Solar Circuits

Overview:

Students can learn a lot about solar cells by playing around with simple circuits. You can build your own solar exploration kit with inexpensive materials purchased online. After you collect your materials keep them together in a box.

Essential Question:

How can we measure the power of a solar cell and find a circuit that can light an LED?

Background:

The most common photovoltaic is the **silicon solar cell**. A single cell has a dark blue front side with a grid of thin current collecting wires and solid conductive back. A single silicon cell produces about .55 volts in full sun and generates current (measured in milliamps, Ma) depending on the light level and the area of the cell. The bare silicon cell is very brittle so it always encased in some kind of protective box or encapsulated with epoxy. Multiple single cells can be wired in **series** (front to back, front to back) in which case the **voltage** of each cell is added creating a higher voltage panel. If cells are wire in **parallel** (back to back, front to front) the voltage is never greater than the lowest cell and the **current** of each cell is added together creating a higher current panel. For any cell or panel the total **power** (in watts) is equal to the voltage times the current (P= v x a). The speed of a motor depends on total power and provided there enough voltage to get it spinning a variety of circuits can work. A light emitting diode (**LED**) need very little current but does require at least 2 volts so a series circuit is usually required. A typical solar panel that is installed on a home measures has 72 cells measures 77" x 39" and produces 350 watts at 30 volts DC. A typical home solar installation uses 12-18 solar panels providing 4000 watts. A solar panel is converts 22-25% of the energy that hits it into electricity, that is the **efficiency**.

Research Connection:

Researchers are looking for new materials that can replace silicon solar that will be less expensive and easier to manufacture and install. Thin film plastic solar cells can be printed like plastic bags, but the efficiency and durability is still not as good as silicon.

NGSS Standards:

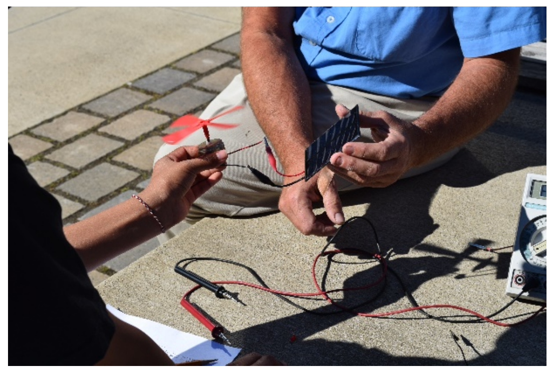
4-PS3-2	Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents
4-PS3-4	Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

Materials-

- 6 mini solar panels
- 1 bag of clipleads
- 1 digital multimeter
- 1 DC motor
- Assorted LEDs + Flashing LED

Procedure:

1) Take a close look at the solar cell. Notice that it has two leads: one red and one black. The recommended cell for this activity is actually a mini solar panel that has three silicon solar cells wired together and embedded in plastic. This makes the cells easy to handle without breaking.
2) Measure the voltage produced by a single solar cell or panel. Show the students how to select the correct setting on your meter dial (usually 2V or 2000m). Notice that the wires on the cell and the leads on the meter are color coded red or positive and black for negative. Use clip leads to make it easier to keep leads connected. Place the solar cell under a bright light and then a regular room light. Have students collect data for each experiment using a data table like below (or use the Solar Panel Exploration Worksheet). (Expect voltages from .5 to 1.5 volts, each cell within the panel contributes .5 volts



Experimental condition	**Voltage (V)**	**Current (mA)**	**Power**	**LED / Motor results**
1 mini panel in sun				

3) Ask students if they are familiar with light emitting diodes (LEDs). Try connecting a single solar cell to a LED. Point out that one of the leads of the LED is longer than the other; the longer lead is the positive side and must be connected to the positive solar cell wire. Does the LED go on if the cell is in full sunlight or held under a bright light? (Depending on your LED and the brightness of your light you might be successful. A single LED needs a minimum turn on voltage between 1.5 and 3 volts.) Try wiring two cells in series, red to black and then to the LED. This should give you enough voltage to turn on the LED. You might point out that an LED flashlight often has several 1.5 V batteries.
4) Repeat your observations with a flashing LED. A flashing LED has three colors of LEDs combined in one housing and an electronic timer that turns each on and off in sequence. Try exposing more or light to the panels and observer the flashing light.
5) Attach the small electric motor to your solar panels. You might attach a plastic coffee cup lid to the motor so you can see it turning. What conditions make the motor rotate the fastest?

Extensions

Try building a Solar Spinner with plans from CEI

Download extended instructions and supplies for a solar exploration kit

Sources

multimeter https://www.ebay.com/itm/DT-830B-Multimeter-LCD-Auto-Range-Digital-Voltmeter-Ohmmeter-Volt-Tester/263340298359?hash=item3d504e1077:m:mO7tUU4qJj9YlHuROQrVadg clipleads

http://www.ebay.com/itm/271687369178?_trksid=p2060353.m2749.l2649&ssPageName=STRK%3AMEBIDX%3AIT

solar panel

http://www.ebay.com/itm/371433325541?_trksid=p2060353.m2749.l2649&ssPageName=STRK%3AMEBIDX%3AIT

LED regular and flashing

https://www.amazon.com/Multicolor-Flashing-Changing-Electronics-Components/dp/B01C19ENG4/ref=sr_1_10?ie=UTF8&qid=1545416623&sr=8-10&keywords=flashing+led

https://www.amazon.com/CO-RODE-Diode-Yellow-Flashing/dp/B0749MD16P/ref=sr_1_4?s=hi&ie=UTF8&qid=1545416755&sr=1-4&keywords=flashing+led

Using the Standards

Notice that these expectation statements model the idea of 3 dimensional learning that combine three or more foundation elements. To fulfill these expectations, students need to use scientific and engineering practices (SEP), and understand Disciplinary Core Ideas (DCI) and Cross cutting concepts (CCC).

Science and engineering practice (SEP)-
Planning and Carrying Out Investigations: Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.
Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.
Disciplinary Core Ideas (DCIs)
PS3.A: Definitions of Energy Energy can be moved from place to place by moving objects, or through sound, light, or electric currents.
PS3.B: Conservation of Energy and Energy Transfer-
• Light also transfers energy from place to place.
• Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy.
Crosscutting Concepts
Energy and Matter: Energy can be transferred in various ways and between objects.

Hands-on activities are naturally engaging but you can increase their impact using guided discussion. Think about questions likes these to help surface the big ideas in NGSS that we are hoping to build.

1) In your investigation, how did you assure that your measurements were accurate and reliable? What problems did you encounter with your measurements?
2) Where did the energy start from and where did it end up? What forms of energy were used in each step of your experiment? Make an energy flow chart.
3) What conditions are needed to make a complete circuit?
4) How is energy transferred from one form to another?
5) What are other examples of energy transfer that you see every day?
6) Can you design a simple invention using these materials?