Solar Cell Simulation

Student Objectives
The student:
- will describe how energy moves from the Sun to the photovoltaic cell to the wire and to the load
- will 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 a little over 60 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.
9. 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 the 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?

Key Words and Definitions

- **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

Further Research

1. Investigate electricity using Squishy Circuits–making circuits using conductive dough, insulating dough, and LED bulbs. **https://squishycircuits.com/pages/dough-recipes**
2. We can detect part of the energy from the Sun 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

- ***Solar Power (Energy for Today)*** by Tea Benduhn (Weekly Reader, 2008)
  This book shows students applications of solar electricity.
- ***Teaching Electricity: Yes, You Can: Grades 3 - 6*** by Steve Tomacek (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.
- ***The Kid's Solar Energy Book*** by Tilly Spetgang (Imagine, 2009)
  Cleverly intertwined with the science of solar thermal and photovoltaics are economics lessons about the cost advantages of energy efficient buildings and the production and price of solar cells. Illustrated with cartoon figures and set in a classroom, this book is appealing to students.
- ***The Magic School Bus and the Electric Field Trip*** by Joanna Cole (Scholastic Paperbacks, 1999)
  Small enough to squeeze through power lines, Ms. Frizzle's class learns how electric current travels through the town, lights up a light bulb, heats up a toaster, and runs an electric motor. This book is a simple and informative introduction to the generation and distribution of electricity.

Internet Sites

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

Energy 101: Solar Power, an animated video that discusses, photosynthesis, photovoltaics and solar thermal technology.

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Florida NGSS Standards & Related Subject Common Core

			.1	.2	.3	.4	.5	.6	.7	.8
Grade 3										
The Role of Theories	**Big Idea 3**	**SC.3.N.3**	**X**	**X**	**X**					
Forms of Energy	**Big Idea 10**	**SC.3.P.10**	**X**	**X**						
Grade 4										
Forms of Energy	**Big Idea 10**	**SC.4.P.10**	**X**	**X**						
Grade 5										
Forms of Energy	**Big Idea 10**	**SC.5.P.10**	**X**	**X**	**X**					
Energy Transfer & Transformations	**Big Idea 11**	**SC.5.P.11**	**X**							

Third Grade Benchmarks

Science–Big Idea 3: The Role of Theories, Laws, Hypotheses, and Models

- SC.3.N.3.1 - Recognize that words in science can have different or more specific meanings than their use in everyday language; for example, energy, cell, heat/cold, and evidence.
- SC.3.N.3.2 - Recognize that scientists use models to help understand and explain how things work.
- SC.3.N.3.3 - Recognize that all models are approximations of natural phenomena; as such, they do not perfectly account for all observations.

Science–Big Idea 10: Forms of Energy

- SC.3.P.10.1 - Identify some basic forms of energy such as light, heat, sound, electrical, and mechanical.
- SC.3.P.10.2 - Recognize that energy has the ability to cause motion or create change.

Fourth Grade Benchmarks

Science–Big Idea 10: Forms of Energy

- SC.4.P.10.1 - Observe and describe some basic forms of energy, including light, heat, sound, electrical, and the energy of motion.
- SC.4.P.10.2 - Investigate and describe that energy has the ability to cause motion or create change.

Fifth Grade Benchmarks

Science–Big Idea 10: Forms of Energy

- SC.5.P.10.1 - Investigate and describe some basic forms of energy, including light, heat,

sound, electrical, chemical, and mechanical.

- SC.5.P.10.2 - Investigate and explain that energy has the ability to cause motion or create change.
- SC.5.P.10.4 - Investigate and explain that electrical energy can be transformed into heat, light, and sound energy, as well as the energy of motion.

Science–Big Idea 11: Energy Transfer and Transformations

- SC.5.P.11.1 - Investigate and illustrate the fact that the flow of electricity requires a closed circuit (a complete loop).

National Next Generation Science Standards
Fourth Grade Standards
Science–Energy

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