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, 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
- can explain the economic problems and solutions their team encountered in powering a specific load with their available monetary resources
- understands 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, motor, propeller, and multimer (1 per group)
- wires with alligator clips (2 per group)

For solar "store"

- mirrors and/or reflective foil
- magnifying glasses
- colored paddles/film or filters
- any other available light related lab equipment (i.e. prisms, Fresnel lens, convex & concave lenses, etc)
- price labels for store
- play money ($5, $10, and $20s)

Background Information

Photovoltaic cells (called PV or solar cells) are made of silicon (sand). The silicon is heated to 1500 - 2000º C. It is doped (coated/mixed) with chemicals, usually boron and phosphorous, creating two different compounds – one with more electrons (the negative) and one with less electrons (the positive). These are layered within the cell creating a positive/negative (P/N) junction. When light strikes this unstable environment within the cell, electrons move across the P/N junction where wires are placed to collect them. The electrical charge flows through the cell and panel and ultimately powers whatever load is attached (in the case of our lab, a motor). This flow of electron charge is called electricity.

PV cells use light to produce electricity. Photovoltaic systems are quiet, clean, and non-polluting.

Procedure (prior to class)

1. Gather supplies for the "solar store" and make copies of play money.
2. Make price tags for store items. Typical prices are:
   - small photovoltaic panels - $10.
   - medium photovoltaic panels - $20.
   - large (3V or larger) photovoltaic panels - $30.
   - mirrors and other reflective surfaces - $5.
   - magnifying glasses and other lens - $5.
   - color paddles, hand warmers or other "confounding" items - $5.
   - wires with alligator clips 2/$5.

Procedure (during class)

1. **Engage:** Discuss what a photovoltaic (PV) 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, they are then to remove their motor and attach their multimeter (set on direct current amperage 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 or turned 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 1.5 amps of sustained reliable renewable power. By producing an amperage output of 1.5, we are saying that 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 1.5 sustained amps. 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 meter to read 1.5A."

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. After a few minutes a group will probably reach 1.5A. Look at their solution, ask how much money they have left over and tell them to keep trying, that they can do it with more money left over. You may also 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 1.5A, 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? *(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)*
    - How could we foster a culture of cooperation in research? .....in corporations? ....in society in general?

Key Words and Definitions

- **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

Related Research

1. 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?
2. How are photovoltaic cells made? Research the difference between single crystal, poly crystalline and thin film cells. Which is the cheapest to produce? Which has the highest efficiency?
3. How are photovoltaics used in your community? Put together a photo album of the local applications.

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.

Internet Sites

https://www.energy.gov/eere/solar/solar-energy-technologies-office

Department of Energy, photovoltaic pages contains articles about current projects, blog posts and technology news.

https://www.energy.gov/eere/videos/energy-101-solar-pv

Department of Energy video *Energy 101, Solar PV*, an animated explanation of how photovoltiacs work

https://www.fsec.ucf.edu/go/solar_basics/

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

https://ed.ted.com/lessons/electric-vocabulary

Ted Ed lesson, *Electric Vocabulary*, tells the interesting story of how we obtained our electric vocabulary. The lesson also includes questions and discussion topics.

https://www.youtube.com/watch?v=EnYjlsGXugo

How We Turn Solar Energy Into Electricity, video produced by Discovery News is an overview of the history of the photovoltaic effect and a look at where the science is going.

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

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Florida NGSS Standards & Related Subject Common Core

		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 8	**SC.912.P.8.**					X															
Standard 10	**SC.912.P.10.**	X																			

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 8: Matter
- SC.912.P.8.5 - Relate properties of atoms and their position in the periodic table to the arrangement of their electrons.

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.

National Next Generation Science Standards
Matter and Its Interactions
- HS-PS1-1 - Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

Motion and Stability: Forces and Interactions
- HS-PS2-6 - Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

Energy
- HS-PS3-3 - Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.