Solar Power for Sun Town

Student Objective
The student

- understands that light energy from the sun can be turned into electricity with a photovoltaic (solar) cell.
- knows variables such as clouds, shading and direction of panel tilt, that can affect the amount of power that the photovoltaic cell produces.
- understands the factors that can increase the amperage output of their photovoltaic system including cell area, collection devices and intensifying devices.
- will be able to explain the economic problems and solutions their team encountered in powering a specific load with their available monetary resources.
- will understand that our current energy problems require cooperation and a new economic model.

Key Words:
load
orientation
photovoltaic (PV) system

Time:
1 class period

Materials

- small photovoltaic cell (1 per group)
- motor (1 per group)
- propeller (1 per group)
- milliamp meter (1 per group)
- wires with alligator clips (2 per group)
- mirrors and/or reflective foil
- magnifying glasses
- colored paddles/film or filters
- any other available light related lab equipment (i.e. prisms, fresnel lense, convex & concave lenses, etc)
- prices printed on small sheets of paper
- play money ($5, $10, and $20s)
- Laboratory Manual

Background Information

- Photovoltaic cells (called PV or solar cells) are made of silicon (sand). The silicon is heated to extreme temperatures. It is doped (coated/mixed) with chemicals, usually boron and phosphorous. This sets up an unstable environment within the photovoltaic cell. When light strikes the cell, electrons are dislodged and travel along wires placed within the cell. The electrons follow the wire and power whatever load is attached, in this case a motor. This flow of electrons is called electricity.
- PV cells use light to produce electricity. Photovoltaic systems are quiet, clean, and non-polluting.

Procedure

1. **Engage:** Discuss what a photovoltaic (PV – 'solar') cell is made of and how it works.
2. Divide the students into teams of 3 - 4 per team. Give each team of students a photovoltaic cell, motor and propeller.
3. **Explore:** Tell the students that they will be using their photovoltaic cell to generate electricity from sunlight. Explain that after they get their motors and propellers to spin, then they are to remove their motor and attach their multimeter (set on direct current voltage in the smallest scale available on their meters) to measure the output of their cell. If your class is not familiar with a multimeter, you may wish to review it with them.
4. Take the 'solar powered systems' outside and activate them in the sunlight. Allow the students time to explore.
5. While outside, discuss the results and suggest things for the teams to try. Points to cover could include:
   - What happens when the panel is turned over away from the light?
   - What happens when part of the panel is shaded with your hand? How much of the panel can you shade before the motor stops?
   - Observe the rotation of the propeller blades, which way are they turning? What happens when the wires are attached the opposite way (red to black)?
   - Does the angle of the cell in relation to the sun make a difference in how fast the propeller turns?
   - What happens when the two alligator clips touch?
   - What happens when you reverse (red-black, black-red) the wires going to the multimeter?
6. Have the students return to their seats (retaining their equipment) and read them the following challenge activity:

Power Up and $ave

You are all members of a quaint community in Florida named Sun Town. Sun Town has one movie theater that serves the entire population. The movie theater has huge electric bills especially in the summer when people like to escape from the heat. Unfortunately, the movie theater may have to close if they can't find a solution to their high electricity bill.

You have been grouped into teams based on the neighborhoods in Sun Town. Each neighborhood (team) has been asked to come up with ideas on how to power the movie theater using solar energy. Each of the neighborhood teams will be given $20 to use towards testing and implementing their plan of action. The goal is to create 500 milliamps of sustained reliable renewable power. By producing 500 milliamps you have successfully powered the movie theater. Because you are responsible citizens you are trying to spend the least amount of the $20 as possible, while accomplishing the goal of 500 sustained milliamps. There are no rules except, no cheating or stealing.

A store has been set up with additional materials that you can use to help you put together your system. Additionally, any item can be returned or exchanged, so you can continue to try out different combinations. Remember, you want to have as much money left over as possible while still getting your milliamp meter to read 500 mA.

7. Turn the groups loose and help with the store as necessary. *(Don't tell them, but since there is only <u>one</u> movie theater that they are all trying to power, the most effective way to power it and have the most money left over would be for all the teams to pool their money and use it for the least expensive solution they can find.)* Your store should have items ranging from $5 pieces of aluminum foil (or mirrors) to additional small panels ($10.). It is also fun if you can have something (like a large fresnel lens) that is priced higher than what they think they can afford ($30 or 40). Remember the teams already have a panel that is worth something (usually $10) at the store. Plan accordingly. The challenge should be tough for them to attain with their $20 but not necessarily impossible.
8. Give the students ample time to try different solutions. You may want to remind them after a few minutes that there is only one movie theater. (However, they may still not catch on. Don't tell them!)
9. **Explain and Elaborate:** After returning to the classroom, ask the groups to tell you the different ways they were able to attain 500 mA, and how much money they had left over.
10. If the students did not think to team up, ask them what would have happened if they would have all worked together to solve the problem of their shared movie theater. As in real life, sometimes one group will want to work together but will be unable to convince the other groups.
11. Discuss how the challenges of the future will necessitate us thinking in different ways, working together and sharing more than we have in the past. Discuss ways that cooperation could have been facilitated between groups.
12. Discuss variables that can affect the output of the photovoltaic cell such as:
    - time of day
    - weather conditions
    - time of year
    - location (latitude) on earth
13. Questions for further discussion:
    - How could you use a solar powered system for a flashlight which you want to use at night when the sun isn't shining where you are?

Hint: You need a device to store the electricity. *(A battery)*

- What could we do to produce more electricity on a cloudy day? *(Use more cells in the system)*

Related Reading

- ***From Space to Earth: The Story of Solar Electricity*** by John Perlin (Aatec Publications, 1999)

  John Perlin surveys the fascinating evolution of photovoltaics from its problematic and controversial nineteenth century beginnings to its indispensable and versatile role as a power source for contemporary daily life. More than the story of a technology, From Space To Earth is also a chronicle of the individuals who persevered, took chances, bucked authority, innovated, invented, and crusaded to provide humanity with renewable energy.

Related Research

- How are photovoltaics used in the space program? In telecommunications? Use the internet to collect data and pictures of these applications. Are the photovoltaic cells different or the same as those used in terrestrial applications?
- How are photovoltaic cells made? Research the difference between single crystal, poly crystal and thin film cells. Which is the cheapest to produce? Which has the highest efficiency?
- At the present time there are more photovoltaics in use on the continent of Africa than the North American continent. Why is this so? (Hint: It has nothing to do with climate, weather or latitude)

Internet Sites

http://www.eere.energy.gov/basics/renewable_energy/solar.html

Department of Energy photovoltaic pages explain how photovoltaics work, the different types of cells, and system components

http://www.jc-solarhomes.com/photovolt.htm

Basics on the physics behind photovoltaics. Includes a Discovery Channel video on how photovoltaic cells are made.

http://www.fsec.ucf.edu/en/consumer/solar_electricity/basics/index.htm

Florida Solar Energy Center (FSEC) basics of photovoltaic page.

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Play Money courtesy of Money Instructor: www.MoneyInstructor.com

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		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Nature of Science																					
Standard 4	**SC.912.N.4**		**X**																		
Physical Science																					
Standard 10	**SC.912.P.10.**	**X**																			

Science Standards

Standard 4: Science and Society

- SC.912.N.4.2 - Weigh the merits of alternative strategies for solving a specific societal problem by comparing a number of different costs and benefits, such as human, economic, and environmental.

Standard 10: Energy

- SC.912.P.10.1 - Differentiate among the various forms of energy and recognize that they can be transformed from one form to others.

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load - a device to which power is delivered, such as a motor, a light, or a household appliance

orientation - set in a definite position with reference to the points of the compass

photovoltaic (PV) - the effect of producing electric current using light
'photo': light
'voltaic': relating to electricity (volt)

system - a group or combination of things or parts forming a complex or unified whole