Here Comes the Sun

Provided by TryEngineering - www.tryengineering.org

Lesson Focus
Lesson focuses on solar panel design, and its application in the standard calculator. It explores how both solar panels and calculators operate and explores simple circuits using solar power.

Lesson Synopsis
The Here Comes the Sun activity explores the concept of how solar energy is gathered by solar panels and adapted to provide power to a variety of machines, from calculators to spacecraft. Students disassemble a solar powered calculator and explore the component parts. Students work in teams to suggest design enhancements to the calculator to improve performance.

Age Levels
8-18.

Objectives

- Learn about solar power and solar panel design and operation.
- Learn about how calculators work and how the product is comprised of many different component parts.
- Learn about teamwork and the engineering problem solving/design process.

Anticipated Learner Outcomes
As a result of this activity, students should develop an understanding of:

- solar power and solar panel engineering
- calculator design and operations
- impact of engineering and technology on society
- engineering problem solving
- teamwork

Lesson Activities

Students learn about how solar energy is gathered and transferred to electrical energy in solar panels. Topics examined include solar panels, simple circuits, and the inner workings of a simple calculator. Students work in teams to disassemble a calculator, evaluate the design and operation of its component parts, recommend changes to improve functionality through redesign and/or material selection, and present to class.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Resource Sheets (attached)
- Student Worksheets (attached)

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- TryEngineering (www.tryengineering.org)
- U.S. Department of Energy, Solar Energy Technologies Program (www1.eere.energy.gov/solar)
- National Renewable Energy Laboratory (www.nrel.gov)
- NREL Video: "Photovoltaics: Turning Sunlight Into Electricity" (www1.eere.energy.gov/solar/video/pv4.mov)
- IEEE Global History Network - Solar Power Satellites (www.ieeeghn.org/wiki/index.php/Solar_Power_from_Satellites)
- History of Solar Energy (www1.eere.energy.gov/solar/pdfs/solar_timeline.pdf)
- ITEA Standards for Technological Literacy: Content for the Study of Technology
- (www.iteaconnect.org/TAA)
- National Science Education Standards (www.nsta.org/publications/nses.aspx)

Recommended Reading

- Solar Electricity Handbook, 2010 Edition: A Simple Practical Guide to Solar Energy - Designing and Installing Photovoltaic Solar Electric Systems by Michael Boxwell (ISBN: 978-1907670008)
- Power from the Sun: A Practical Guide to Solar Electricity by Dan Chiras (ISBN: 978-0865716216)

Optional Writing Activities

- Write an essay or a paragraph describing how solar panels have been engineered into a product you find in your home or school. Explain why solar energy is a good choice for powering this product.

Here Comes the Sun

For Teachers:
Teacher Resources

◆ Lesson Goal
Explore solar power and how solar panels operate. Students learn about engineering design by taking apart a solar powered calculator and examining the component parts, how they interact, and determine a design improvement which they present to the class.

◆ Lesson Objectives
- Students learn about solar power and solar panel design and operation.
- Students learn about how calculators work and how the product is comprised of many different component parts.
- Students learn about teamwork and the engineering problem solving/design process.

◆ Materials
- Student Resource Sheets
- Student Worksheets
- One set of materials for each group of students:
  - One old or new calculator (many less than $5) -- look for ones with screws on back for easy disassembly
  - Eyeglass Repair Kit or mini screwdriver (must be very small gauge)
  - scotch tape

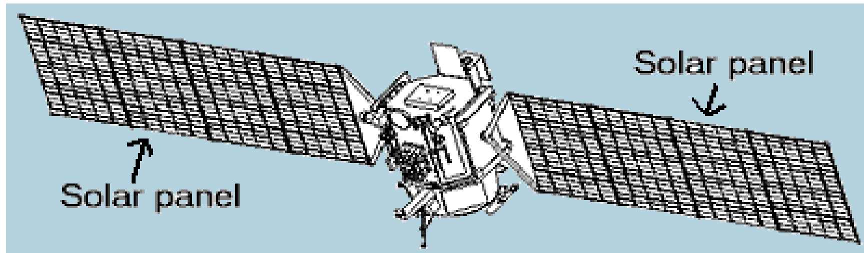
◆ Procedure
1. Show students the various Student Reference Sheets. These may be read in class or provided as reading material for the prior night's homework.
2. Divide students into groups of 3-4 students; provide one set of materials per group.
3. Ask students to complete the student worksheet. As part of the process, the students work in teams to dissect a calculator, evaluate the component parts including the solar panel, and in teams of "engineers" to design a new enhancement to the calculator. They plan and present their ideas to the class.

◆ Time Needed
One to two 45 minute sessions.

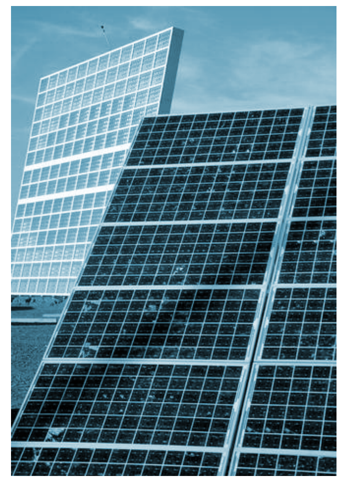
Here Comes the Sun

Student Resource: How Solar Panels Work

◆ Solar Panel Basics



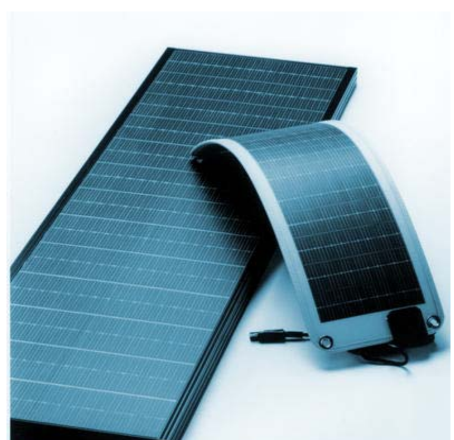
Sunlight is made up of tiny packets called photons. Every minute enough of this energy reaches the world to meet the world's energy demand for the whole world. Solar panels convert the sun's energy into electricity which can be used to power many products from small calculators to spacecraft. Many road and traffic signs along highways are now powered by the sun, and you have likely seen garden or path lights that are solar powered and automatically turn on at night.



Each solar panel is comprised of solar cells or semiconductors attached by wire to a circuit. Light reaching the semiconductor is converted into electricity which then flows through the circuit. Solar cells only operate when light is present. So, solar panels on spacecraft usually move to point toward the sun, regardless of the direction of the spacecraft. The more solar cells that are included in a solar panel, the greater the electricity that can be generated. A small panel is required to power a calculator, while spacecraft require enormous panels for power. Batteries are included in most systems to store energy for use when the sun isn't shining.

◆Solar Concentrators

Some spacecraft use solar concentrators to enhance the available light. It works the same way as a magnifying glass can multiply the power of light to focus the rays of light on kindling to start a fire. Solar concentrators use Fresnel lenses to take a large expanse of sunlight and point it toward the solar panels to boost the amount of energy that can be derived from the sun by a spacecraft in orbit.



Flexible and Rigid Photovoltaic Modules
(Courtesy National Renewable Energy Laboratory)

◆Solar Panel Components

Some photovoltaics used on spacecraft are made out of gallium arsenide (GaAs). GaAs is made into a cylinder that is then sliced into cells. The solar cells are connected to the rest of the power network. Solar concentrators, made of clear plastic, are placed above them to focus the Sun's rays. More common in commercial, Earth-bound systems are crystaline silicon wafers, which are grown into cylinders and sliced to make cells. These are less efficient than GaAs cells, but are much less expensive to manufacture.

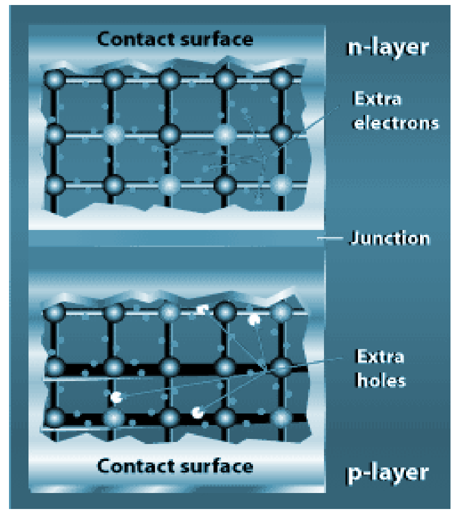
(Some content/images courtesy of NASA and the National Renewable Energy Laboratory.)

Student Resource: Solar Power History and Innovation

In 1839, Edmond Becquerel discovered the process of using sunlight to produce an electric current in a solid material. But it took more than another century to truly understand this process. Scientists eventually learned that the photoelectric or photovoltaic (PV) effect caused certain materials to convert light energy into electrical energy at the atomic level.

◆ So, How Does it Work?

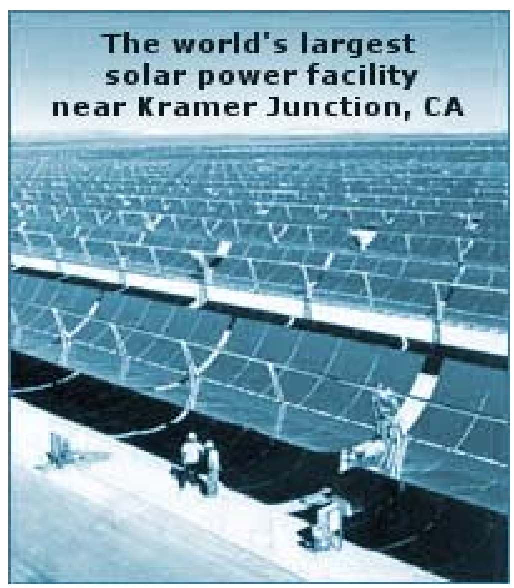
To induce the built-in electric field within a photovoltaic cell, two layers of somewhat differing semiconductor materials are placed in contact with one another. One layer is an "n-type" semiconductor with an abundance of electrons, which have a negative electrical charge. The other layer is a "p-type" semiconductor with an abundance of "holes," which have a positive electrical charge.



Although both materials are electrically neutral, n-type silicon has excess electrons and p-type silicon has excess holes. Sandwiching these together creates a p/n junction at their interface, thereby creating an electric field.

When n- and p-type silicon come into contact, excess electrons move from the n-type side to the p-type side. The result is a buildup of positive charge along the n-type side of the interface and a buildup of negative charge along the p-type side.

Because of the flow of electrons and holes, the two semiconductors behave like a battery, creating an electric field at the surface where they meet -- called the p/n junction. The electrical field causes the electrons to move from the semiconductor toward the negative surface, where they become available to the electrical circuit. At the same time, the holes move in the opposite direction, toward the positive surface, where they await incoming electrons.



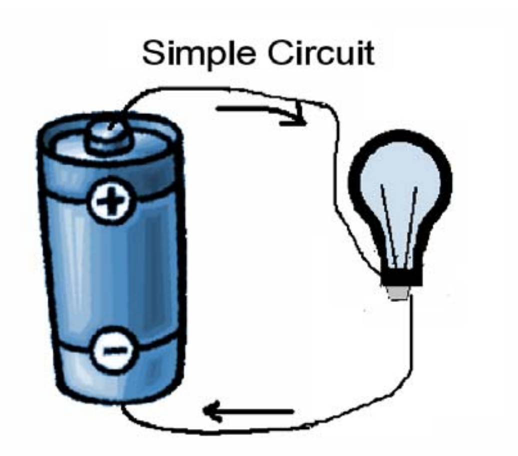
To make the p-type ("positive") and n-type ("negative") silicon materials that will eventually become the photovoltaic (PV) cells that produce solar electricity, an element is added to the silicon that either has an extra electron or lacks an electron. This process of adding another element is called doping.

(Some content/images courtesy of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy.)

Student Resource:
What is a Simple Circuit?

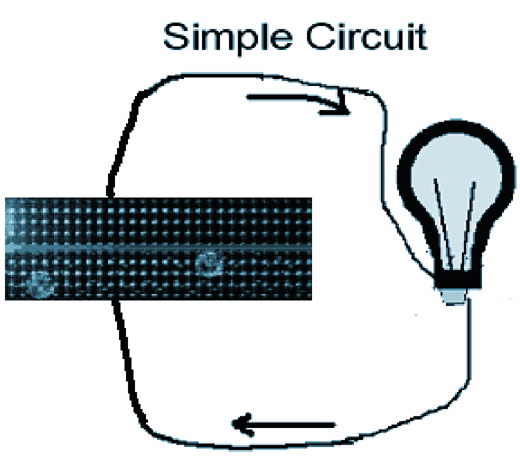
◆ Simple Circuit

A simple circuit consists of three minimum elements that are required to complete a functioning electric circuit: a source of electricity (battery), a path or conductor on which electricity flows (wire) and an electrical resistor (lamp) which is any device that requires electricity to operate. The illustration below shows a simple circuit containing, one battery, two wires, and a bulb. The flow of electricity is from the high potential (+) terminal of the battery through the bulb (lighting it up), and back to the negative (-) terminal, in a continual flow.



◆ Simple Circuit

The following illustration shows a simple circuit using a solar panel as the power source

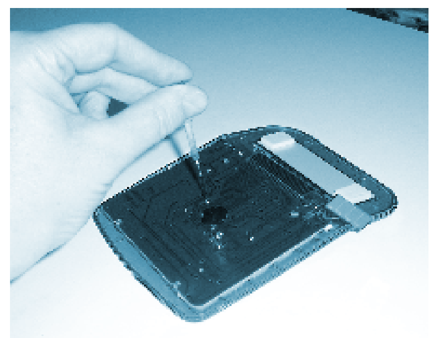


Student Worksheet:
Dissect a Solar Powered Calculator

Step One: As a team, observe whether the calculator operates when you completely block the solar power panel. What happens if you partially block the solar panel? Write you observations, and explanations of what you found below.

Step Two: Suggest five other products you can think of that are either completely or partially powered by solar panels.

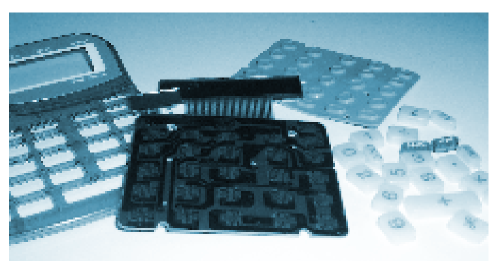
Step Three: As a team, disassemble either a new (inexpensive) or old unusable solar powered calculator, using the materials provided to you. Be sure that you remove all the small screws that hold the top and bottom together, some are often hidden under pads or rubber strips. You will need to use a very small screwdriver, such as the type commonly found in eyeglass repair kits. And, you will need to unscrew the circuit board from the front panel of the calculator too -- there are many screws. ***Safety Note:*** Be careful touching the solar panel and the LCD (liquid crystal display) as the glass edges may be sharp.



Step Four: As a team, observe the solar panel and see how it is connected to the other parts of the calculator. Examine all the other parts of the calculator, and discuss what you find. Then answer questions below.

Questions:

1. How many individual parts did you find? Describe them.



2. What surprised you the most about the interior parts of the calculator?

3. How was the solar panel connected to the circuit board?

Student Worksheet:
Dissect a Calculator (continued)

4. If there was a battery back up for this calculator, how was it connected to the circuit board?

5. Some calculators will still operate in the disassembled state, as long as the wires from the solar panel and battery are still connected to the circuit board. Does your calculator still operate? If you reconnect the wires with scotch tape, does it still work?

6. Why do you think there was a rubber or plastic sheet separating the circuit board from the buttons you press?

7. What type of material do you think is embedded under the plastic or rubber sheet and the circuit board? Why do you think engineers included this sheet in their design?

8. Assuming you could repower your calculator, if you reconstructed your calculator with all the buttons in different positions, would it still work properly? Why, why not?

9. Is there anything you would recommend, as part of an engineering team, to improve the functionality of the calculator you disassembled? Attach a drawing or sketch of your proposed component part or improvement, and answer the questions below:

What new materials will you need (if any)	What materials or parts will you eliminate (if any)	How will this new product improve the functionality of a calculator?	How do you think your new design will impact the cost of this calculator? Why?

5. Present your ideas to class.

For Teachers:
Alignment to Curriculum Frameworks

Note: All lesson plans in this series are aligned to the National Science Education Standards which were produced by the National Research Council and endorsed by the National Science Teachers Association, and if applicable, also to the International Technology Education Association's Standards for Technological Literacy or the National Council of Teachers of Mathematics' Principles and Standards for School Mathematics.

◆National Science Education Standards Grades K-4 (ages 4-9)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop
- ✦ Understanding about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of the activities, all students should develop an understanding of
- ✦ Properties of objects and materials
- ✦ Light, heat, electricity, and magnetism

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop
- ✦ Abilities of technological design
- ✦ Understanding about science and technology

◆National Science Education Standards Grades 5-8 (ages 10-14)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop
- ✦ Understandings about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of
- ✦ Transfer of energy

CONTENT STANDARD E: Science and Technology

As a result of activities in grades 5-8, all students should develop
- ✦ Abilities of technological design
- ✦ Understandings about science and technology

◆National Science Education Standards Grades 9-12 (ages 14-18)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop
- ✦ Understandings about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop understanding of
- ✦ Interactions of energy and matter

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop
- ✦ Abilities of technological design
- ✦ Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of
- ✦ Science and technology in local, national, and global challenges

For Teachers:
Alignment to Curriculum Frameworks (continued)

◆Standards for Technological Literacy - All Ages

The Nature of Technology

- Standard 1: Students will develop an understanding of the characteristics and scope of technology.
- Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society

- Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.
- Standard 5: Students will develop an understanding of the effects of technology on the environment.
- Standard 6: Students will develop an understanding of the role of society in the development and use of technology.

Design

- Standard 8: Students will develop an understanding of the attributes of design.
- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

- Standard 13: Students will develop abilities to assess the impact of products and systems.

The Designed World

- Standard 16: Students will develop an understanding of and be able to select and use energy and power technologies.