Solar Cell Inquiry

Suggested Level: Grades 3 through 7

LEARNING OUTCOME

Students begin with an open-ended inquiry of how solar panels and an AA battery can be used to power lamps and motors. Then, they infer what forms of energy are used in each instance and predict how long each power source might be able to operate a device.

LESSON OVERVIEW

In this lesson, students use a selection of solar panels, lamps, motors, and an AA battery to get as many motors or lights to operate as they can within an allotted time period. For each successful arrangement, they draw a diagram of their setup, label the energy source and the forms of energy used, and make inferences and predictions.

MATERIALS

Per work group

- One or two (different, if possible) small DC motors with an operating range of 0.5 to 4 volts
- One or two (different, if possible) light-emitting diodes (LEDs)
- One or two (different, if possible) small incandescent flashlight bulbs
- Two 1V, 400 mA mini–solar panels
- Sunlight, a gooseneck lamp with 100-watt incandescent bulb, or both
- One AA battery in holder
- Alligator clip wires

SAFETY

- Warn students not to touch lighted incandescent bulbs because they become hot enough to cause a burn.
- Caution students not to let the alligator clips on the two wires connected to the battery touch, or the battery will quickly become “dead.” (Also, the battery might become hot enough to cause a burn.)

TEACHING THE LESSON

Introduce the concept that there are different forms of energy, such as light, mechanical, electrical, chemical, and heat energy. Solar cells are objects that convert light energy into electrical energy.

Organize students into teams of two or three. Provide each team with two solar cells, 1 AA battery in a holder, motor(s), a selection of light-emitting diodes (LEDs), a selection of small flashlight bulbs, and if direct sunlight is unavailable, a gooseneck lamp with a 100-watt incandescent bulb.

Challenge students with the task of connecting together items they have been given in ways that will cause an LED or bulb to light up or a motor to spin. Each time they are successful, have them fill in a Record of Inquiry (see student handout) for that test.

Have students determine how long a circuit will remain “on” and compare the results with the proposal they recorded in the Record of Inquiry.

Have students calculate the cost of running a motor for one hour, one week, and one month with a 1V, 400 mA solar cell (approximately $5.00) vs. the cost of one AA battery. (An approximate price is $1.00 per battery.)

Discussion:

Review with students the different forms of energy that they encountered. Stress the particular form of energy at the source of power (light for solar-powered circuits and chemical for battery-powered circuits).

Compare the concept of power with the concept of energy. Ask students to identify which test setups produced more power, as evidenced by a faster turning motor or a brighter glowing bulb, and which setups had the longer lasting source of energy.

Check to see if any teams noticed that LEDs work only when the red and black wires are connected according to the proper polarity (red to the positive terminal, black to the negative terminal). In contrast, the motors and incandescent lamps work when the red and black wires are connected to either terminal. Have students complete research to explain this phenomenon.

Discuss the pros and cons of powering simple circuits using solar cells versus batteries. (See the Background Information section below.)

ACCEPTABLE STUDENT RESPONSES

Answers will vary. Complete answers will include the following:

1) Clearly drawn and labeled diagrams.

2) Correct labeling of each form of energy that exists in the circuit depicted.

3) Correct identification of the source of energy (light from the sun or a light bulb for solar-powered circuits and stored chemical energy for battery-powered circuits).

4) An appropriate identification of the power output provided by the circuit.

5) A cogent and feasible explanation of the energy available to power the circuit depicted.

ADDITIONAL SUPPORT FOR TEACHERS

Photovoltaic Cells: When a solar cell is exposed to typical light sources, negatively charged electrons almost instantly move to the top of the cell, leaving behind at the bottom of the cell a crystal lattice of atoms having more positively charged protons than negatively charged electrons. This movement rapidly reaches an internal state of equilibrium where the solar cell exhibits a voltage difference of about 0.5 volts between the top and the bottom of the cell.

When metal contacts are placed on the top and the bottom of a solar cell, and each cell is connected to an electric circuit, electrons are drawn off the top of the cell, producing a current that can be used externally. Electrons from the top of the cell move through the electric circuit, replacing the missing electrons in the bottom of the cell. This movement continues as long as the cell is exposed to light having photons of sufficient energy to excite the photovoltaic crystal's electrons.

Power Vs. Energy: Power is the rate at which work is done. Energy is the capacity of a physical system to do work. In this lesson, power is proportional to how fast a motor spins or how bright a bulb glows.

Energy available to do work depends on the circuit present. Circuits powered by batteries have energy to do work as long as the batteries are "charged" rather than "dead." The length of time that such a circuit will do work depends on the amount of energy stored in the battery. Circuits powered by solar cells have energy to do work as long as light is present.

Light-Emitting Diodes (LEDs): A light-emitting diode produces light when current passes through it. Unlike an incandescent bulb, current can pass through an LED in only one direction. LEDs are now readily available for many uses. Generally, LEDs last 25 times longer and save up to 85% more energy than incandescent bulbs.

(STUDENT HANDOUT FOLLOWS)

Name ______________________________ Date ____________

Solar Cell Inquiry

Complete a Record of Inquiry each time a new arrangement succeeds—that is, each time a lamp goes on or a motor works.

Record of Inquiry

Test Number: _____________

1) Draw a diagram that shows how the items you used are connected. On your diagram, label each item and the color of the wires.

2) On your diagram, identify where each of the following forms of energy is present.

Light Mechanical Electrical Chemical Heat

3) Where does the energy that powers the small lamp or motor come from?

4) How fast is the motor spinning, or how bright is the lamp operating? On a scale of one to five, circle the appropriate number.

LAMP					MOTOR				
1	2	3	4	5	1	2	3	4	5
Dim				Bright	Slow				Fast

5) How long do you predict the motor or lamp will remain on, if left as you have it connected? Back up your claim by explaining your prediction.