

SUGGESTED REFERENCES

- *NREL, National Renewable Energy Laboratory Solar Research*
<http://www.nrel.gov/solar/>
and
http://www.nrel.gov/learning/re_photovoltaics.html
- *U.S. Dept. of Energy, Solar Energy Technologies Program*
http://www1.eere.energy.gov/solar/pv_basics.html
- *NASA - How do photovoltaics work?*
<http://science.nasa.gov/science-news/science-at-nasa/2002/solarcells/>
- *NASA, Science News - The Edge of Sunshine*
http://science.nasa.gov/science-news/science-at-nasa/2002/08jan_sunshine/
- *Solar Reserve*
<http://www.solar-reserve.com/>

NATIONAL SCIENCE EDUCATION STANDARDS

Grades K - 4, 5 - 8
Science & Technology
 Abilities of technological design
 Understandings about science & technology

Grades 5 - 8
Science in Personal & Social Perspectives
 Populations, resources, & environments
 Science & technology in society

Grades 5 - 8
Physical Science
 Motions & forces
 Transfer of energy

*Source: *National Science Education Standards, 1996, National Academy Press*

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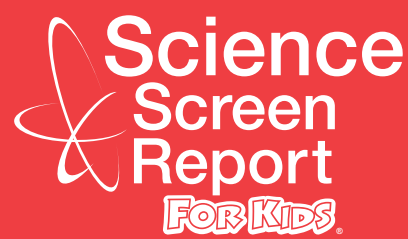
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SOLAR POWER - *Clean Energy from the Sun*

SYNOPSIS

Developing clean energy from renewable sources has become an important aspect of our energy needs. Alternative energy sources are being researched and developed to improve efficiency and reduce costs. Fluctuating costs of oil, coal and natural gas, along with their possible negative effects on the environment, has made energy sources such as wind and solar more cost-competitive with fossil fuels. More energy strikes the Earth in an hour than humans need in a year. We are now hard at work developing a variety of technologies to convert its power into energy that we can use to heat, cool and light our homes and businesses.

This program sheds some light on photovoltaic cells, concentrated solar power and how they are able to convert the sun's energy into electricity.



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BACKGROUND

All life on earth is fueled by the biological processes of the Sun. More energy from the Sun falls on the earth in one hour than is used by everyone in the world in one year. It is no wonder that a variety of technologies have been created and more are being researched to convert the Sun's energy to heat, cool, and light our homes and businesses.

Our energy needs are supplied to us mostly by coal, oil, and natural gas. These commodities have fluctuating costs, a finite supply, and possible negative effects on our environment. These factors have driven scientists and engineers all over the world to look for ways to increase efficiency and decrease costs of power generated by solar means.

The Sun's rays contain photons, or subatomic particles that carry the electromagnetic force and are a quantum of electromagnetic radiation. Some materials have the ability to absorb photons of light and release electrons, resulting in an electric current. Photovoltaic cells convert light photons into voltage using the PV effect.

Polycrystalline silicon, an element found in sand, is most often used in solar cells to create an electric charge when exposed to sunlight. Most cells are manufactured in a casting process with two layers of different semiconductor materials. One layer is an "N-type", which contains an abundance of electrons that have a negative charge. The other layer is a "P-type" semiconductor that has an abundance of holes that carry a positive charge. Joined together they form a positive/negative junction that creates an electric field. The silicon materials obtain their positive and negative structures by adding elements that either have extra electrons or are lacking an electron. This process of adding another element is called doping.

When light photons contact a solar cell, they knock electrons free in the positive silicon crystal structure forcing them through an external circuit, these free electrons are propelled up conductive contacts in the positive layer and cross over to contacts on the negative layer creating an electrical potential.

Solar cells are usually wired in series with 30 to 36 cells forming a string. Multiple strings are joined to form a photovoltaic array. This produces a solar module with a 12 volt output that can be wired in series with other modules to charge a battery bank.

Concentrated solar power uses mirrors to reflect sunlight to receivers that retain the Sun's energy and convert it to heat. The resulting thermal energy is used to produce electricity using a steam turbine or heat engine to operate a generator.

CRITICAL THINKING EXERCISES

1. Research the efficiency levels of solar cells over the past several decades. What contributing factors have allowed for advances in efficiencies and reduction in costs?
2. Create a map depicting how much solar energy is generated by each state in the United States. What variables influence the use of solar power nationwide?
3. There are two big issues with solar energy: it can't be generated at night and the efficiency of solar cells is still developing. Assess the possibility that solar energy will be able to replace energy generated by fossil fuels.
4. Judge the efficiency of both concentrated solar power and photovoltaics. Create a diagram to compare and contrast the two systems.

CAREER POSSIBILITIES

- CHEMIST
- ENGINEER
- TECHNICIAN

ADVANCED ORGANIZERS

Prior to viewing this program, students should have some understanding of the following Benchmarks for Science Literacy, Oxford University Press which are excerpted and, in some cases, abbreviated below. Refer to the Benchmarks for more information.

Benchmark 8. The Designed World Section B: Design & Systems, Grades 3-5

- Sunlight is used to run many devices.
- Some people try to reduce the amount of fuels they use in order to conserve resources, reduce pollution, or save money.

Grades 6-8

- Different ways of obtaining, transforming, and distributing energy have different environmental consequences.
- In many instances, manufacturing and other technological activities are performed at a site close to an energy resource.
- Some forms of energy are transported easily, others are not.
- Electrical energy can be generated from a variety of energy resources and can be transformed into almost any other form of energy. Electric circuits are used to distribute energy quickly and conveniently to distant locations.
- Energy from the Sun (and the wind and water energy derived from it) is available indefinitely. Because the transfer of energy from these resources is weak and variable, systems are needed to collect and concentrate the energy.
- Industry, transportation, urban development, agriculture, and most other human activities are closely tied to the amount and kind of energy available. People in different parts of the world have different amounts and kinds of energy resources to use, and use them for different purposes.
- Some resources are not renewable or renew very slowly. Fuels already accumulated in the Earth, for instance, will become more difficult to obtain as the most readily available resources run out. How long the resources will last, however, is difficult to predict. The ultimate limit may be the prohibitive cost of obtaining them.
- By burning fuels, people are releasing large amounts of carbon dioxide into the atmosphere and transforming chemical energy into thermal energy which spreads throughout the environment.

**Benchmarks can be found at www.project2061.org/tools/bencho/bolintr.htm*

VOCABULARY

- Direct Current** An electric current of constant direction, having a magnitude that does not vary or varies only slightly.
- Doping** A method of adding a dopant to a pure semiconductor to change its electrical properties.
- Heliostat** An instrument consisting of a mirror that automatically moves to track the sun, for reflecting the Sun's rays in a fixed direction.
- Photon** The subatomic particle that carries the electromagnetic force and is the quantum of electromagnetic radiation. It has a rest mass of zero, but has measurable momentum, exhibits deflection by a gravitational field, and can exert a force. It has no electric charge, has an indefinitely long lifetime, and is its own antiparticle.
- Photovoltaics** A semiconductor technology involving the direct conversion of sunlight (electromagnetic radiation) into electricity.
- PV Effect** The creation of voltage in a material from exposure to sunlight.
- Silicon** A metalloid element that occurs in both gray crystalline and brown non-crystalline forms. It is the second most abundant element in the Earth's crust and can be found only in silica and silicates. Silicon is used in glass, semiconductors, concrete, and ceramics.
- Solar Cell** A photoelectric cell that converts sunlight into electrical energy, usually consisting of layers or sheets of specially prepared silicon. Electrons, displaced through the photoelectric effect by the Sun's radiant energy in one layer, flow across a junction to the other layer, creating a voltage across the layers that can provide power to an external circuit.
- Voltage** A measure of the difference in electric potential between two points in space, a material, or an electric circuit, expressed in volts.