Angling for Energy

Students examine the effect sun angle has on a solar panel's sun collection in order to determine the Earth's latitude that holds the most potential for solar power.

Grade Level: 6th

Objectives:
- Students will be able to explain why more solar energy can be collected in some seasons than others.

Materials:
- Small solar panels
- Alligator clips
- Small motors
- Fan blades
- Protractors
- Flashlights
- Compass
- Graph paper
- Colored pencils

Time Considerations:
Preparations: 10-45 minutes
Lesson Time: 55-60 minutes
Introduction: 5 minutes
Activity 1: 15 minutes
Activity 2: 30 minutes
Conclusion: 5-10 minutes

Related Lesson Plans:
Sun Rays, Solar Energy, Geothermal Energy

Nevada Department of Education Standards

Atmospheric Processes and the Water Cycle
E.8.A.1 Students know seasons are caused by variations in the amounts of the Sun's energy reaching Earth's surface due to the planet's axial tilt.

Energy
P.8.C.1 Students know visible light is a narrow band within the electromagnetic spectrum.

P.8.C.5 Students know heat energy flows from warmer materials or regions to cooler ones through conduction, convection and radiation.

Excellence in Environmental Education Guidelines

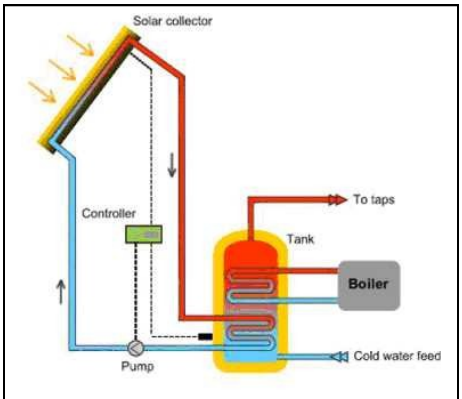
Strand 3.1—Skill for Analyzing and Investigating Environmental Issues
C) Learners are able to identify and develop action strategies for addressing particular issues.

Background

Much of the energy on Earth can be traced back to the sun. In fact 50 billion kilowatt hours of energy reach the earth every second warming the planet and providing plants with the energy they need to carry out photosynthesis. In contrast Americans use roughly 900kWh of electricity each month. (*eia.gov*)

Although an immense amount of solar energy reaches the earth, it is relatively hard to collect. Several different types solar collectors exist but all of them can be categorized as either thermo or photovoltaic collectors.

Thermal collectors absorb the sun's heat energy in order to heat a building, pool or water used to power turbines. Some of these thermal collectors use a series of metal or glass reflectors to help direct more sun into the collection area. These are called concentrating greenhouse-like hot boxes to



This thermal solar collector uses heat from the sun to warm water.

sophisticated turbine systems they all absorb energy in the same way that standing out in the sun warms our bodies.

A more complex method of collecting solar energy uses something called photovoltaic cells, also called solar panels. Solar panels are made from semi-conducting materials like silicon and may be tainted with boron or other materials.

When the sun's rays hit solar panels they knock tiny particles called electrons loose from the material. Since the electrons have a negative charge they repel other electrons causing a flow of electricity within the cell. Wires embedded in the solar cells collect this electricity so it can be used in homes and offices.

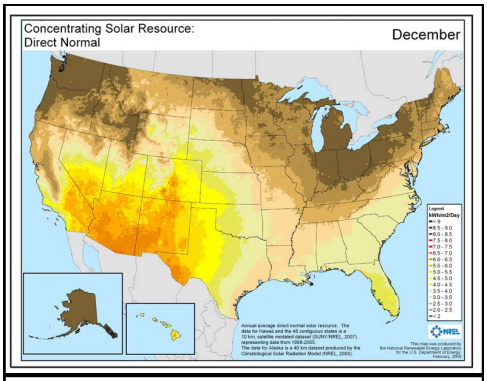
Unfortunately both thermal collectors and solar panels collect only a fraction of the sun's energy. Scientists are currently working to find new materials that can be used for more efficient solar panels.

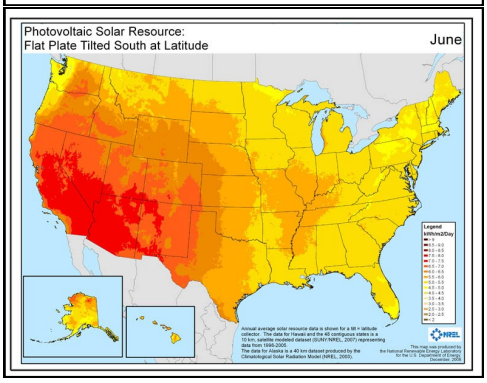
The other obstacle with solar power is that the sun does not shine constantly. Clouds, night, location on the globe and even seasons get in the way of collecting solar energy.

Imagine a bucket of confetti. If the bucket is dumped, the mess is in a relatively small area and pretty easy to clean up. If you throw that bucket in the air, the confetti spreads out and is much harder to collect because it is so scattered. This is similar to the effect that seasons have on Earth's solar potential.

At latitudes higher (or lower) than the equator the natural tilt of our planet limits the amount of solar energy that can be collected in that area. For example, in the winter the Northern Hemisphere gets the same amount of sun as in the summer but spread over a much larger area. So while Nevada experiences high amounts of solar radiation in June, in December that number drops drastically.

Another consideration that must be made with solar cells is the angle of the sun. Due to the Earth's rotation the sun appears to move across the sky from east to west. As the day progresses the angle at which sun reaches a certain area changes. This is why shadows are long in the morning and afternoon but almost nonexistent at midday.





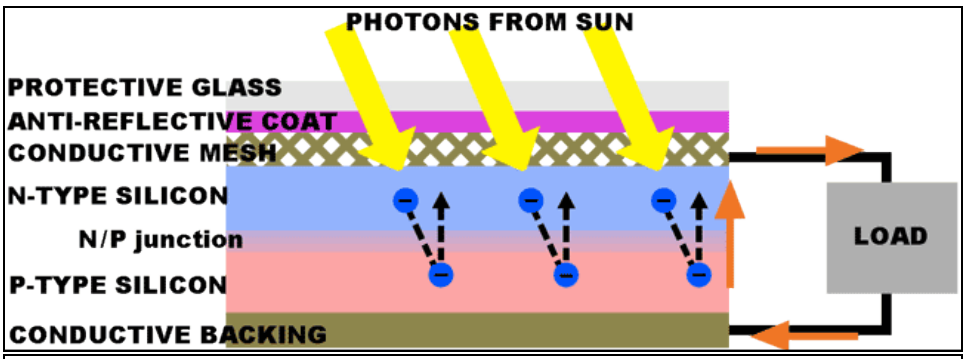
These maps show a significant decrease in the amount of solar radiation that reaches Earth from June to December.

There are a number of suggestions about how to place solar panels so that they absorb the maximum amount of energy. This activity will test solar cells positioned at several angles and directions to determine which conditions collect the most energy.

Preparation

If necessary, solder leads to the solar cells.

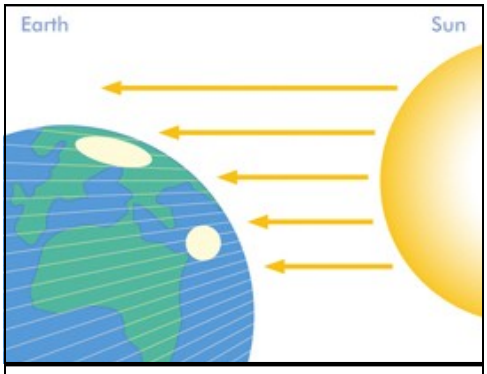
Use a compass to place markers or chalk an accurate compass rose on the sidewalk where the second activity will be completed.



Rays from the sun (photons) cause electrons to move through solar cells creating an electric current that can be harvested.

Doing the Activity

Introduction:
Ask the students to define energy and brainstorm common energy sources. (solar, coal, gas, hydroelectric, geothermal, wind)



Striking the earth at an angle causes sunlight to be diluted from spreading over a larger area.

Ask the students where they think the United States gets most of its energy. Explain to the students that although an immense amount of solar energy reaches the earth every second only 1/10,000 of it gets used. Instead most of the United States relies on coal for most of its energy.

Explain to the class that they will be doing some experiments to figure out why solar energy isn't more widely used.

Activity 1: Spread the Warmth
Divide the class into groups of three and give each group a light and a sheet of graph paper.

Instruct the class to hold their papers vertically with their science notebooks behind the paper for support. Have the students hold their flashlight about six inches from the paper and trace the circle of light using a colored pencil. Lightly shade the circle. This represents the sunlight that reaches the Northern Hemisphere during the fall and spring.

Next have the students tilt their paper slightly away from the light and trace the resulting shape in a new color. This represents winter in the Northern Hemisphere. After shading the second shape the students should calculate the area of each shape using the boxes on the graph paper.

As a group discuss how the planetary tilt that causes the seasons affects the amount of light that reaches the earth. (The amount of light is the same, but it is spread out over a larger area.)


Solar panels atop a city building.

Ask the students for ideas about other factors that could affect the amount of energy solar panels are able to absorb. (how they're made and position)

Activity 2: Panel Shenanigans
Provide each group of students with a solar cell, alligator clips, a motor and a fan. Show the students how to connect the motors to their solar panels and explain how the second experiment will be conducted:

Tell the students that since we don't have any fancy instruments to tell exactly how much sun is being absorbed we'll have to watch, feel and listen very carefully to sense the differences in cell placement.

Have each group connect their motor and observe the effect of having the solar cell flat on the ground compared to vertically.

After comparing the fan's motion with the cell horizontal and vertical, have the students angle their cells toward each of the cardinal directions at 20, 45 and 70 degrees.
As a class discuss the results.

Conclusion

Was facing the cell one direction better than another? How did the angle affect the speed of the fan? If you were building solar panels in your yard, how would you position them?

Tell the students that in the Northern Hemisphere it is recommended that solar panels face due south at an angle of about 54 degrees. (*www.macslab.com*)

Discuss whether some sun would still be "wasted" instead of harvested by the solar panel. (Yes, cell efficiency, weather conditions and planetary movement all affect the energy absorbed.)

Assessment

Assess students based on their observations and responses in their science journals.

Extensions

Experiment with different light filters to determine how they affect solar collection. Try colored films, normal and polarized sunglasses, or plastic wrap covered in sunscreen.

Find a voltmeter or similar instrument and track the amount of sun collected during different times of the day or over several weeks or months.

Track the sun's angle throughout the year and determine the optimum panel placement for your area in each season.

Vocabulary

Energy: the ability of something to do work, measured in Joules

Passive Collector: (thermal collector) a solar energy collector that uses heat from the sun to heat buildings or water

Photovoltaic Cell: silicon and metal chips that make the smallest portion of solar panels

Solar Panel: device made of multiple photovoltaic cells used for harvesting solar energy and converting into electricity

Sources

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