Solar Cell Simulation

Student Objective
The student:
- will be able to describe how energy moves from the sun to the photovoltaic cell to the wire and to the load
- will be able to explain what happens when a photovoltaic cell is shaded.

Key Words:
current
electron
load
photon
photovoltaic
simulation

Materials:
- open area (field or playground)
- chalk or traffic tape to outline areas
- bell
- 40 ft thick string or rope, with 10 knots 2 feet apart (remainder unknotted), and ends of rope knotted together to form a large circle

Time:
½ hour

Background Information

Photovoltaic refers to the process of turning the energy of the sun directly into electrical current through the use of photovoltaic cells. These cells (commonly called solar cells) are manufactured in several different ways, however the most common method uses silicon that undergoes a chemical process to add electrons and increase its instability. The silicon mixture is allowed to form crystals from which the photovoltaic cells are made. Electricity is produced when a photon of light energy strikes the solar cell, exciting the electrons. This action causes the electrons to 'flow', starting an electric current. The conversion of sunlight to electricity happens silently and instantly with no moving parts to wear out, no emissions and without a depletion of resources.

Photovoltaic technology is relatively new; as a viable energy source, it is only 50 years old. However, it has great potential for the future. As a source of energy, sunlight is free, its supplies are unlimited and it is available in the majority of areas of the world. However, at this time the relatively high cost of photovoltaic cells and systems is limiting its use. This is expected to change as our supplies of fossil fuels diminish, new methods of producing photovoltaic cells are discovered, and the increase in demand for the technology brings the price down.

Procedure

1. Show the students a small photovoltaic panel with its load (i.e. motor, light, etc) or photos of large systems. Explain that photovoltaics is a way to turn the energy in sunlight into electricity.
2. Explain to the students what 'simulation' means.
3. Outline an area on the ground approximately 10 feet by 10 feet to represent the photovoltaic (PV) cell.
4. Outline another area representing the sun as a large circle 15 feet in diameter.
5. Half of the students spread out in the PV cell, holding onto the rope at a knot. They represent the electrons in the cell.
6. The other students stand in the sun and represent the photons emerging from the sun.
7. Place the bell outside the PV cell and have the student with the last knot on the rope before the unknotted part stand near the bell. The rope then circles back into the cell (without knots) simulating the electrical circuit.
8. Explain the following to the class:
   - one student who represents a photon will walk and join hands with the first student (electron) inside the PV cell. This gives the electron energy and it starts to move
   - the photon and electron holding hands move together down the rope to the next electron and tag it. This student then moves down the rope to tag the next student. This movement and tagging continues until the energy reaches the last student on the knotted part of the rope
   - this student activates the load on the circuit (rings the bell). The whole class yells out "Hurray for solar energy". The electron student circles around on the unknotted part until it comes back to the first knot (now vacated) ready to be tagged
   - another photon leaves the sun, and the movement continues in the same way (the photon pairs up with an electron, moves down the rope, tags the next electron, until the bell is rung, class chants, electron travels back on the circuit to the PV cell, etc.)
   - continue this movement until all the photons are gone from the Sun.

8\. Gather students together and lead a discussion about what happened. Make sure that students understand what real-world things the different groups represented. Refer back to the small PV system or photographs as needed. Points to include in discussion:
   - Do actual photons leave the sun one at a time?
   - In real life, the sun shines on more than just this area we have demonstrated. What happens to all those other photons?
   - Could we simulate a cloudy day? What would happen?

Further Research

1. Investigate electricity. Attach a set of wires with alligator clips on the ends to the terminals of a 9 volt battery. Touch the other ends to the base of a flashlight bulb. What happens when only one touches? What happens when both are touching and making a

circle?

2. Part of the energy from the sun we can detect through our sense of sight. How far are these photons traveling? What about the light energy from other stars–how far are their photons traveling to reach us?

Related Reading

- ***Energy and Power*** by Rosie Harlow and Sally Morgan (Kingfisher, 2002)
  Energy and Power explains what energy is and how we use it. It covers our use of both renewable and non-renewable resources, as well as various forms of alternative energy.
- ***Solar Power (Energy Forever Series)*** by Ian Graham (Raintree, 1999)
  This book examines solar energy, its history, uses, advantages and disadvantages, and new developments in the field.
- ***Solar Power (True Books)*** by Christine Petersen (Children's Press, 2004)
  This book provides readers with a lucid picture of the sun and wind as natural forces before introducing some of the technology (windmills, turbines, solar panels) used to harness energy on a large scale. The captioned photos are well chosen, and the science and the explanations of the technology are eminently clear. Peterson ends the book with a forecast of the future that informs kids about the advantages and disadvantages of such renewable resources and speculates on their use in years to come.
- ***Solar Power of the Future: New Ways of Turning Sunlight into Energy*** by Susan Jones (Rosen Publishing Group, 2003)
  Discusses various kinds of solar energy, the history and development of their use, economic aspects of solar energy, and future possibilities.
- ***Teaching Electricity: Yes, You Can: Grades 3 - 6*** by Steve Tomecek (Scholastic, 1999)
  Use balloons, paper clips and other easy-to-get stuff for super easy, super-cool activities that light up kids' science learning. Each lesson includes background information along with simple activities.

Internet Sites

http://www.eere.energy.gov/roofus/

Department of Energy, Energy Efficiency and Renewable Energy Network. Roofus' solar roof and neighborhood explains solar technology and shows students how to be energy smart in their own homes.

http://www.eere.energy.gov/solar/multimedia.html

Department of Energy, Energy Efficiency and Renewable Energy Network**.** Video: *Photovoltaics: Turning Sunlight into Electricity*

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Energy	**Standard 1**	**SC.B.1.2-**	**X**	**X**	**X**	**X**		
	Standard 2	**SC.B.2.2-**						
Earth and Space	**Standard 1**	**SC.E.1.2-**			**X**			
	Standard 2	**SC.E.2.2-**						
Nature of Science	**Standard 1**	**SC.H.1.2-**					**X**	
	Standard 2	**SC.H.2.2-**						
	Standard 3	**SC.H.3.2-**						

Benchmark SC.B.1.2.1 - The student knows how to trace the flow of energy in a system.
Grade Level Expectations
The student:
Fourth
- knows how to trace the flow of energy in a system

Fifth
- knows how to trace the flow of energy in a system.

Benchmark SC.B.1.2.2 - The student recognizes various forms of energy.
Grade Level Expectations
The student:
Third
- knows different forms of energy

Fourth
- knows that there are a variety of sources for electricity.

Benchmark SC.B.1.2.3 - The student knows that most things that emit light also emit heat.
Grade Level Expectations
The student:
Third
- knows that the Sun provides energy for the Earth in the form of heat and light.

Benchmark SC.B.1.2.4 - The student knows the many ways in which energy can be transformed from one type to another.
Grade Level Expectations

The student:
Fourth
- knows ways that energy can be transformed.

Benchmark 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.
Grade Level Expectations
The student:
Fourth
- knows how the energy of the sun can be captured as a source of heat and light on Earth.

Benchmark SC.H.1.2.5 - The student knows that a model of something is different from the real thin, but can be used to learn something about the real thing.
Grade Level Expectations
The student:
Third
- uses sketches, diagrams and models to understand scientific ideas

Fourth
- knows that a model of something is different from the real thing, but can be used to learn something about the real thing.

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current - the flow of an electric charge

electron - negatively charged particle of electricity

load - a device on an electric circuit to which power is delivered

photon - the small pieces of light

photovoltaic (PV) - the effect of producing electric current using light

simulation - the imitation of the way in which a system or process works