SOLAR POWER

BENCHMARKS and TASKS

SC.B.1.2.2 The student recognizes various forms of energy (e.g., heat, light and electricity).
SC.B.1.2.4 The student knows the many ways in which energy can be transformed from one type to another.
SC.B.1.2.5 The student knows that various forms of energy (e.g., mechanical, chemical, electrical, magnetic, nuclear, and radiant) can be measured in ways that make it possible to determine the amount of energy that is transformed.
SC.B.1.2.6 The student knows ways that heat can move from one object to another.
SC.B.2.2.2 The student recognizes the costs and risks to society and the environment posed by the use of nonrenewable energy.
SC.B.2.2.3 The student knows that the limited supply of usable energy sources (e.g., fuels such as coal or oil) places great significance on the development of renewable energy sources.
SC.E.1.2.3 The student knows that the Sun is a star and that its energy can be captured or concentrated to generate heat and light for work on Earth.

- The student recognizes that energy comes in many different forms: (e.g., **mechanical**, energy of position and motion; **electrical**, energy of moving electrons; **chemical**, energy stored in chemical bonds; **thermal,** heat energy - the energy of moving and vibrating molecules; **nuclear**, energy contained in the nuclei of atoms; and **radiant,** energy that travels in waves like sunlight).
- The student measures the gain or loss of energy by using a variety of tools (e.g., thermometer, electric meter, meter stick).
- The student discovers through experiences ways that energy can be transformed from one form to another (e.g., electricity to light, light to heat, potential to kinetic).
- The student experiments to discover that some materials conduct heat much better than others, and poor conductors can reduce heat loss.
- The student experiences that heat energy moves from one place to another in three different ways: radiation, convection, and conduction.
- The student examines the risk factors associated with the use of nonrenewable energy sources (e.g., economic factors and health factors).
- The student explains that the energy in fossil fuels, such as oil and coal, comes from the sun indirectly, the main source of energy for people, because the fuels come from plants that grew long ago.
- The student recognizes that the limited supply of usable energy sources (e.g., fuels such as coal or oil) places great significance on the development of renewable energy sources.
- The student explores the development of alternative energy sources (e.g., solar energy, winds, synthetic fuels, geothermal energy).

KEY QUESTION

How can we heat water using the sun as an energy source?

BACKGROUND INFORMATION

Natural **resources** are the raw materials we use for housing, clothing, transporting, heating, cooking, etc. They include the air we breathe, the water we drink, the land we farm, and the space we use for living. They are all the things we use in our physical **environment** to meet our needs and wants. Natural resources can be classified as **renewable** or **nonrenewable**. Renewable resources (e.g., water, solar energy, wind) are materials that can be replenished through natural and/or human processes. However, people sometimes use renewable resources in such a way that they disappear completely. Nonrenewable resources (e.g., **fossil** fuels) cannot be replenished. All fossil fuels, the **energy** source most commonly used today, started out as plants that got their energy from the **sun.** It took millions of years for the stored energy to be **chemically changed** to coal, petroleum, and natural gas, so fossil fuels are classified as nonrenewable.

Solar energy will most likely be available far into the future, so we can think of it as being unending, a form of renewable energy. Solar energy doesn't cause air pollution or involve damaging the earth's surface, and it requires no difficult and expensive extraction procedures. Since we are exhausting our energy sources at such an alarming rate, solar energy is a source we need to explore and develop.

Direct conversion of solar energy is being used in many parts of the world to heat water, dry crops, and to distill fresh water from impure water sources. The main problem with solar energy is what to do when the sun doesn't shine. By careful design and positioning of houses, sunlight can be used to warm homes and domestic water. This will help to reduce fossil fuel use, but at this time, it's not enough to replace traditional fuels entirely. Sunlight can be concentrated by solar collectors. The collectors can focus sunlight from a large area onto a central vessel in which water is heated to become very high temperature steam. The expanding steam can power a turbine and generate electricity on a large scale.

This activity gives students a chance to see how the direct heating of water by radiant heat from the sun is accomplished. The plastic trays act as solar collectors and are designed to increase the direct collection of energy from the sun. The ridge system in the tray helps to increase the surface area in the tray and keep the water closer to the top. The plastic lid prevents air flow, which would cool the water. The black trays increase the intensity of the energy collected. Students can explore the effect that two variables have on the amount of solar energy transferred to the water.

A good absorber of radiant energy appears black because it absorbs rather than reflects light. A good absorber of radiant energy is also a good emitter (thermal equilibrium – all objects absorb as much energy as they emit.) A black pot of tea cools faster than a silver pot.

Heat energy is transferred by: conduction (the transfer of energy from molecule to molecule – collisions between **atoms** or molecules), convection (movement of a hotter substance such as water heated in a boiler in a basement rising to warm the radiators upstairs), and radiation (the transmission of energy by electromagnetic waves).

MATERIALS

Per pair of students

1 black and 1 white t-shirt
2 thermometers

Per group
2 black solar trays
2 white solar trays
2 solar tray covers
4 thermometers
large container of water (a gallon milk jug works well)
Solar Energy data sheet

TEACHING TIPS

1. Locate an area outside in full sunlight for setting up the solar trays.
2. The trays will need to be left outside undisturbed on grass or soil (rather than concrete) for a period of time.
3. Set the jugs of water outside in the sun ahead of time so the water will be the same temperature as the outside air.

ENGAGE

1. Have students pair with a partner. One should bring a light-colored t-shirt and one should bring a dark-colored t-shirt to class.
2. Tell the students to lay their shirts in a sunny area and to place a thermometer inside each shirt.
3. At set intervals, have students read the thermometer and record the temperature.
4. Discuss the results.

EXPLORE

1. Show the class the black and white solar trays and covers. Demonstrate pouring water into the trays only up to the fill line of the tray.
2. Pass the data sheets and have students predict the order of the solar collectors from most efficient to least efficient (to be determined by the final temperature of the water).
3. Distribute materials to students and move outside to the designated area.
4. Place the four thermometers in the bucket of water and record the temperatures after three minutes. (The thermometers should register approximately the same temperature.) Tell students that this will be the starting temperature for all the trays. Have students record the starting temperatures on the data sheets.
5. Direct each group to set out all four trays and pour water into them. Have students place a thermometer face up in each tray in such a way that it can be easily read.
6. Tell students to place a tray cover on one white tray and one black tray. **Make sure the lids are securely sealed or this will affect the results.** The other two trays should be left uncovered.
7. On the data sheets, have students record the time the trays were set up.
8. Return to the classroom and discuss the use of solar energy.
9. Return to the site approximately ½ hour later and have students record the time on the date sheet.
10. Have students record the temperature of the water in the two open trays first, followed by the two covered trays.
11. Students should pour out the water and return to the classroom with all materials.

EXPLAIN

1. Have students order the four trays according to the temperature of the water.
2. Discuss:
   Which of the four trays resulted in the warmest water? Why do you think so?
   Which of the four trays resulted in the coolest water? Why do you think so?
   What factors may have influenced the temperature readings?
   How did the results compare with your predictions?
   What effect did the lid have on the temperature? (The lid prevents air flow and prevents the solar energy from escaping.)
   What effect did color have on the temperature? (Dark colors absorb radiant energy which causes an increase in temperature. Light colors act as reflectors and bounce light off.)
   How was the heat energy transferred? (The sun is a star and its energy was used to generate heat by radiation, the transmission of energy by electromagnetic waves.)
   How does this experiment relate to the t-shirt experiment you did earlier?
   What are the risks of continuing to rely on fossil fuels as our main energy sources? (Fossil fuels, such as coal and oil, are nonrenewable and in limited supply. It took millions of years for the fossil fuels to be formed, so they cannot be replaced by nature as quickly as they are used. Extracting fossil fuels requires difficult and expensive extraction procedures. Burning fossil fuels causes air pollution.)
   Why is it important to develop alternative energy sources, like solar energy? (We are exhausting our energy resources at an alarming rate, so scientists must continue exploring alternative fuel sources that are efficient and affordable. Also, alternative energy sources are far less polluting than traditional fuels.)
   What are some things we can do to help preserve our supply of energy? (car pool, develop alternative energy sources, reduce, reuse, recycle)

EXTEND/APPLY

1. Have students brainstorm about how their lives would be impacted if our nonrenewable energy sources were unavailable for use. *How would life as they know it change?*
2. Discuss why people choose light-colored cars as opposed to dark-colored cars. Which cars do you think would be cooler in the summer? (You might arrange ahead of time to take the students to the faculty parking lot and measure the inside temperatures of a light and dark-colored car at intervals throughout the school day. Caution students that this should only be done with adult supervision.)

ASSESSMENT

Ask students to respond to the question, Why do people often choose to wear white or light-colored clothes in hot weather?

SOLAR POWER

Beginning Time: **Ending Time:**

Solar Collector	Beginning Temperature	Ending Temperature	Difference in Temperatures
White tray, uncovered			
White tray, covered			
Black tray, uncovered			
Black tray, covered			

In the first column, list the solar collectors from most effective to least effective, according to your prediction. In the second column, list the solar collectors in order of effectiveness based on the actual results.

Prediction	Actual Results