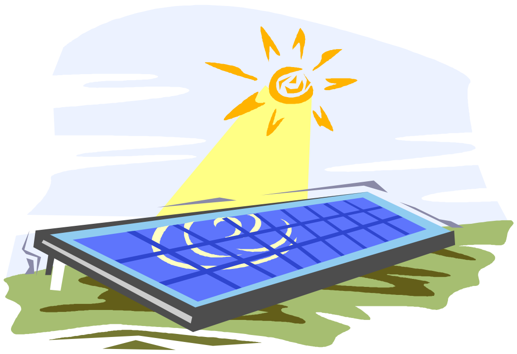


Solar Energy

Lab Manual

Goals

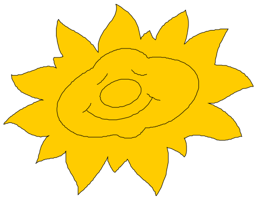
Without the sun, life as we know it on earth would not be possible. It would not be warm enough to survive, all drinking water would be tied up as ice, and there would be no food. There would also be no weather. With no heat to make the winds move and no heat to evaporate water, clouds and rain could not happen.

The sun is a massive source of energy. Every day it warms the earth with way more than enough energy to satisfy our energy needs several times over. But, are their ways we can use it?

In this module, we will be looking at ways that energy from the sun can be turned into energy that humans can use in our everyday lives.

Supplies Needed

The experiment is designed for teams of 3-4. Each team needs this lab manual and a solar building kit.



Passive Solar Energy

When you get into a car after it has been sitting in the hot summer sun with the windows closed, what do you experience? Very hot, right? Energy from the sun heated the inside of the car, and you didn't have to do anything to make it happen. No fans, no motors, no pumps, no nothing. Because you didn't have to do anything, this is called *passive solar energy*.

Passive solar energy can be used in a number of ways, such as:

- Solar heat can be captured through glass, such as car windows, atriums in office buildings, and greenhouses. The glass allows the solar energy to get in, but doesn't allow the heat to get back out. "Bubble pack" pool covers also work this way.

- Some houses in the southwestern US have a thick adobe wall on the south side of the house, called a *trombe* wall. During the day, the sun heats up the outside of the wall. Heat then moves inward into the wall. During the night, that wall then warms the inside of the house.

- Using stone floors in areas of buildings that receive direct sunlight to absorb heat during the sunny hours and warm the air around it during the non-sunny hours.

- Holding water in black tanks on the roof so that it is already warmed up by the time it needs to be heated by a conventional hot water heater.

The National Renewable Energy Laboratory says that buildings built with passive solar designs use 47% less energy than conventional new buildings.

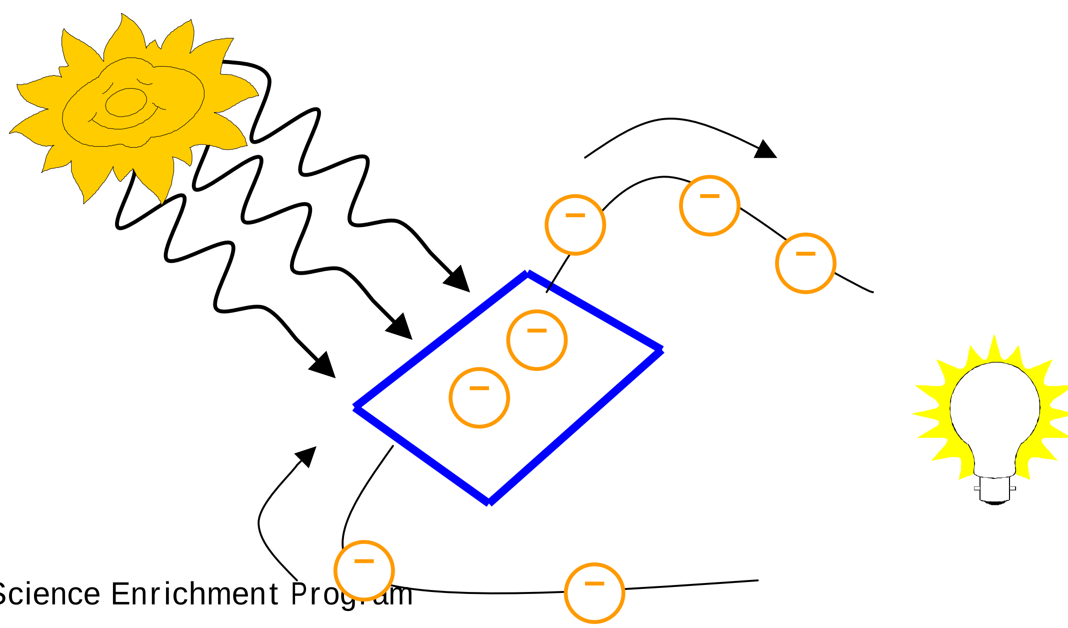
Active Solar Energy

One of the problems with passive solar energy is that you might want to heat something or some area where the sun cannot directly reach. You might want to heat the water inside your hot water heater, or the water inside your pool, or the air inside your house. How can we get the solar energy to move somewhere else?

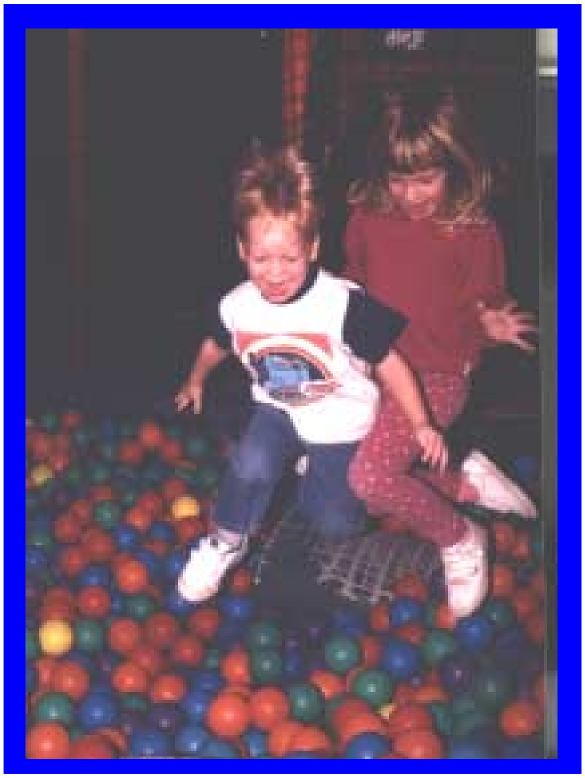
The answer is to use the sun to warm some fluid (water or air, for example) and then use some active methods, such as pumps or fans, to move that fluid to where the heating is really needed.

Photovoltaic Solar Energy

Certain materials can generate electricity when exposed to the sun. The photons from the sun "knock" electrons out of the photovoltaic material. These electrons then flow through a wire, producing electricity.



In some ways this is hard to imagine, since photons and electrons are so small. Since we have never seen them, it is hard to visualize how they really work. One mental image of this process is jumping into a ball pit at a fast food restaurant. The "photons" hit the brightly colored "electrons" and give up their energy to them. The newly energized "electrons" fly up into the air. If there was a trough about a foot above the surface of the balls, the energized balls would be caught in it and roll in the trough on a track that ended up back into the ball pit.



A Couple of Photons Prepare to Dislodge a Few Electrons

Small photovoltaic panels are used in many common applications. You see them in uses such as:

- No-battery wristwatches
- Solar calculators
- Power for Help Phones along the freeway

Small photovoltaic panels are simple enough to be used for science experiments. We will use the one in your kit to understand a few properties of photovoltaic panels. To make this panel work, you will need a fairly bright light source. The sun or a bright incandescent lamp will work. Fluorescent lights and flashlights probably will not work.

Experiment #1: Angle

Goal: In this experiment, we will see how closely the panel needs to be pointing at the light source and what happens if it is not.

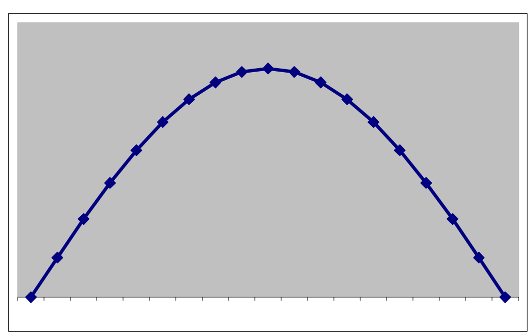
Supplies needed: solar panel and motor from kit, light source

Procedure:

1. Connect the panel to the motor.
2. Aim the panel directly at the sun or the light. The light shining on the panel is producing an electron flow in the wire that is then turning the motor. Listen to how fast the motor spins.
3. Now, slowly rotate the panel so it is no longer pointing directly at the light. What happens to the speed of the motor?
4. What is happening? When the panel is rotated, the same amount of light energy falls on the panel as before, but it is spread out over more area. So, the energy per square inch goes down.

   (You can see the same affect if you shine a flashlight directly at a wall and then rotate it so it is no longer shining directly at the wall. The spot of light that the flashlight makes spreads out so the light intensity goes down.)

Scientists who study this know that the light intensity, and therefore the electrical energy, goes down by something called the *cosine* of the angle. In ordinary terms, it produces a graph like this.



When the panel is pointing perfectly at the light, the electrical voltage produced is at a maximum. When it is rotated either way, the voltage drops off.

This is why it helps to be closer to the equator. Farther away from the equator, the sun is lower in the sky and is harder to point a solar panel directly at.

Experiment #2: Clouds and Dust

Goal: In this experiment, we will see the effect of clouds and dust on photovoltaic energy.

Supplies needed: solar panel and motor from kit, light source, wax paper, 2 pieces of clear plastic, colored plastic.

Procedure:

1. Again, point the panel directly at the light.
2. Listen to how fast the motor spins.
3. Now place various materials between the panel and the light. Try:

    - Clear plastic
    - Two pieces of clear plastic
    - Colored plastic
    - Wax paper

Try anything else you can find that is somewhat clear. Listen to how fast the motor spins with each material. Which materials are best at letting solar energy through? Which are worst?

Experiment #3: Other Lights

Try aiming the panel at other light sources such as different types of lamps. Listen to how fast the motor spins with each. What lamps are intense enough to produce photovoltaic energy? What lamps are not?

Conclusions

Photovoltaic systems are a way that solar energy can augment other energy sources, but they cannot be used everywhere. Photovoltaic systems are very sensitive to their angle with respect to the sun and sensitive to having clouds and dust block the sun. Also, as shown in the photograph, photovoltaic panels must be much larger than your panel in order to produce enough electrical power to be useful.

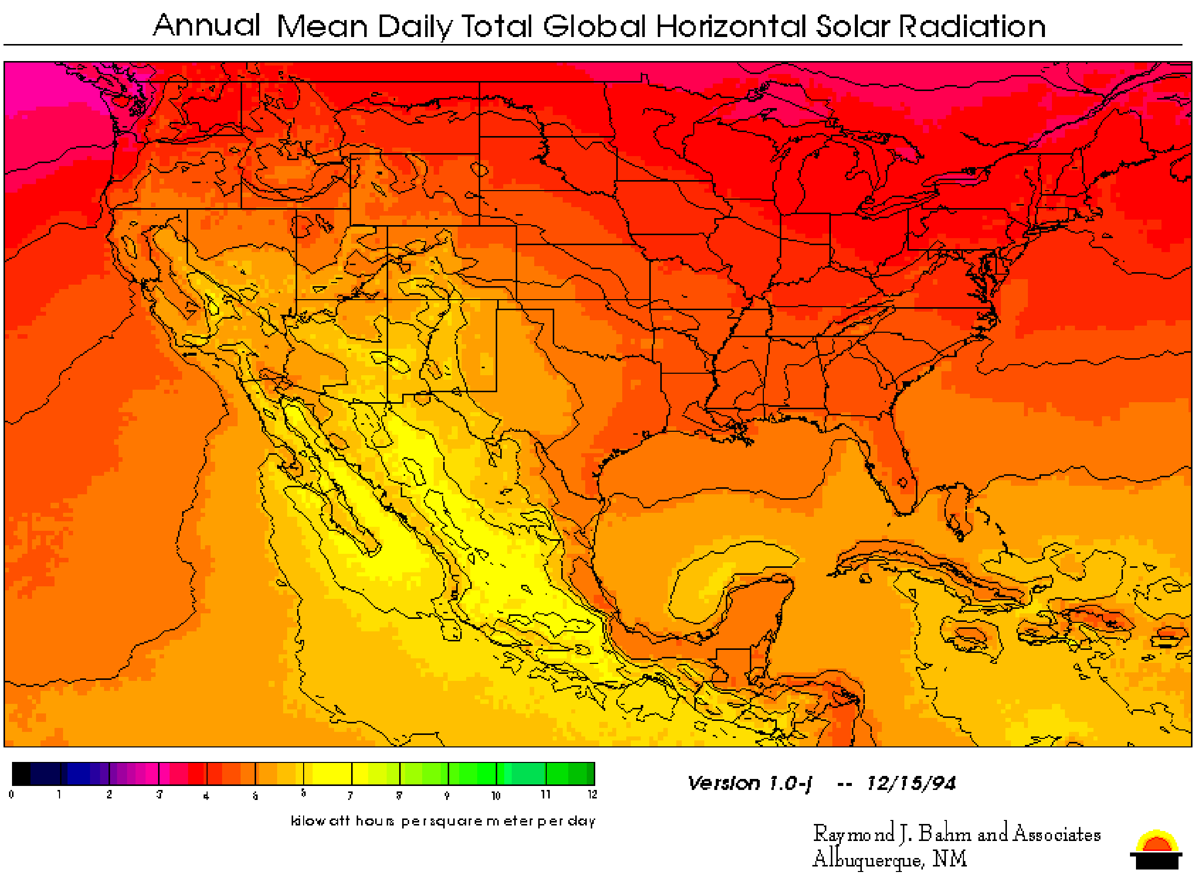
Can Everyone Use Solar Energy?

Every one of us takes advantage of solar energy in some form. Otherwise we would not be alive. But, in order for solar energy to be really practical as a major contributor to our daily energy needs, you need to live in a part of the world that:

1. Is close enough to the equator that the sun is intense enough

2. Has very few clouds or dust in the air

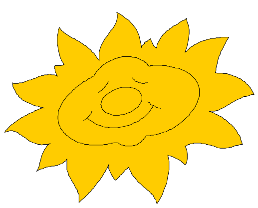
In the diagram below, Bahm and Associates have created a map showing where the best parts of the United States are for solar energy. In this map, red is bad, yellow is good, and green is better. This is why most of the serious solar energy effort in the United States is in New Mexico, Arizona, Nevada, and California.



Benefits of Solar Energy

Solar energy has three major benefits: financial, energy conservation, and cleanliness:

1. The sun shines for free and will do so for many generations to come. If we can figure out how to tap its energy for our own needs, we will have to spend less money on energy.
2. The sun is considered to be an unlimited energy source. It will never burn out, at least not for many thousands of years. However, other energy sources, such as oil and natural gas, are limited. Relying on more solar power will help us stretch our limited reserves of fossil fuels.
3. The sun is a clean energy source. Unlike oil and natural gas, using it produces no pollutants.



So, Why Isn't Everyone Using Solar Energy?

There are two major reasons, cost and capacity:

1. At the moment, active and photovoltaic solar energy is expensive. Per kilowatt, it is more expensive than other common forms of energy production.

2. Solar energy is not yet efficient enough to produce the massive amounts of energy necessary to support entire cities and countries.

Solar energy researchers are working to correct these problems, but for the foreseeable future, solar will continue to be used in spot applications.

But, There is Hope – Check This Out!

Pacific Park, on the Santa Monica Pier, has just created the world's first solar-powered Ferris Wheel! The Wheel is 9 stories tall and can hold up to 120 people. It is powered by a $360,000 photovoltaic system. To design it, engineers figured out what motors were needed, how much electricity they would use, how many revolutions the Wheel would make in a year, and how much sun Santa Monica could expect to get each year. From that, they determined that the photovoltaic system would need to provide 50 kilowatts of electricity. This translated into 7 large panels of photovoltaic cells, one of which is shown here in the photograph.

Interesting Solar Energy Information on the WWW

http://www.rt66.com/rbahm/ Raymond J. Bahm and Associates is an excellent resource for information on solar energy. Their web site also contains pointers to other sites of interest.

http://www.mrsolar.com/ Mr. Solar is a company specializing in alternative energy solutions. Through this page you can find papers on solar energy and a catalog of solar energy products.

http://www.csn.net/solar/ The American Solar Energy Society (ASES) is a national organization dedicated to advancing the use of solar energy for the benefit of U.S. citizens and the global environment. ASES promotes the widespread near-term and long-term use of solar energy.

Using the Solar K'Nex Kits

The Solar K'Nex kits come with detailed building plans. For younger girls, the recommended model is the solar flyer shown on page 10 of the 10 Model set building guide. Extra copies of the plans are contained in the kit. Older girls should be encouraged to try some of the more complicated models.