ENERGY OFFICE

LESSON PLAN

Energy from the Sun

Grades 4, 6 & 7

SUMMARY

In this lesson, the students will explore how solar energy is converted to thermal/heat energy.

LESSON OBJECTIVES

Upon completing this lesson the students will:

- Measure the amount of solar heat that comes from the sun; and
- Describe ways this energy can be used to help reduce our dependence on traditional fossil fuels and nuclear power.

ESSENTIAL QUESTION

How much energy comes to us from the sun?

DURATION

The activity requires one class period.

MATERIALS

This activity works well for small groups of students. For each group performing the experiment, you'll need the following items.

- 2 Styrofoam Cups
- 2 Thermometers
- Food Coloring
- Aluminum Foil
- A Measuring Cup
- A Metric Ruler
- A Watch with Second Hand
- Insulation Materials (packing foam, shredded newspaper, etc.)
- A Cardboard Box (It should be the same height as the cups. Trim the box if needed.)

COLLEGE & CAREER-READY SCIENCE STANDARDS 2021

GRADE 4

STANDARD

4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

DISCIPLINARY CORE IDEA (DCI)

PS3.B: Conservation of Energy and Energy Transfer

Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.

Light also transfers energy from place to place.

Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light.

CROSS-CUTTING CONCEPTS (CCC)

Energy and Matter

Energy can be transferred in various ways and between objects.

GRADE 6

STANDARD

6-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

DISCIPLINARY CORE IDEA (DCI)

PS3.B: Conservation of Energy and Energy Transfer

The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.

CROSS-CUTTING CONCEPTS (CCC)

Scale, Proportion, and Quantity Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

GRADE 7

STANDARD

7-PS3-5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

DISCIPLINARY CORE IDEA (DCI)

PS3.B: Conservation of Energy and Energy Transfer

When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

CROSS-CUTTING CONCEPTS (CCC)

Energy and Matter
Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).

WHY SOLAR ENERGY?

The sun is our most powerful energy resource. It heats our planet and nourishes the plants we eat. Without the sun, we could not exist. The energy from the sun is there for the taking. It is not only free, it never runs out. If we could harness all of the sun's energy that falls on one square meter of the Earth's surface for one hour, we could light up a whole city for one year. Also, the energy from the sun poses no environmental hazards.

THE CHALLENGE OF TAPPING THE SUN'S ENERGY

With these many advantages, why are we not using solar energy to meet all of our energy needs? The answer is that tapping the sun's energy is not a straightforward process. To effectively use the sun, it must be constantly available. Yet, even under ideal weather conditions, the sun does not shine 24 hours a day, 365 days a year. To be useful, sunlight must be collected, moved to where it is needed, and stored. This is no easy challenge.

People have been using the sun's energy for thousands of years for space and water heating purposes. With the beginning of the space age, scientists were able to develop a system that converts sunlight into electricity. This is called a photovoltaic system. Utilizing the sun's energy is categorized into three main systems. These are:

- **Passive Systems**;
- **Active Systems**; and
- **Hybrid Systems**.

The last, a hybrid system is some combination of the other systems. In all of the systems, they must face the sun in order to work. We know that the sun moves across the sky during the day from the east to the west. This creates the problem of where to face the system to get the maximum amount of energy from the sun. The answer is to position the system so that it faces due south, or only slightly east or west of south. There also is solar technology available that will allow solar panels to move or "track" the sun as it moves across the sky. This helps increase the efficiency of these solar panels. For more information about these systems, visit **www.eesi.org/topics/solar/description**.

PASSIVE SOLAR SYSTEMS

Passive solar systems do not use any mechanical equipment to move the energy. In these systems, the actual building components become part of the system. These components, or thermal storage materials, are used to store heat during the day for use at night. Among the most commonly used thermal storage materials are tile, concrete, brick, and water. All of these materials are very good at absorbing and holding heat. As with all systems that utilize solar energy, location is a most important consideration in designing a passive solar house. To be most effective, the windows in a passive solar house must face south. In this position, they will be exposed to maximum sunlight. In addition, insulation should be placed around the glass to reduce heat loss. Windows, doors, and walls need to be free of leaks so that trapped heat stays trapped.

Outside landscaping is another important part of passive solar systems. For example, evergreen trees that won't lose their leaves in winter can be planted on the north side of a home to provide winter wind protection. Trees that lose their leaves in winter can likewise be planted on the south side of a home to give it access to winter sunlight and to protect it from hot, summer sunshine.

Learn more about passive solar home design at **www.energy.gov/energysaver/energy-efficient-home-design/passive-solar-home-design**.

ACTIVE SOLAR SYSTEMS

Active solar systems use mechanical and electrical equipment such as pumps, photovoltaic panels and fans to move energy around. Four types of active systems are discussed in this section. Space heating, water heating, photovoltaic systems, and concentrated solar power. A house using active space heating will have to face south, with most of its windows on the south wall. This allows winter sunlight to enter the house, thereby heating the air inside. This heated air is then circulated throughout the house by fans.

When sunlight passes through glass into an enclosed space, the wavelength of the light changes. This new wavelength can not pass back through the glass, thereby entrapping it in the house. This is known as the greenhouse effect. Think of it just like getting into the car on a cold winter day and finding the inside of the car warm.

More equipment needs to be added to the system if night time heating is necessary. The air is heated in collectors and circulated through a rock bed storage compartment. This is an insulated box which contains small rocks. These rocks are heated during the day, and at night, the air inside the home is circulated through the rock bed. As it passes through the rocks, it extracts the stored heat, and heated air is circulated back through the house.

Water heating systems are more complicated than space systems and can be used year-round. A collector panel is mounted on the roof (facing south). This consists of an insulated box with a clear glass or plastic cover. Inside this panel are many copper pipes and fins. These pipes are painted black to absorb and conduct the sun's heat to the water that is pumped through them. This collector panel is attached to the water heater tank which is located inside the house.

The water is circulated between the collector and the water tank by electric pumps. Cold water is pumped from the water tank to the collector, and hot water is pumped back from the collector to the water tank. Thermosensors, which recognize changes in temperature, tell the pump when to cut on and off.

Concentrated solar power (CSP) is an active system distinguished from other solar energy systems by its ability to function as a utility-scale power plant. CSP uses fields of mirrors to concentrate solar energy into channels holding heat-responsive fluid. The high temperatures excite the fluid to a point where it powers a turbine or engine, which in turn runs an electric generator. More information on concentrated solar projects is available at the U.S. Department of Energy's website – **www.energy.gov/lpo/concentrating-solar-power-projects**.

Photovoltaic systems are a type of active system. They convert radiant energy from the sun into electricity. While photovoltaic technology has been around for more than 150 years, its actual development did not occur until 1954. It was first used in 1958 to provide electric power for U.S. spacecraft and satellites.

The cost of producing electricity through photovoltaic technology has dropped significantly in the past few years. Prices have gone from more than $12 per watt to less than $4 per watt. Lawrence Berkeley National Lab tracks this information each year. For more information, visit **https://emp.lbl.gov/tracking-the-sun**.

Photovoltaic systems, while once seen as too expensive, are becoming more commonplace. Photovoltaic systems are often used in remote areas, where it is too expensive for power companies to bring in electric power lines. Also, they are being used to light road signs and bus shelters. Researchers developing electric cars are making use of photovoltaic technology as well.

***SOURCE:** **www.eesi.org/topics/solar/description**

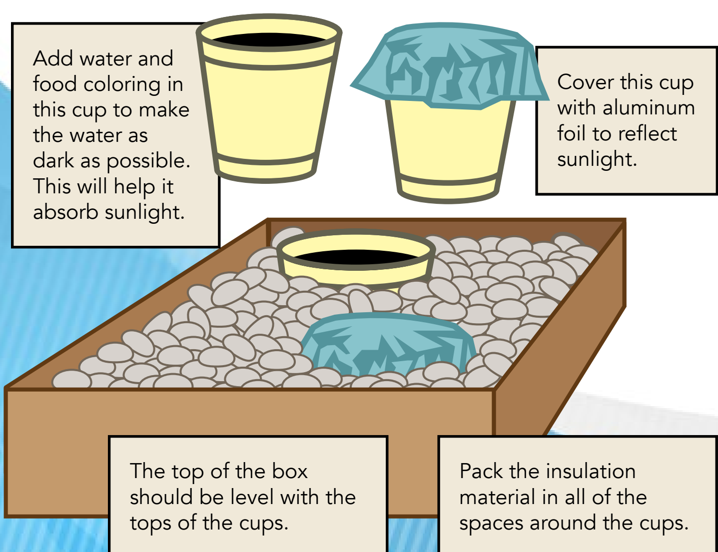
ENGAGE

Review with the class the background information on solar energy. Ask ***How can we measure solar energy?*** Solar energy is measured as heat or calories.

EXPLORE

Have the students work in small groups to perform this experiment to measure solar energy. Have each group record their results. To set up the experiment, have the students follow these steps.

- Fill two foam cups with a measured amount of very cold water. Set a standard amount for students to use based on the size of the cups.
- To one of the cups of water, add several drops of food coloring to turn the water dark. Make the water as close to black as possible. Black absorbs sunlight.
- To the other cup of clear water, cover the top with a piece of aluminum foil. This foil will reflect the sun.
- Place the cups in the cardboard box. If necessary, trim the box so that it is the same height as the cups.
- Add insulation material around the cups. See the illustration below.
- Place the box in the sun for 10 minutes. The hottest time of the day is usually between 3 and 4 p.m.
- Have students predict what will happen to the water in each of the cups. Instruct students to write their predictions down in their science notebooks.
- After 10 minutes, stir the water in the cups with the thermometers and record the temperatures in a data table. NOTE: These measurements should be taken at the same time.



EXPLAIN

Have the students evaluate their predictions. Were their predictions correct or incorrect? Have them construct explanations for why their predictions were correct or incorrect. Discuss how darker colors absorb more heat.

ELABORATE

Use these results to do the following calculation to find out how many calories, or the amount of solar heat, received on 1 square centimeter in one minute at your location.

$$\text{Area} = \frac{\pi d}{4} = \_\_\_\_\_\_\_\_\_\_\_\_ \text{ centimeters}$$

$$\text{Calories} = \frac{\text{ml of } H_2O \text{ in 1 cup X difference in temperate of both cups after being in the sun for 10 minutes}}{\text{Area (square centimeters) of water X 10}}$$

The calories calculation is the same as the amount of solid heat received on 1 square centimeter in 1 minute at your location. Multiply by 10,000 to get the results for 1 square meter.

Explain to the groups that scientists have measured the amount of solar energy beyond our atmosphere at about 2.0 calories per square centimeter per minute. About 1.5 calories per square centimeter per minute reaches earth after passing through the atmosphere. This is called the Solar Constant. Explain to the students that the Solar Constant is important for the study of heat-exchange processes in the earth's atmosphere and for the investigation of processes occurring in the sun.

EVALUATE

After the experiment, have students consider how this solar energy might be applied to their everyday lives. What inventions or modifications to existing systems do they see as practical for using solar energy? For example, could passive solar energy be used effectively by schools, since most school buildings are not used at night? What about electric school buses? Have the students explain their idea and how it would save nonrenewable energy resources. Have the students reflect on these questions in their Science notebook. Set time aside to have a large group discussion where the students can share their reflections.

E-LEARNING ACTIVITY

- **Online Solar Games and Activities** – **www.eia.gov/kids/games-and-activities/**
- **Colleton Solar Farm** – **www.santeecoopersolar.com/Solar-Share/Colleton-Solar-Farm/Index.aspx** (Flash is required to view.)
- **Illinois Solar Schools Live Dashboard** – **www.illinoissolarschools.org** (Pick a school from the A-Z list and click on "Show Solar Data" to see a live look at their solar.)