Summary: Students will learn how and why the sun heats different items.

Solar Explorations

Grade Level: K-4 (5-8)

Subject Area: Science

Setting:
Classroom and outdoor setting

Time:
Preparation: 50 minutes
Activity: Two to three 50-minute periods

Vocabulary:
Energy, Heat, Solar energy, Temperature

Major Concept Areas:
Theme II
- Development of renewable energy resources
  - Solar energy

Academic Standards:
SC: A.8.6, A.8.8, B.8.4, C.8.1, C.8.2, C.8.4, C.8.6, C.8.7, C.8.9, C.8.10, D.8.4, D.8.8, D.8.9, G.8.7

Getting Ready:
Paint the insides of one shoebox white, another black, and line a third box with aluminum foil. Set up stations for students to fill the soup cans with sand/soil, water, shredded paper, and salt.

Objectives

Students will be able to explain what role colors and/or materials play in solar energy production and energy efficiency.

Rationale

Understanding how different colors and/or materials are heated by the sun helps build a basis for understanding solar energy and the implications of solar energy as a potential heat source.

Materials

See materials listed under ***Sun Experiments***.

Background

For more information, see the ***Renewable Energy Fact Sheets*** in the Appendix. Energy from the sun can be categorized in two ways: heat and light.

Solar energy is used to heat the air and water for applications such as space heating, pool heating, and water heating for homes and businesses. These technologies are solar thermal since they use the heating properties of solar energy. Solar thermal collectors are often mounted in a sunny spot like the roof of a building.

The color of the solar thermal collector plays an important part in collecting the sun's heat. Dark colors collect more energy than light colors. Therefore, a dark panel will collect more energy than a light panel. Darker colors are commonly used in the construction of solar panels.

Photovoltaic (PV) technology converts the sun's light energy directly into electrical current. The electrical current can be used right away or stored in a battery for future use. PV panels come in many shapes and sizes. You can see them on buildings or on roadside construction signs. New technologies are being developed to incorporate PV panels into building materials such as shingles.

Photovoltaic panels mounted on the roof supply the household with electrical energy.

Solar panels collect thermal energy from the sun to heat water for household use. Picture from North Carolina Sustainable Energy Association.

Procedure

Orientation

Ask students which they would wear on a hot summer day – a black or a white shirt. Explain to students that they will be exploring how the sun affects materials and colors. Place an incandescent lamp so it shines on a piece of white paper and a piece of black paper for at least fifteen minutes. Ask students which paper will be hotter and why. Allow students to go feel the paper to see if they were correct.

Steps

1. Have students conduct the ***Sun Experiments***.
   NOTE: ***Sun Experiments*** includes a variety of ways students can explore different aspects of the sun and how sunlight is absorbed by other objects. You may want to conduct each experiment as a class or in small groups. Older students may conduct the experiments on their own at individual stations.

2. Tell students that they will be asked to figure out what happened in the experiments. They should think carefully about their answers and then discuss what they think with classmates.

Closure

Have students record and discuss the results.

Assessment

Formative

- Are students able to identify which colors absorb the most light?
- Why do students think it might be important to know which materials absorb light?
- Can students explain which substances retained heat the longest after being removed from the sun?

Summative

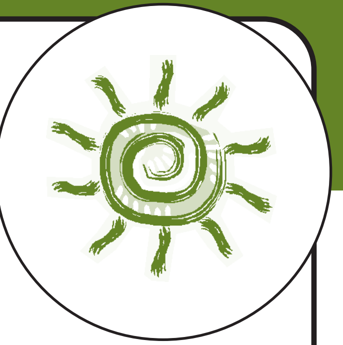
Show students pictures of different types and colors of roofing materials (black roof, tin roof, clay, etc). Have students discuss what type of roof would maintain cool temperatures in a house and why. Ask them what material collects the sun's energy most effectively and could be used to build solar panels.

Extension

Which will cool a building better – changing its black roof to white or adding a roof garden? Gather three identical cardboard boxes (copy paper boxes will work well), three thermometers, black and white paint, a bag of potting soil, several small plants, and aluminum foil. Paint the top of one box black and another box white. Plant a garden on the top of the third box by making a shallow pan with the aluminum foil. Fill pan with about an inch of potting soil and plant several small plants. Keep the soil moist, not wet, during this entire experiment. Place the three boxes in a sunny spot with a thermometer inside each one. Record the temperatures inside the box for one week as well as the weather outside (sunny, cloudy, raining, etc.). Check the temperature at 10:00 a.m. and at 2:00 p.m. Use the information gathered to determine which box stayed the coolest.

Sun Experiments

Visit the KEEP Web site for more renewable energy investigations



Solar Soup Cans

Materials:

- 16 soup cans
- Four shoeboxes and lids
- At least four thermometers
- Salt
- Sand/soil
- Water
- Shredded paper
- Black paint
- White paint
- Aluminum foil
- Paint brush
- Plastic wrap
- Masking tape

* A data sheet for Solar Soup Cans is located on the KEEP Web site on the *Doable Renewables* Support Page.

Divide students into four groups: A, B, C, and D. Have each group fill up four soup cans with water, sand/soil, shredded paper, and salt. Give Group A the shoebox with a black painted interior. Group B will use a box painted white inside. Group C will use a box lined with aluminum foil, and Group D will use a box without a painted inside (should not be black or white). Have students place thermometers in each can. Take an initial reading for each substance. Have each group place the soup cans in their boxes and set them in a sunny window. Cover each box with plastic wrap and secure it with masking tape.

At 10-minute intervals, students should read and record the temperature of each substance. They can stop after they have taken four or five temperature readings. Put lids on the boxes and remove them from the sun. After 15 minutes and again after 30 minutes, take the temperatures of the substances by quickly removing the lids and checking the thermometers. Record data on data sheet provided on Web site (or create your own).

NOTE: For younger grades, simplify the activity to test one aspect, either colors or materials.

Solar Balloon

Materials:

- 2 large, thin black garbage bags
- Scissors
- Tape

Select one bag, but do not open it. Lay the bag on a flat surface and, using scissors, cut open the sealed end of the bag. Get another plastic bag and do not cut off the end. Align the uncut bag with the first bag so that the cylinder will be closed off at one end. Tape the adjoining open ends of the two bags together (instead of using tape you can use a low setting on an iron to seal the ends of the bags). This should result in a two-bag cylinder or solar balloon with one closed end.

When it is sunny and the winds are calm, take the solar balloon into a large open area free of obstacles. While holding the bag open walk or run to inflate the balloon. Using kite string, tie off the open end of the bag leaving extra string to hold onto the solar balloon. If there is a breeze, stand upwind of the balloon. The balloon may start to slide across the ground. If it does, walk with the balloon until it starts to rise on its own. Ask students, what does the color of the bag have to do with absorbing heat? Why did the bag begin to rise? (Molecules in the bag started to heat up and move faster which then caused more pressure inside the bag). Before deflating the balloon, open one end and have students observe the temperature inside the bag.

Sun Prints

Materials:

- Light-sensitive photographic paper (available at a photography or craft store)
- Various objects to form negative images on paper (e.g., paper clips, pencils, combs)
- Cardboard (large enough to cover photographic paper)

Practice by putting objects on regular paper. When you find a pattern you like, sit in a dark area and arrange the objects on the light-sensitive paper (you'll need to prepare these in a dark room). Cover the arrangement and the light-sensitive paper with cardboard, and carry it into the sunlight. Remove the piece of cardboard and expose the arrangement to the sun for about two minutes. Take the objects off the light-sensitive paper. Quickly rinse the paper in developing liquid or water (this process should be done by an adult unless water only is used).

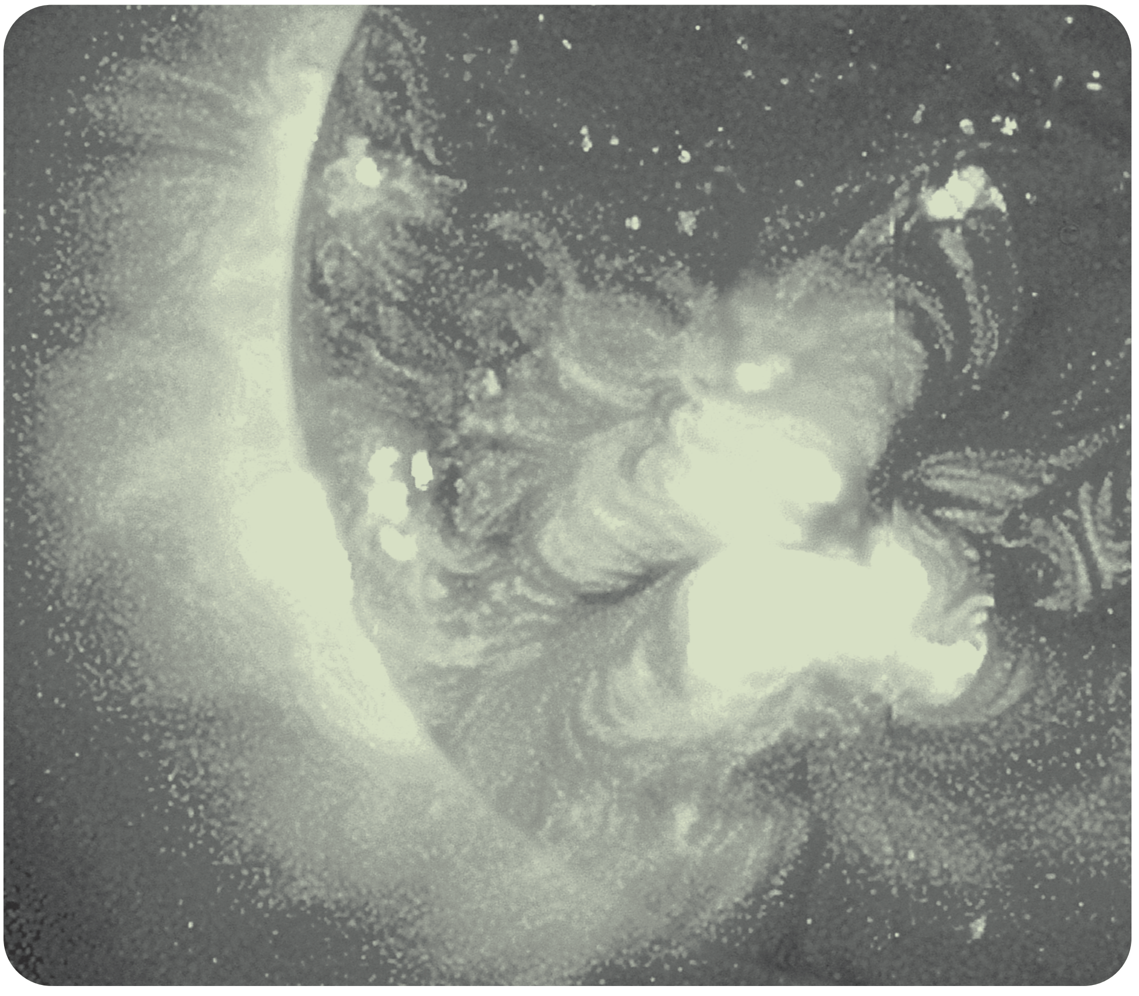
NOTE: A simpler version of this activity is to use dark construction paper and cover portions of it with designs and letters you've cut out. The uncovered portions will be bleached by the sun when left in the sun for at least four hours. The covered portions will retain the original color. Weigh down the designs and letters so they don't shift or blow away.

Introduction

Renewable Energy Fact Sheets

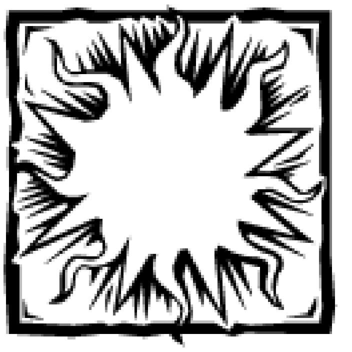
Energy resources are described as renewable or nonrenewable. Nonrenewable resources are either replaced very slowly or are not replaced by natural processes. Nonrenewable resources include fossil fuels—coal, oil, and natural gas—and nuclear fuels such as uranium. Renewable energy resources can be replaced quickly by natural processes. Renewable resources include solar energy, wind, hydropower, biomass, and geothermal energy. Even some of these resources can be depleted if their rate of use exceeds their rate of replacement.

The following fact sheets provide more information about renewable energy resources. The fact sheets developed by the Wisconsin K-12 Energy Education Program provide general overviews of renewable energy resources and their use. Additional fact sheets are available on the Focus on Energy Web site and they provide information about specific renewable energy technologies. The fact sheets may be photocopied for teacher and student use.



Facts about Solar Energy: Solar Electricity

Introduction



Harnessing energy from the sun holds great promise for meeting future energy needs because the sun is a renewable and clean energy resource. Fossil fuels will eventually run out and the future of nuclear power is uncertain. For these reasons, other energy sources need to be developed. Solar energy is one of these sources.

Solar energy is produced by the sun, which is a gigantic nuclear fusion reactor running on hydrogen fuel. The sun converts five million tons of matter into energy every second. Solar energy comes to Earth in the form of visible light and infrared radiation. Scientists expect that the sun will continue to provide light and heat energy for the next five billion years.

Solar Energy Potential

The amount of solar energy that strikes Earth's surface per year is about 29,000 times greater than all of the energy used in the United States. The solar energy falling on Wisconsin each year is roughly equal to 844 quadrillion Btu of energy, which is about 550 times the amount of energy used in Wisconsin.

Although the amount of solar energy reaching Earth's surface is immense, it is spread out over a large area. There are also limits to how efficiently it can be collected and converted into electricity and stored. These factors affect the amount of solar energy that can actually be used.

Producing Solar Electricity

Solar electricity is measured in kilowatt-hours, a unit of energy. Solar cells convert sunlight directly into electricity. Most cells are made of silicon, a material that comprises 28 percent of the Earth's crust. One solar cell measuring four inches across can produce one watt of electricity on a clear, sunny day. To produce more electricity, cells are wired together into panels, and panels are wired together to form arrays.

Solar cells are reliable and quiet, and they can be installed quickly and easily. They are also mobile and easily maintained. They provide an ideal electrical power source for satellites, outdoor lighting, navigational beacons, and water pumps in remote areas. In the United States, tens of thousands of homes are powered by solar cells, and many more are planned.

Solar energy can be used to heat a fluid to produce steam that spins a turbine connected to an electrical generator. These systems are called solar thermal electric systems. One type of solar thermal electric system, the solar power tower, uses mirrors to track and focus sunlight onto the top of a heat collection tower. An experimental 10-megawatt solar power tower called Solar Two is being tested in the desert near Barstow, California.

Another type of solar thermal electric system uses curved, mirrored collectors shaped like troughs that focus the sun's heat on pipes running through the middle of the collectors. The largest system of this type is located in Southern California and has a generating capacity of 347 megawatts, which is equal to the capacity of a medium-sized electric power plant in Wisconsin.

Solar Electricity Production

Of the total electricity production in the United States, solar energy still provides less than one percent. In Wisconsin, a negligible amount of electricity from solar energy is currently being generated by individual homeowners and businesses.

Effects

Solar electricity has many benefits. Solar electric systems have no fuel costs, low operating and maintenance costs, and produce virtually no air emissions or waste. Solar electric systems can be built quickly and in many sizes. They are well-suited to rural areas, developing countries, and other communities that do not have access to centrally generated electricity.

Solar electricity also has limitations. It is not available at night and is less available during cloudy days, making it necessary to store the produced electricity. Backup generators can also be used to support these systems.

Large-scale solar electric systems need large amounts of land to collect solar energy. This may cause conflicts if the land is in an environmentally sensitive area or is needed for other purposes. One solution is to locate large-scale solar electric systems in deserts or marginal lands. Another idea is to place solar cells on rooftops, over parking lots, in yards, and along highways, and then connect the systems to an electric utility's power-line system. As the use of solar electric systems increases, laws may be needed to protect people's right to access the sun.

Outlook

The sun is expected to remain much as it is today for another five billion years. Because we can anticipate harvesting the sun's energy for the foreseeable future, the outlook for solar energy is optimistic. The flexibility and environmental benefits of solar electricity make it an attractive alternative to fossil and nuclear fuels. Although high costs, land issues, and the need for electricity storage or backup systems are obstacles, many experts are confident that these obstacles can be overcome.

In the near future, the use of solar electric systems will likely increase in the southern and western parts of the United States where sunshine is plentiful, in remote villages in the developing world, and in nations such as Japan that have few fossil and nuclear energy resources. Widespread use of solar electric systems is more likely to appear in Wisconsin 10 to 50 years from now, as fossil fuel supplies decline and the environmental advantages of solar electricity become increasingly important. On the other hand, a number of homeowners and businesses in Wisconsin have already demonstrated that solar electric systems can meet their needs.

References:

Miller, G. Tyler, Jr. *Environmental Science: Working with the Earth*. 5th ed. Belmont, Calif.: Wadsworth, 1995.

U.S. Department of Energy, Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels. *Renewable Energy Annual 1995*. Washington, D.C., December 1995. DOE/EIA-0603 (95).

U.S. Department of Energy, Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels. *Renewable Energy Annual 1996*. Washington, D.C., April 1997. DOE/EIA-0603 (96).

Wisconsin Division of Energy, Department of Administration. *Wisconsin Energy Statistics*. Link to most recent version found on the KEEP Web site.

Facts about Solar Energy: Solar Heating

Introduction

Harnessing energy from the sun holds great promise for meeting future energy needs because the sun is a renewable and clean energy resource. Fossil fuels will eventually run out and the future of nuclear power is uncertain. For these reasons, other energy sources need to be developed. Solar energy is one of these sources.

Solar energy is produced by the sun, which is a gigantic nuclear fusion reactor running on hydrogen fuel. The sun converts five million tons of matter into energy every second. Solar energy comes to Earth in the form of visible light and infrared radiation. Scientists expect that the sun will continue to provide light and heat energy for the next five billion years.

Solar Energy Potential

The amount of solar energy that strikes Earth's surface per year is about 29,000 times greater than all the energy used in the United States. The solar energy falling on Wisconsin each year is roughly equal to 844 quadrillion Btu of energy, which is about 550 times the amount of energy used in Wisconsin. Although the amount of solar energy reaching Earth's surface is immense, it is spread out over a large area. There are also limits to how efficiently it can be collected and used for heating.

Solar Heating

Solar energy used for heating is measured in Btu (British thermal units). There are two ways to use solar energy for heating. The first uses a solar collector to heat a fluid (e.g., water or air) and then pumps or blows the fluid through tubes or ducts to deliver heat where it is needed. The heat can also be stored in an insulated tank that holds a heated liquid or in heated materials like brick or stone. These systems are called active solar heating systems.

Residential active solar heating systems use rooftop collectors to capture sunlight. The collected heat is most often used for water heating, space heating, and for heating swimming pools. Some industries use active solar heating systems for manufacturing.

The second way to use solar energy for heating is to design buildings that capture solar energy and use it to heat the interior. Rooms called sunspaces or solariums, as well as greenhouses, can be built onto the south side of a home or building to collect solar energy. The building is often designed so that the warmed air from these spaces can naturally circulate to other rooms. Some buildings use brick or stone walls and floors to store solar energy for nighttime heating. These systems are called passive solar heating systems; they differ from active solar heating systems in that they do not use mechanical systems to collect or transfer heat.

Solar Heating Production

Active solar heating systems are used throughout the United States. Most of these systems are located in Florida, California, Arizona, Hawaii, and Puerto Rico, places that receive larger amounts of solar energy than most parts of the nation. In Wisconsin, solar heating systems produce less than one percent of the total energy used. However, using the sun for water heating is becoming more popular in Wisconsin.

Effects

Solar heating offers several benefits. Solar heating systems have minimal, if any, fuel costs. Passive solar heating systems have very low operating and maintenance costs, although costs for active systems are somewhat higher. Solar heating systems produce virtually no air emissions or waste. They can be built quickly and in many sizes. They are also easily adapted to the needs of rural and developing communities and are well-suited for communities with limited access to other energy resources.

One limitation of solar heating is that the sun is not available at night and is less available on cloudy days. Solar heating systems either need to store the heat they collect or use backup heating systems (e.g., a woodstove, an electric heating system, or a small oil furnace).

Outlook

The sun is expected to remain much as it is today for another five billion years. Because we can anticipate harvesting the sun's energy for the foreseeable future, the outlook for solar energy is optimistic.

The environmental benefits of solar heating and its ability to meet the heating needs of most homes and buildings make it an attractive alternative to using nonrenewable fossil fuels. The high cost of solar heating systems is the main obstacle. Reducing costs by mass-producing equipment, designing buildings that include passive solar energy features, and improving energy efficiency may help make solar heating systems more acceptable to consumers. Price increases in fossil fuels may also make solar heating systems more attractive.

In the near future, it is more likely that increased use of solar heating systems will occur in the southern and western parts of the United States where solar energy is plentiful. On the other hand, a number of homeowners and businesses in Wisconsin have already demonstrated that active and passive solar heating systems can adequately meet their needs. These systems may become more common in Wisconsin as fossil fuel supplies decline and the environmental advantages of solar heating become increasingly important.

References:

Miller, G. Tyler, Jr. *Environmental Science: Working with the Earth*. 5th ed. Belmont, Calif.: Wadsworth, 1995.

U.S. Department of Energy, Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels. *Renewable Energy Annual 1995*. Washington, D.C., December 1995. DOE/EIA-0603 (95).

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Solar Explorations

Solar Soup Cans
Experiment Data Sheet
(developed by Jayne Hoffman, Westside Elementary, River Falls, WI)

Color of inside of shoebox: (circle one) Black White Aluminum foil Brown (cardboard)

Sand/Soil

	Temperature			
	Black Box	**White Box**	**Aluminum foil**	**Brown**
Inside (initial reading)				
Outside (15 minutes)				
Outside (30 minutes)				
Outside (45 minutes)				

Water

	Temperature			
	Black Box	**White Box**	**Aluminum foil**	**Brown**
Inside (initial reading)				
Outside (15 minutes)				
Outside (30 minutes)				
Outside (45 minutes)				

Shredded Paper

	Temperature			
	Black Box	**White Box**	**Aluminum foil**	**Brown**
Inside (initial reading)				
Outside (15 minutes)				
Outside (30 minutes)				
Outside (45 minutes)				

Salt

	Temperature			
	Black Box	**White Box**	**Aluminum foil**	**Brown**
Inside (initial reading)				
Outside (15 minutes)				
Outside (30 minutes)				
Outside (45 minutes)				