 (92 U-233), by the neutrons produced within the breeder reactor core.

FISSION -- The splitting of heavy nuclei into two parts (which are lighter nuclei), with the release of large amounts of energy and one or more neutrons.

FUSION -- The process of combining the nuclei or centers of two light atoms to form a heavier atom, releasing great quantities of energy. The sun produces its energy by fusion.

OCEAN THERMAL ENERGY CONVERSION (OTEC) -- A process of generating electrical energy by harnessing the temperature differences between surface waters and ocean depths.

OIL SHALE -- A sedimentary rock found mostly in the Western United States which can be heated to release an oil-like material, kerogen.

PASSIVE SOLAR ENERGY SYSTEM (see SOLAR ENERGY SYSTEM -- PASSIVE)

PAYBACK PERIOD -- The length of time, usually expressed in months or years, that it will take for an energy conservation investment to pay for itself in energy savings.

PETROLEUM -- An oily, flammable liquid that may vary from almost colorless to black, and occurs in many places in the upper strata of the Earth. It is a complex mixture of hydrocarbons and is the raw material for many products.

PHOTOSYNTHESIS -- The conversion of radiant energy (sunlight) to chemical energy by the action of chlorophyll in plants and algae.

PHOTOVOLTAIC (SOLAR) CELL -- A cell mounted for exposure to light and connected through a sensitive current meter to terminals, converting solar energy directly into electricity. Sunlight striking certain materials (silicon is most commonly used) causes the release of electrons. The migration of the released electrons produces an electricial current. The conversion process is called the photovoltaic effect.

POTENTIAL ENERGY -- "Stored" energy. Energy in any form not associated with motion; such as that stored in chemical or nuclear bonds, or energy associated with the relative position of one body to another.

RADIANT ENERGY (see ENERGY -- RADIANT)

RADIATION -- The emission and diffusion of rays of heat, light and electricity. The flow of energy, including solar energy, via electromagnetic waves.

RENEWABLE RESOURCE -- A resource derived from an endless or cyclical source, such as the sun, wind, falling water (hydroelectric) or biomass.

RETROFIT -- To modify an existing building through the application of a new design or additional fittings, such as a solar heating or cooling system, a greenhouse or insulation, to improve its energy efficiency.

SOLAR CELL -- (see PHOTOVOLTAIC CELL)

SOLAR ENERGY -- The use of radiant energy from the sun for heating and cooling or electricity.

SOLAR ENERGY SATELLITE -- Vehicle orbiting in space which will beam solar energy to earth in the form of microwaves, which will then be converted to electricity.

SOLAR ENERGY SYSTEM -- A system comprised of components for collection, storage, transportation (transmission) and control to make use of the sun's energy.

> ACTIVE SOLAR ENERGY SYSTEM -- A system using collectors and water or rock heat storage devices and relying upon mechanical means of distribution like fans or pumps to heat and cool buildings and provide hot water.
>
> PASSIVE SOLAR ENERGY SYSTEM -- A system for solar heating and cooling which requires no mechanical devices to operate, like buildings designed and constructed to collect and store solar energy themselves.

SYNFUEL (SYNTHETIC FUEL) -- The conversion of coal into fuels to be used instead of natural gas (gasification) or petroleum (liquification).

TAR SANDS -- Sandy geologic deposits that contain a low-grade heavy hydrocarbon bitumen.

THERMAL MASS -- The characteristic of a material that allows it to store heat. Water has a greater thermal mass than stone or concrete which in turn retains more heat than wood.

THERMODYNAMICS -- The science and study of the relationship between heat and other forms of energy.

FIRST LAW OF THERMODYNAMICS -- Matter and energy can neither be created nor destroyed, only transformed from one form to another.

SECOND LAW OF THERMODYNAMICS -- At each step of transformation, matter is changed into a less usable form and energy is lost through dissipation.

TIDAL POWER PRODUCTION -- Harnessing the energy of the daily ocean tides by means of power plants designed to produce electricity.

WEATHERIZATION -- The process of decreasing the energy needs of a building through reducing winter heat loss and summer heat gain. Examples of weatherization techniques are: weather stripping around doors and windows, caulking cracks and insulating the walls and roof, using storm windows. ...

WIND ENERGY -- The process which converts mechanical energy from the wind to electricity, heat, or fuel, which is used directly or stored.

Grade Level ______

Subject area ______

Solar Spots Questionnaire

1. Were the instructions easy to follow?

   NO — YES, definitely

   1 2 3 4 5

2. Was there enough background information?

   NO — YES, definitely

   1 2 3 4 5

3. To what extent does the material fit into your curricula?

   Not at All — Very well

   1 2 3 4 5

4. To what extent do your students find the materials interesting?

   Not at all — Very interesting

   1 2 3 4 5

5. To what extent is the content of the material appropriate for your students?

   Not at all — Very appropriate

   1 2 3 4 5

6. To what extent have the materials contributed to your students' awareness and understanding of the role of solar energy in the U.S.?

   No Contribution — Considerable Contribution

   1 2 3 4 5

7. In your opinion what are the strengths and weaknesses of Solar Spots?

   Strengths: ______

   ______

   ______

   Weaknesses: ______

   ______

   ______

8. How did you obtain Solar Spots?

   _____ Called the Energy Hotline _____ Attended a workshop

   _____ Other ______
   specify

9. For the activities you have used, please circle the number that best depicts your opinion of that activity. Also indicate if you will use that activity again.

Title	Poor				Excellent	Use Again?
A Corny Look at the Sun	1	2	3	4	5	____
Sunlight and Plant Growth	1	2	3	4	5	____

FOLD AND STAPLE

Title	Poor			Excellent		Use Again?
A Human Sun-Earth System	1	2	3	4	5	______
What Causes Rainbows?	1	2	3	4	5	______
Angle of the Sun	1	2	3	4	5	______
Turn on to Energy	1	2	3	4	5	______
Modus Operandi	1	2	3	4	5	______
Energy Questions	1	2	3	4	5	______
Problems/Solutions	1	2	3	4	5	______
Run For Energy Relay	1	2	3	4	5	______
History of Solar Energy	1	2	3	4	5	______
More ______________ specify	1	2	3	4	5	______
Solar Juice Collectors:						
Color	1	2	3	4	5	______
Insulation	1	2	3	4	5	______
Thermal Mass	1	2	3	4	5	______
Passive Solar House	1	2	3	4	5	______
Sunny Side of the Street	1	2	3	4	5	______
Build a Solar Broccoli Cooker ______________ specify	1	2	3	4	5	______
Dance with the Wind	1	2	3	4	5	______
Rise and Shine	1	2	3	4	5	______
Everyone Knows It's Windy	1	2	3	4	5	______
Puzzles	1	2	3	4	5	______

Stamp

Michigan Department of Commerce
Energy Administration
6520 Mercantile Way
Suite 1
Lansing, MI. 48910

Attention:
Education Unit