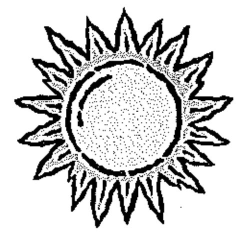
Let's Get Energized: Lessons for Community Planning



Terrace Town Workshop

Presented by:

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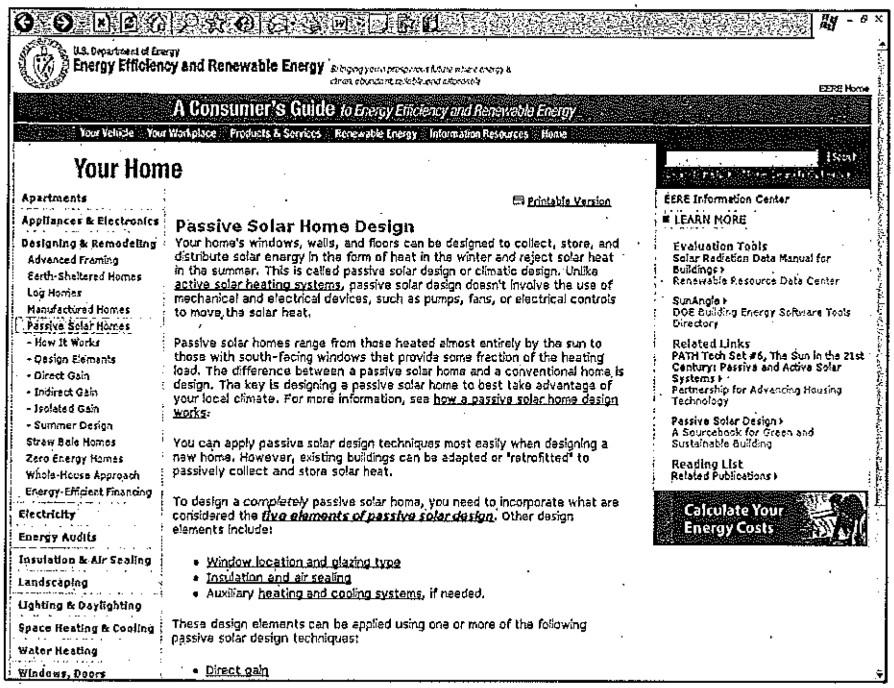
WISCONSIN DEPT. OF NATURAL RESOURCES

February 11, 2010
Monona Terrace

U.S. DOE - Energy Efficiency and Renewable Energy

http://www.eere.energy.gov/consumer/your_home/designing_remodeling/



U.S. Department of Energy
Energy Efficiency and Renewable Energy

EERE Home

A Consumer's Guide to Energy Efficiency and Renewable Energy

Your Vehicle | Your Workplace | Products & Services | Renewable Energy | Information Resources | Home

Your Home

Apartments
Appliances & Electronics
Designing & Remodeling
Advanced Framing
Earth-Sheltered Homes
Log Homes
Manufactured Homes
Passive Solar Homes
- How It Works
- Design Elements
- Direct Gain
- Indirect Gain
- Isolated Gain
- Summer Design
Straw Bale Homes
Zero Energy Homes
Whole-House Approach
Energy-Efficient Financing
Electricity
Energy Audits
Insulation & Air Sealing
Landscaping
Lighting & Daylighting
Space Heating & Cooling
Water Heating
Windows, Doors

Printable Version

Passive Solar Home Design

Your home's windows, walls, and floors can be designed to collect, store, and distribute solar energy in the form of heat in the winter and reject solar heat in the summer. This is called passive solar design or climatic design. Unlike active solar heating systems, passive solar design doesn't involve the use of mechanical and electrical devices, such as pumps, fans, or electrical controls to move the solar heat.

Passive solar homes range from those heated almost entirely by the sun to those with south-facing windows that provide some fraction of the heating load. The difference between a passive solar home and a conventional home is design. The key is designing a passive solar home to best take advantage of your local climate. For more information, see how a passive solar home design works.

You can apply passive solar design techniques most easily when designing a new home. However, existing buildings can be adapted or "retrofitted" to passively collect and store solar heat.

To design a *completely* passive solar home, you need to incorporate what are considered the ***five elements of passive solar design***. Other design elements include:

- Window location and glazing type
- Insulation and air sealing
- Auxiliary heating and cooling systems, if needed.

These design elements can be applied using one or more of the following passive solar design techniques:

- Direct gain

EERE Information Center

LEARN MORE

Evaluation Tools
Solar Radiation Data Manual for Buildings
Renewable Resource Data Center
SunAngle
DOE Building Energy Software Tools Directory

Related Links
PATH Tech Set #6, The Sun in the 21st Century: Passive and Active Solar Systems
Partnership for Advancing Housing Technology

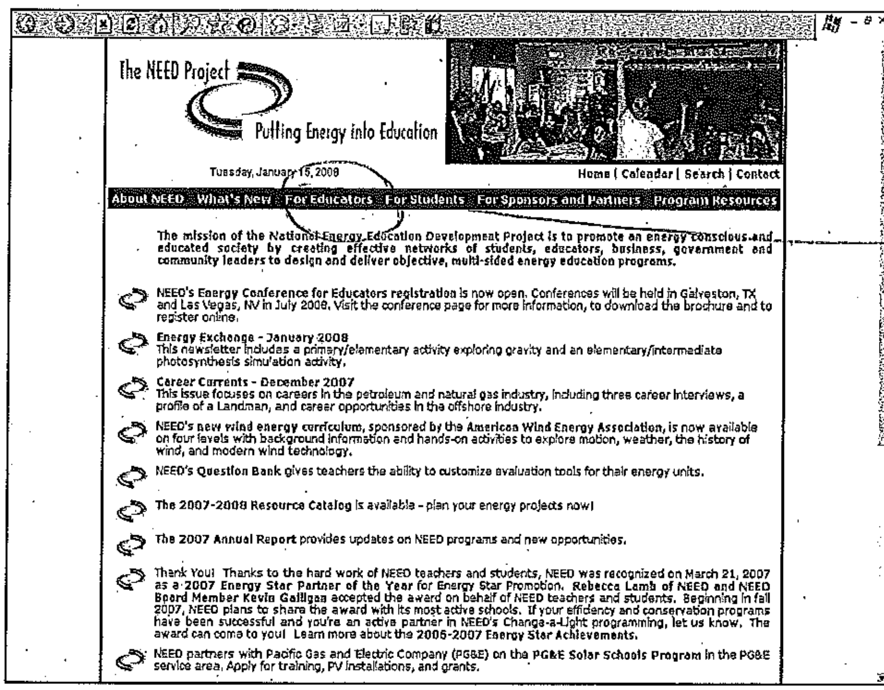
Passive Solar Design
A Sourcebook for Green and Sustainable Building

Reading List
Related Publications

Calculate Your Energy Costs

National Energy Education Development (NEED) Project

http://www.need.org/



The NEED Project
Putting Energy into Education

Tuesday, January 15, 2008

Home | Calendar | Search | Contact

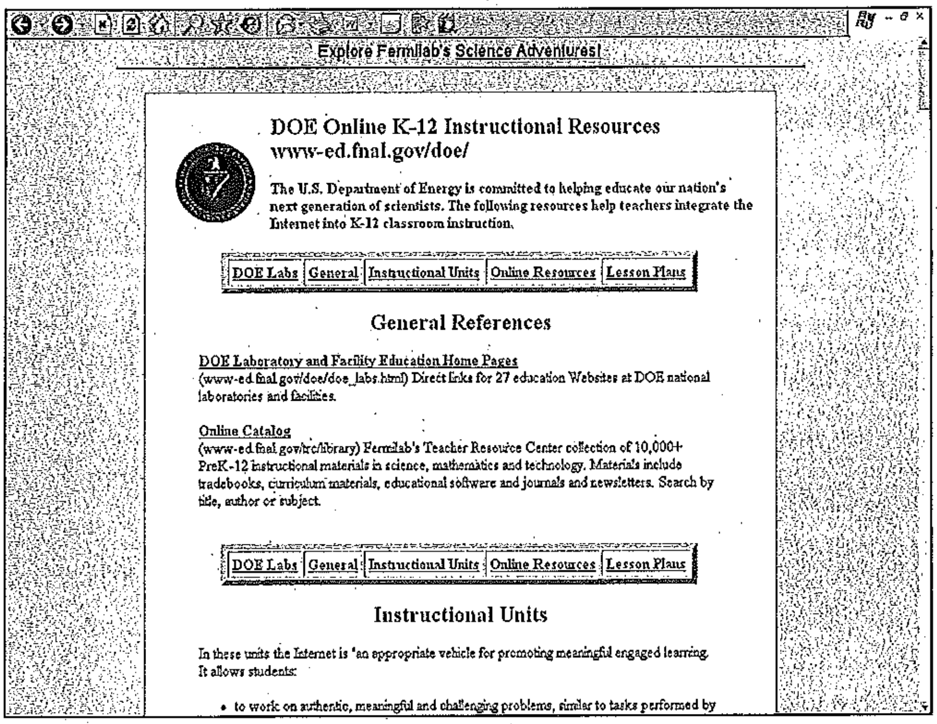
About NEED | What's New | For Educators | For Students | For Sponsors and Partners | Program Resources

The mission of the National Energy Education Development Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

- **NEED's Energy Conference for Educators** registration is now open. Conferences will be held in Galveston, TX and Las Vegas, NV in July 2008. Visit the conference page for more information, to download the brochure and to register online.
- **Energy Exchange - January 2008**
  This newsletter includes a primary/elementary activity exploring gravity and an elementary/intermediate photosynthesis simulation activity.
- **Career Currents - December 2007**
  This issue focuses on careers in the petroleum and natural gas industry, including three career interviews, a profile of a Landman, and career opportunities in the offshore industry.
- **NEED's new wind energy curriculum**, sponsored by the **American Wind Energy Association**, is now available on four levels with background information and hands-on activities to explore motion, weather, the history of wind, and modern wind technology.
- **NEED's Question Bank** gives teachers the ability to customize evaluation tools for their energy units.
- **The 2007-2008 Resource Catalog** is available - plan your energy projects now!
- **The 2007 Annual Report** provides updates on NEED programs and new opportunities.
- Thank You! Thanks to the hard work of NEED teachers and students, NEED was recognized on March 21, 2007 as a **2007 Energy Star Partner of the Year for Energy Star Promotion. Rebecca Lamb of NEED and NEED Board Member Kevin Galligan** accepted the award on behalf of NEED teachers and students. Beginning in fall 2007, NEED plans to share the award with its most active schools. If your efficiency and conservation programs have been successful and you're an active partner in NEED's Change-a-Light programming, let us know. The award can come to you! Learn more about the **2006-2007 Energy Star Achievements.**
- NEED partners with Pacific Gas and Electric Company (PG&E) on the **PG&E Solar Schools Program** in the PG&E service area. Apply for training, PV installations, and grants.

Readings for students

U.S. DOE Online K-12 Resources
http://ed.fnal.gov/doe/index.html



Explore Fermilab's Science Adventures!

DOE Online K-12 Instructional Resources
www-ed.fnal.gov/doe/

The U.S. Department of Energy is committed to helping educate our nation's next generation of scientists. The following resources help teachers integrate the Internet into K-12 classroom instruction.

DOE Labs | General | Instructional Units | Online Resources | Lesson Plans

General References

DOE Laboratory and Facility Education Home Pages
(www-ed.fnal.gov/doe/doe_labs.html) Direct links for 27 education Websites at DOE national laboratories and facilities.

Online Catalog
(www-ed.fnal.gov/trc/library) Fermilab's Teacher Resource Center collection of 10,000+ PreK-12 instructional materials in science, mathematics and technology. Materials include tradebooks, curriculum materials, educational software and journals and newsletters. Search by title, author or subject.

DOE Labs | General | Instructional Units | Online Resources | Lesson Plans

Instructional Units

In these units the Internet is "an appropriate vehicle for promoting meaningful engaged learning. It allows students:

- to work on authentic, meaningful and challenging problems, similar to tasks performed by

Visit The Energy Information Administration's Kid's Page at:

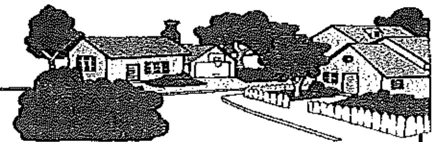
www.eia.doe.gov/kids/

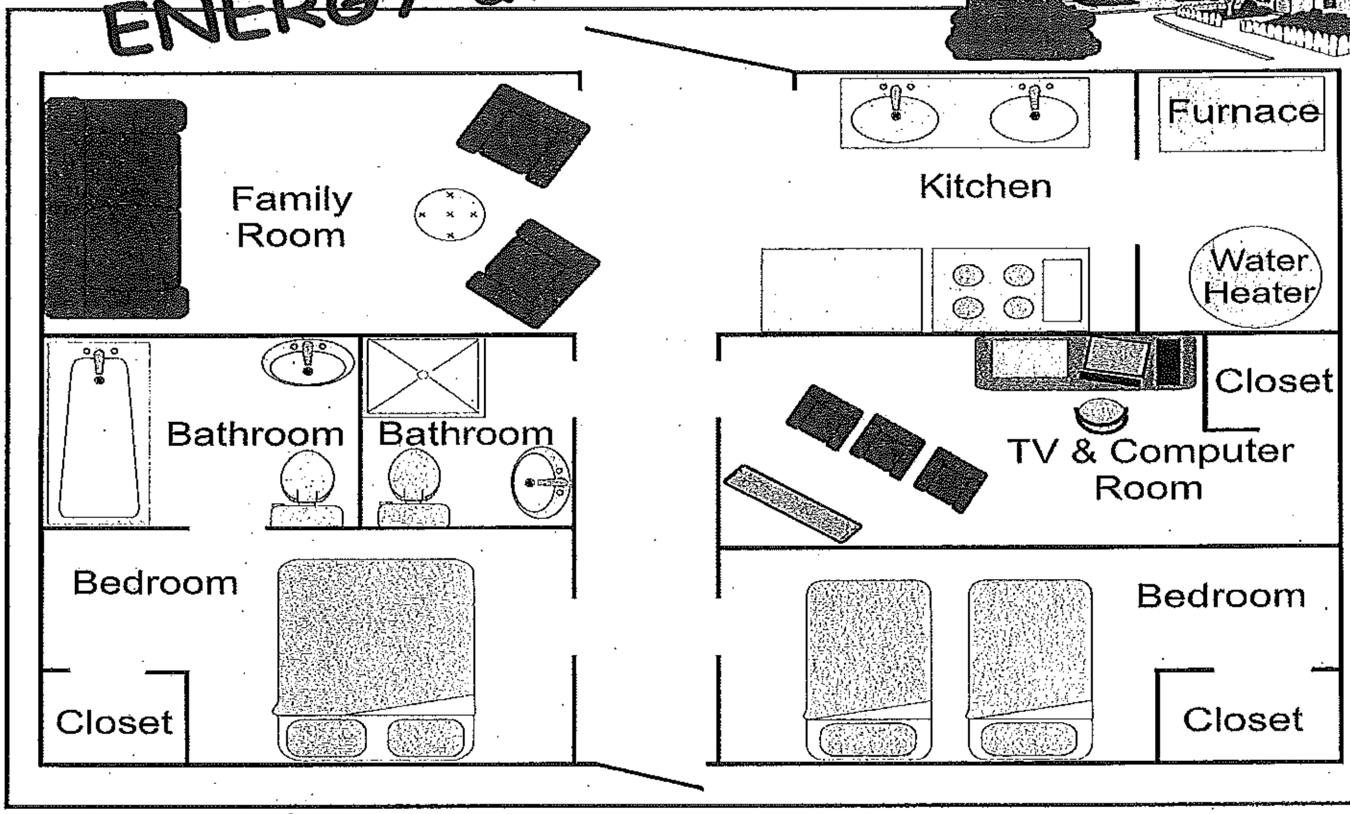
Visit The National Energy Education Development Project at:

www.need.org

ENERGY ACTIVITY:

ENERGY at Home





1. How many live in this house (count the pillows on the beds)? ________

2. Each bathroom has two . How many are in all the bathrooms? ________

3. Each bedroom has two and each closet has one . How many in all? ____________

4. The family room, kitchen, utility room, hall and TV/computer room each have one . How many are there in the whole house? __________

5. Each uses one for four hours each day. How many hours a day are they used in all? __________

6. Each uses ten cents ($0.10) worth of electricity per hour. How much does the family pay for electricity for every day? __________

7. Two take showers every day and two take baths. Each shower uses 10 gallons of and each bath uses 20 gallons. The family also uses 20 gallons of a day to wash dishes. How many gallons of are used each day? ________

School Survey

1. What kind of energy heats our school in winter?
2. What kind of energy cools our school in summer?
3. What kind of energy cooks our food?
4. What kind of energy heats our water?
5. What kind of energy runs our school buses?
6. What kind of energy powers our lights and our computers?
7. What kinds of things does the school recycle?
8. How do we waste energy?
9. How do we save energy?
10. What things can we do to save more energy?

School Building Survey

General Information

1 When was the school built?

2 What changes have been made since the school was built? When were they made?

3 What other things use energy on the school grounds? Lighted fields? Outdoor lighting?

4 What fuels are used in the school? For heating, cooling, water heating, lighting, other?

5 How much does the school pay each year for energy? How much for electricity? How much for heat?

6 Are there other energy costs that the school pays for, like buses?

7 How many hours is the school in use each week?

8 Do other groups that use the school pay for the energy they use?

9 Who is in charge of controlling energy use in the school?

10 Who is in charge of maintaining the equipment?

Building Envelope

1 What is the building made of? Is it in good condition?

2 In which direction does the building face?

3 How many windows are on each side of the building? Are any windows cracked or broken?

4 Are the windows single or double-paned? Can they be opened? Do the windows have adjustable blinds?

5 How many outside doors are there? Are they insulated? Are there windows in the doors? Are any cracked or broken?

6 Does the building have insulation in the walls and ceiling?

7 Are inside stairwells open or enclosed?

8 Do windows and doors seal tightly, or do they leak air?

9 Are there overhangs over the windows to shade windows from the sun in warm weather, and allow the slanted rays of the sun in winter to enter?

10 Are trees placed around the building to provide shade in warm months?

School Building Survey

Heating/Cooling Systems

1 What kind of heating system is used in the school? What fuel does it use?

2 How old is the heating system?

3 Does the heating system have a programmable thermostat to control temperature? What are the settings?

4 What kind of cooling system is used in the school?

5 How old is the cooling system?

6 Does the cooling system have a programmable thermostat to control temperature? What are the settings?

7 Is there an air exchange system to provide fresh air when the heating and cooling systems are not operating?

8 Are the pipes and ducts sealed and insulated?

Lighting

1 What kind of lighting is used in the school? Outside the school? Exit lights?

2 Can the lights be controlled with dimmer switches? In which areas or rooms?

3 Does the school make use of skylights and natural lighting?

4 Are there timers for the outside lights so they go off automatically?

Water Heating

1 What fuel is used to heat water in the school?

2 Is there more than one water heater? How many?

3 How old are they?

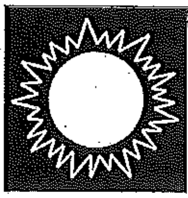
4 Do the water heaters have timers?

5 At what temperatures are the water heaters set?

6 Are the water heaters and water pipes insulated?

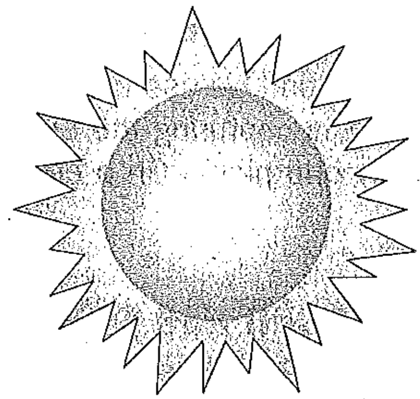
7 Are there leaks in the hot water system?

SOLAR



We get most of our energy from the sun. We call it **solar energy.** It travels from the sun to the earth in rays. Some are light rays that we can see. Some rays we can't see, like x-rays.

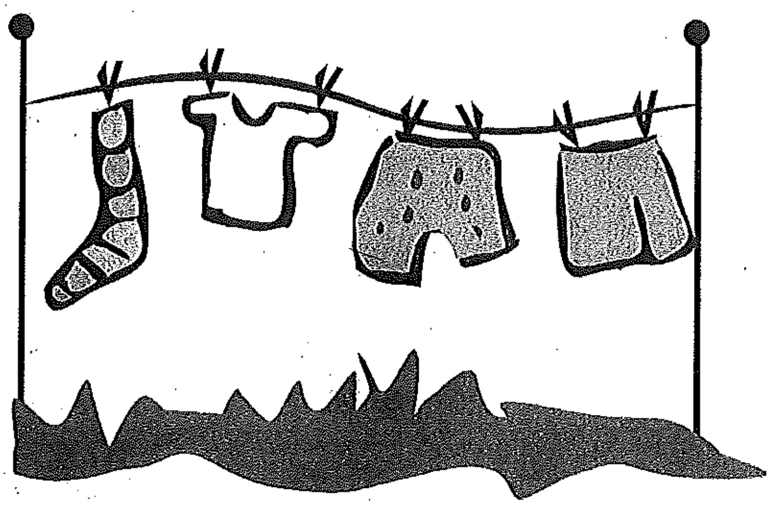
The sun is a giant ball of gas. It sends out huge amounts of energy every day. Most of the energy goes off into space. Only a small part reaches the earth.



We depend on solar energy.

We use solar energy in many ways. All day, we use sunlight to see what we're doing and where we're going.

Sunlight turns into heat when it hits things. Without the sun, we couldn't live on the earth—it would be too cold. We use the sun's energy to heat water and dry clothes.



Plants use the light from the sun to grow. Plants take the energy in light and store it in their roots and leaves. That energy feeds every living thing on earth. We can also burn plants to make heat.

The sun's energy is in many things.

The energy from the sun makes rain fall and wind blow. We can capture that energy with dams and windmills.

Coal, oil and natural gas were made from prehistoric plants and animals. The energy in them came from the sun. We use that energy to cook our food, warm our houses, run our cars, and make electricity.

Solar energy is renewable.

Solar energy is free and clean. There is enough for everyone, and we will never run out of it. Solar energy is **renewable**. The sun will keep making energy for millions of years.

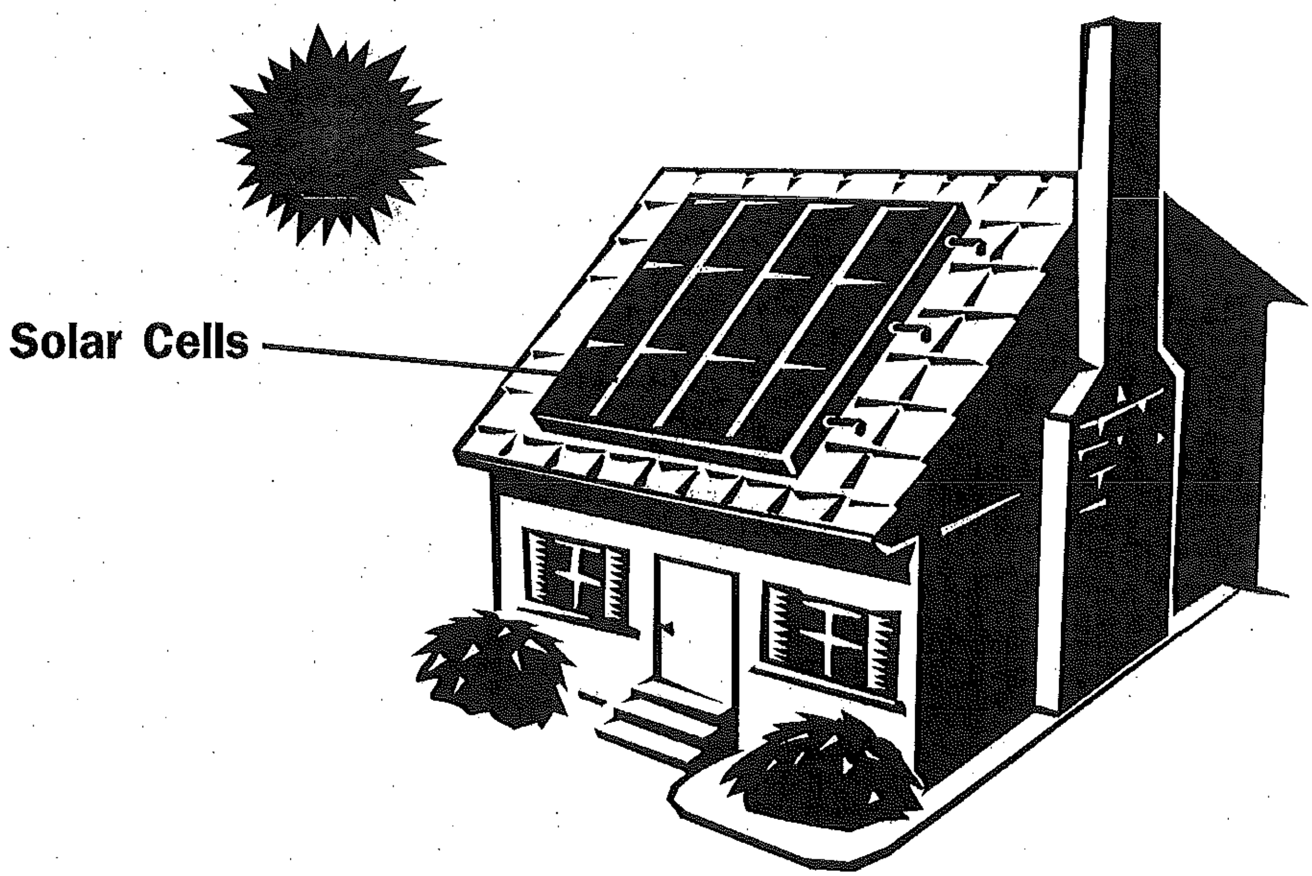
Why don't we use the sun for all our energy needs? We don't know how to yet. The hard part is capturing the sunlight. It shines all over the earth and only a little bit reaches any one place. On a cloudy day, most of the light never reaches the ground at all.

We can use solar energy.

Lots of people put **solar collectors** on their roofs. Solar collectors capture the sunlight and turn it into heat. People heat their houses and their water using the sun's energy.

Solar cells can turn light energy into electricity. Some toys and calculators use solar cells instead of batteries. Big solar cells can make enough electricity for a house. They are expensive, but they are good for houses far away from power lines.

Today, solar energy provides only a tiny bit of the electricity we use. In the future, it could be a major source of energy. Scientists are looking for new ways to capture and use solar energy.

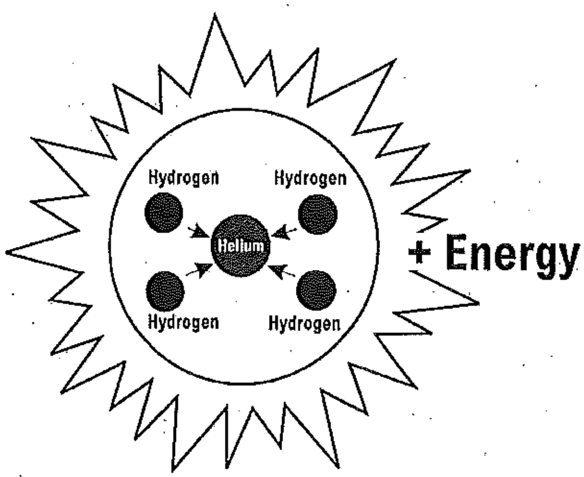


Solar Energy

WHAT IS SOLAR ENERGY?

Every day, the sun radiates (sends out) an enormous amount of energy—called **solar energy.** It radiates more energy in one second than the world has used since time began. This energy comes from within the sun itself.

Like most stars, the sun is a big gas ball made up mostly of hydrogen and helium gas. The sun makes energy in its inner core in a process called **nuclear fusion.**



During a process called FUSION, four hydrogen atoms combine to form one helium atom, with a loss of matter. This matter is emitted as radiant energy.

Only a small part of the solar energy that the sun radiates into space ever reaches the earth, but that is more than enough to supply all our energy needs. Every day enough solar energy reaches the earth to supply our nation's energy needs for a year!

It takes the sun's energy just a little over eight minutes to travel the 93 million miles to earth. Solar energy travels at a speed of 186,000 miles per second, the speed of light.

Today, people use solar energy to heat buildings and water and to generate electricity.

SOLAR COLLECTORS

Heating with solar energy is not as easy as you might think. Capturing sunlight and putting it to work is difficult because the solar energy that reaches the earth is spread out over a large area. The sun does not deliver that much energy to any one place at any one time.

The amount of solar energy an area receives depends on the time of day, the season of the year, the cloudiness of the sky, and how close you are to the earth's equator.

A **solar collector** is one way to capture sunlight and change it into usable heat energy. A closed car on a sunny day is like a solar collector. As sunlight passes through the car's windows, it is absorbed by the seat covers, walls, and floor of the car. The absorbed light changes into heat. The car's windows let light in, but they don't let all the heat out. A closed car can get very hot!

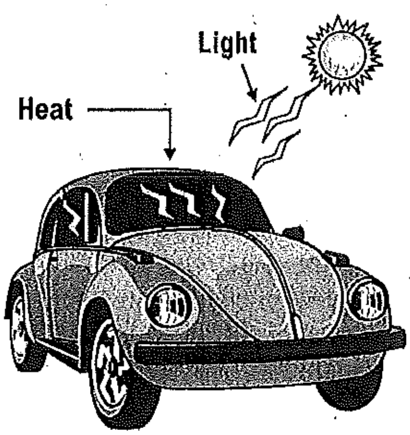
SOLAR SPACE HEATING

Space heating means heating the space inside a building. Today, many homes use solar energy for space heating. A **passive solar home** is designed to let in as much sunlight as possible. It is like a big solar collector.

Sunlight passes through the windows and heats the walls and floor inside the house. The light can get in, but the heat is trapped inside. A passive solar home does not depend on mechanical equipment, such as pumps and blowers, to heat the house.

An **active solar home**, on the other hand, uses special equipment to collect sunlight. An active solar house may use special collectors that look like boxes covered with glass.

SOLAR COLLECTOR



On a sunny day, a closed car becomes a solar collector. Light energy passes through the window glass, is absorbed by the car's interior and converted into heat energy. The heat energy becomes trapped inside.

These collectors are mounted on the rooftop facing south to take advantage of the winter sun. Dark-colored metal plates inside the boxes absorb sunlight and change it into heat. (Black absorbs sunlight more than any other color.) Air or water flows through the collector and is warmed by the heat. The warm air or water is distributed to the rest of the house, just as it would be with an ordinary furnace system.

SOLAR HOT WATER HEATING

Solar energy can be used to heat water. Heating water for bathing, dishwashing, and clothes washing is the second biggest home energy cost.

A solar water heater works a lot like solar space heating. In our hemisphere, a solar collector is mounted on the south side of a roof where it can capture sunlight. The sunlight heats water in a tank. The hot water is piped to faucets throughout a house, just as it would be with an ordinary water heater. Today, more than 1.5 million homes in the United States use solar water heaters.

SOLAR ELECTRICITY

Solar energy can also be used to produce electricity. Two ways to make electricity from solar energy are photovoltaics and solar thermal systems.

Photovoltaic Electricity

Photovoltaic comes from the words *photo* meaning *light* and *volt*, a measurement of electricity. Sometimes photovoltaic cells are called PV cells or solar cells for short. You are probably familiar with photovoltaic cells. Solar-powered toys, calculators, and roadside telephone call boxes all use solar cells to convert sunlight into electricity.

Solar cells are made up of **silicon**, the same substance that makes up sand. Silicon is the second most common substance on earth. Solar cells can supply energy to anything that is powered by batteries or electrical power.

Electricity is produced when sunlight strikes the solar cell, causing the electrons to move around. The action of the electrons starts an electric current. The conversion of sunlight into electricity takes place silently and instantly. There are no mechanical parts to wear out.

You won't see many photovoltaic power plants today. Compared to other ways of making electricity, photovoltaic systems are expensive.

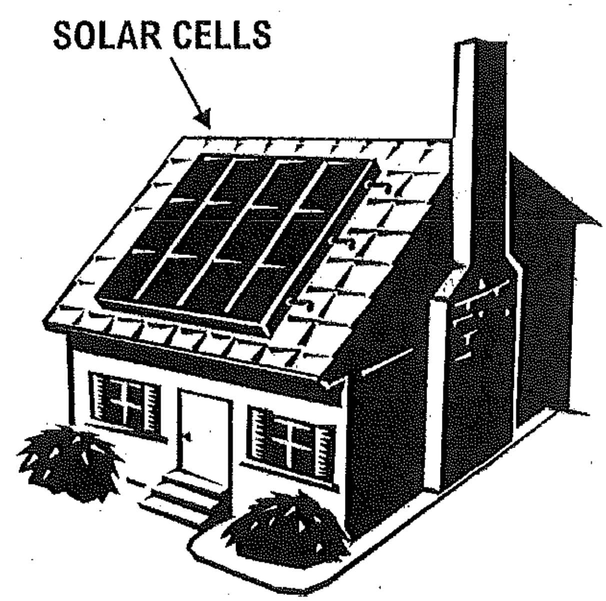
It costs 10-20 cents a kilowatt-hour to produce electricity from solar cells. Most people pay their electric companies about nine cents a kilowatt-hour for the electricity they use, large industrial consumers pay less. Today, solar systems are mainly used to generate electricity in remote areas that are a long way from electric power lines.

Solar Thermal Electricity

Like solar cells, **solar thermal systems** use solar energy to produce electricity, but in a different way. Most solar thermal systems use a solar collector with a mirrored surface to focus sunlight onto a receiver that heats a liquid. The super-heated liquid is used to make steam to produce electricity in the same way that coal plants do.

Until recently, the most successful thermal power plant was the LUZ plant in the Mojave desert of California. LUZ made electricity as cheaply as most coal plants. Then in 1992, LUZ had to shut down because of financial problems.

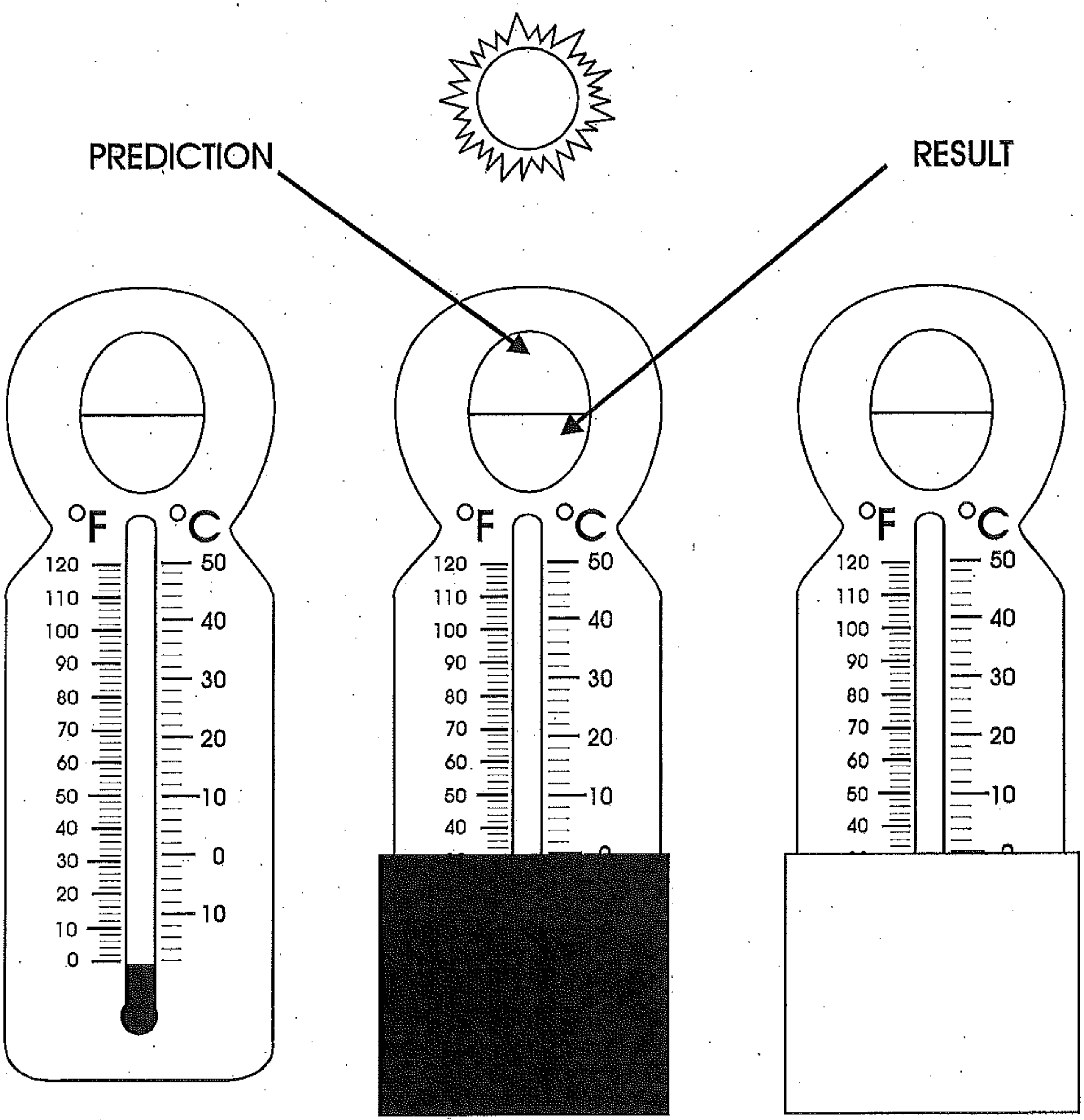
Solar energy has great potential for the future. Solar energy is free, and its supplies are unlimited. It does not pollute or otherwise damage the environment. It cannot be controlled by any one nation or industry. If we can improve the technology to harness the sun's enormous power, we may never face energy shortages again.



PRIMARY ENERGY ACTIVITY: Energy from the Sun

When solar energy hits objects, some of the energy is reflected and some is absorbed and changed into heat. Some colors absorb more solar energy than others.

Step 1: Put three thermometers in a sunny place.
Step 2: Cover the bulb of one with black paper. Cover the bulb of one with white paper.
Step 3: Predict which thermometer will get hottest. Number them 1-3, with 1 as the hottest.
Step 4: Wait five minutes.
Step 5: Record your results by coloring the tubes of the thermometers.
Step 6: Look at the results and number the thermometers 1-3 with 1 as the hottest.
How well did you predict?



ELEMENTARY EXPLORATION: Solar Collectors

Solar collectors absorb radiant energy, convert it into heat and hold the heat.

PURPOSE: To explore solar collection.

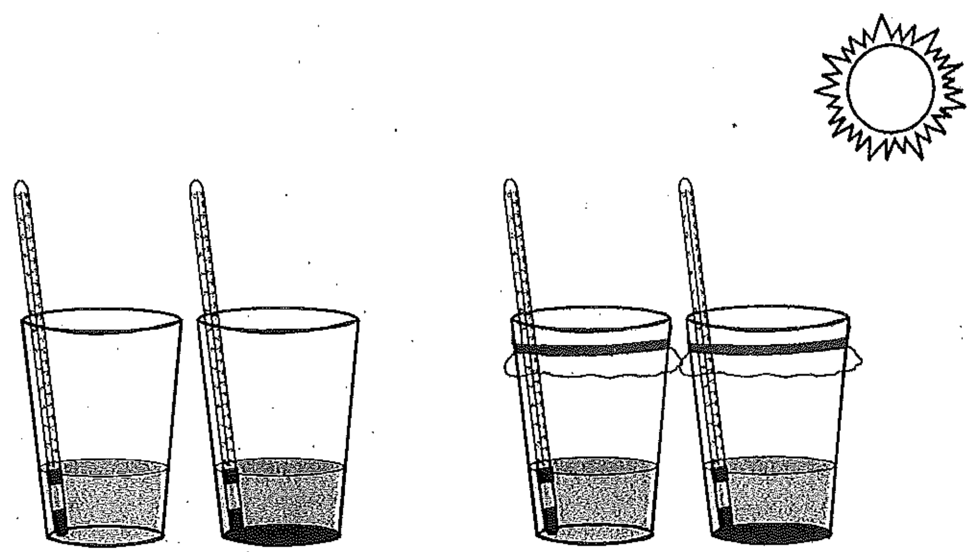
MATERIALS: 4 plastic containers, black & white construction paper, water, thermometer, plastic wrap, rubber bands, scissors

Step 1: Cut two circles each of white and black construction paper to fit the bottom of the containers. Place the circles on the bottom of the containers and cover with 100 ml of cold water. Record the temperature of the water.
Step 2: Cover one black and one white container with clear plastic wrap held in place with rubber bands.
Step 3: Place the containers in a sunny place so that the sun is directly over the containers. Record the temperature of the water after ten minutes.
Step 4: Calculate and record the changes in temperature.

RECORD THE DATA

	WHITE NO COVER	BLACK NO COVER	WHITE WITH COVER	BLACK WITH COVER
Original Temperature-C				
Temperature-C After 10 min				
Change in Temperature				

CONCLUSIONS: Look at your data. What have you learned about collecting solar radiation?

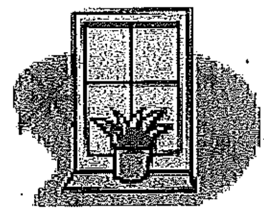


Alliance to Save Energy's Green Schools Program

Elementary Lesson Plans

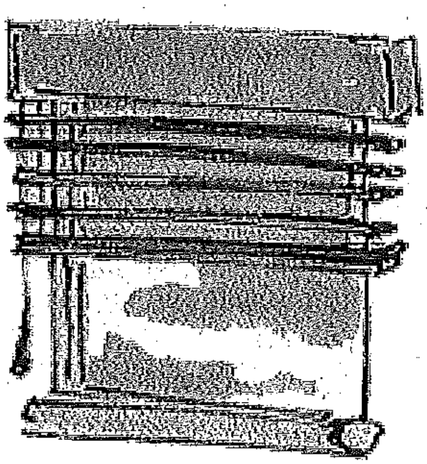
By Jeff Saks, Bemis Elementary School
Rialto Unified School District, California

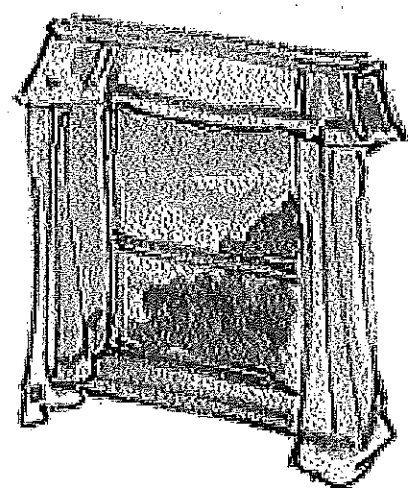
Why is it so hot when I sit next to the window?



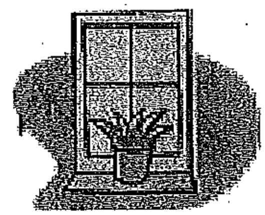
There are teachable moments all around us. A student's question or just body language can be enough to generate a great lesson. This lesson was sparked by a student practically getting undressed (I teach first grade so this is not all that uncommon) because he was so hot sitting by a window. The morning sun was coming in the window and beating right on his chair. I asked him what was the problem and his exasperated reply was "I am cooking here!" After a brief discussion on whether or not the young man was indeed "cooking" this lesson developed.

The students had a wonderful time applying the film to the windows and taking all the measurements. They were very excited about their findings and took the data to the principal of the school. The results were then relayed to the maintenance and operations department of the school district. They in turn came out and applied window tint to all the east facing windows in our school.





Why is it so hot when I sit next to the window?



Grade level: K – 5

Subject areas: Science, Math, Language Arts.
Grade level standards are met in each of the subject areas for each of the grade levels.

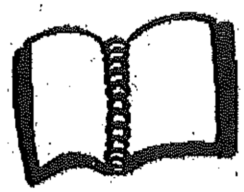
Time Required: Two to three hours on the first day and one hour a day for 4 days.

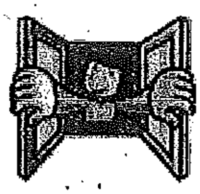
Objectives:

- The students will learn how to reflect heat energy.
- Students will show how glass can transmit energy.
- Students will demonstrate how this information can be used at home and in the community.

Materials/Resources:

- You will need to get permission to put film on some windows.
- Windows
- Calculators
- Chart paper
- Various types of window film
- Thermometers
- Paper, pencils, crayons
- Journals





Procedure:

Day one

1. Ask students why they think it is hotter by the window. Write their answers on the whiteboard. Discuss.
2. Have students come up with some solutions. Mention window tinting or film. List them on the whiteboard.
3. Ask the students how the heat and the light coming from the window might affect energy usage. Explore.
4. Show the students different kinds of window film. Ask them which one they think will reduce the amount of heat coming through the window. (You can also measure the amount of light if you have access to a light meter.)
5. Have the students find some windows that all face the same direction and are in direct sunlight for a portion of the day.
6. Pick a number (at least one for each kind of tint) of windows to apply window tint film to and a number to leave uncovered as statistical control windows.
7. Apply the film to the windows.

8. Have the students record in their science journal what their hypothesis is and record what procedures they have completed.

End of day one.

Day two through five

1. Tape a thermometer to the inside of the window and place another somewhere inside the room, near the window but not in direct sunlight.
2. Tape another thermometer to the outside of the window.
3. You will need a chart to record your data. I made one that looked like this. I made it on tag board so it would hold up.

We collect our data each day at 10:00.							
Day of the week	Window tint sample room	Temperature inside on the window.	Temperature inside the room.	Difference of the inside window temperature and the inside of the room	Temperature outside of the window	Difference between the outside temperature and the inside window temperature.	Percent of change
Tuesday	B-1						
Tuesday	B-3						
Tuesday	B-5						
Tuesday	C-1						
Tuesday	C-3						
Tuesday	C-3						

4. Make one for each of the four days that you will gather data.
5. Gather your data and record it on the chart.
6. Have the students calculate the differences and the percent of change, record the data in their journals.
7. Discuss with the students the findings; see if any want to revise their hypothesis. Have them record their thoughts and findings in their journal or log.

Putting it all together:

- After all the data collection is complete, have the students graph their findings. Discuss the findings.
- Did the different film make a difference? If so, how could this information be applied to their school and their home? Would they save enough energy to pay for the film?
- Have the students present their findings to the school or district administration.
- Have the students talk to their parents about what they have discovered and possibility have film applied to their home.

Funding for this lesson was provided by **California ratepayers under the auspices of the California Public Utilities Commission.**

U.S. Department of Energy - Energy Efficiency and Renewable Energy

A Consumer's Guide to Energy Efficiency and Renewable Energy

Five Elements of Passive Solar Home Design

The following five elements constitute a *complete* passive solar home design. Each performs a separate function, but all five must work together for the design to be successful.

Aperture (Collector)

The large glass (window) area through which sunlight enters the building. Typically, the aperture(s) should face within 30 degrees of true south and should not be shaded by other buildings or trees from 9 a.m. to 3 p.m. each day during the heating season.

Absorber

The hard, darkened surface of the storage element. This surface—which could be that of a masonry wall, floor, or partition (phase change material), or that of a water container—sits in the direct path of sunlight. Sunlight hits the surface and is absorbed as heat.

Thermal mass

The materials that retain or store the heat produced by sunlight. The difference between the absorber and thermal mass, although they often form the same wall or floor, is that the absorber is an exposed surface whereas thermal mass is the material below or behind that surface.

Distribution

The method by which solar heat circulates from the collection and storage points to different areas of the house. A strictly passive design will use the three natural heat transfer modes—conduction, convection, and radiation—exclusively. In some applications, however, fans, ducts, and blowers may help with the distribution of heat through the house.

Control

Roof overhangs can be used to shade the aperture area during summer months. Other elements that control under- and/or overheating include electronic sensing devices, such as a differential thermostat that signals a fan to turn on; operable vents and dampers that allow or restrict heat flow; low-emissivity blinds; and awnings.

Shadows in the Schoolyard

Summary:
Students measure shadow lengths to appreciate how the sun's height and location in the sky varies throughout the day.

Grade Levels: K-4

Subject Areas:
Earth and Physical Science, Math

Setting:
Outdoor site where there are shadows that can be measured

Time:
Preparation: 20 minutes
Activity: 50-minute period plus time needed for shadow measurements throughout the day

Vocabulary:
Light, Shadow, Solar energy, Sun

Materials:
- **Energy Learning Log** and writing implements
- Piece of schoolyard equipment, a tree located in an open area
- Compass (optional)
- Rulers
- Copies of **Schoolyard Shadow Table**

Objective

- Students will demonstrate that the sun's position in the sky determines shadow length and direction.

CAUTION: Because too much exposure to the sun can be harmful, remind students to dress properly and use sunscreen when doing outdoor activities for long periods. Also, remind the children they should never look directly into the sun. Sunglasses are always a good idea.

Procedure

1. Tell students they are going to investigate "The Mystery of the Schoolyard Shadows" (embellish the story as desired; you can play the part of a person who keeps losing his or her shadow). Explain that the shadows in the schoolyard keep changing throughout the day and they must help to solve this mystery. Ask them what they think happens to shadows, and have them write the answer in their **Energy Learning Logs.** Ask them to predict when the shadows will be longest and when they will be shortest.

2. Find a sunny, flat area near your school. Orient students to north and review how to use a ruler as needed. NOTE: To help younger students understand directions, you might want to orient them to a landmark in the schoolyard, such as a tree or a building that is north of them. They can use this landmark as a reference point. For measuring they can use a string, a piece of yarn, or another adapted measuring tool.

3. Choose an object that will cast a shadow that is easy to measure. The object can be a mailbox, pole, or piece of playground equipment, or you (the teacher). At various times of day, have the students go outside and measure the length of the assigned object's shadow with a yardstick or string, recording the length and direction of the shadow and the time of day in the **Schoolyard Shadow Table.** After each measurement, have students compare it to the previous measurement and predict how the shadow will be cast next time. See if they notice a pattern.

4. Have students look at the table to determine if they predicted correctly. Why does the shadow change throughout the day? Continue to investigate this case for at least a week. Are the shadows the same day after day?

5. Were students able to solve the mystery of why the shadows change throughout the day? The students that worked together can present their findings as a

Related KEEP Activities:

To investigate how shading, coloring, and other factors affect temperature, refer to "Taking Temperatures." Refer to "Exploring Heat" and "Shoebox Solar Cooker" to help students understand heat and thermal properties of sunlight. Energize students by exploring light energy through the use of mini solar panels. To generate ideas on how to power up radios, toys, and more in your classroom, refer to "The Miracle of Solar Cells." To further explore the heat and light properties of the sun, refer to KEEP Energy Sparks "Exploring Light Energy" and "Exploring Heat."

Procedure (Continued)

group, or the entire class can work together to solve the mystery. Continue the discussion until students understand that the sun appears to be positioned differently in the sky during the day due to Earth's rotation (i.e., be sure students understand that the sun is stationary while it is our planet that is moving). Earth's orbit changes during the different seasons, which also seems to change the position of the sun.

Assessment

- Have students collect data throughout the week, record their findings in their **Energy Learning Log,** and use the information to compile the **Energy Flow Mural.**
- With a drawing or a play, have students demonstrate the sun's position in the sky and the change in shadows throughout the day.

Extensions

Repeat these activities over the course of the school year. Have the students keep a seasonal log to track the data obtained and to look for patterns.

Investigate what happens to the length of shadows in your schoolyard in the morning, afternoon and evening by having students trace other classmates' shadows on large pieces of butcher paper. Compare the proportions.

Compare the time of day and where on the horizon the sun sets in summer, fall, winter, and spring. Is there a relationship between outside temperatures and sun height in the sky? What do people wear each season in response to temperature changes? Have the students create a collage or perform a fashion show that illustrates the various kinds of clothing people wear during different seasons.

Use the sun to determine which direction (north, south, west, or east) the front of your school faces. Which part of the school faces the sun when it rises? Label the east and west sides. Which side or part of your school is always in the shade? This is the northern side.

Schoolyard Shadow Table

Date	Time	Shadow Length* (inches)	Shadow Direction* (N, W, E, S)	Change since last measurement (inches)

*Younger students can draw the length of string on a wall chart to measure shadow length and identify the schoolyard landmark to record shadow direction.

Average Vehicle Occupancy (AVO) In Your Community

Al Stenstrup
Education Outreach

Mittsy Voiles
Air Education Specialist

National Academic Standards:

<u>Science</u>
Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Science in Personal and Social Perspectives
- Natural Resources
- Environmental Quality

<u>Social Studies</u>
Production, Distribution, and Consumption
- Compare how values and beliefs influence decisions in different societies

<u>Physical Education and Health</u>
Reducing Health Risks
- Demonstrate the ability to practice health-enhancing behaviors and reduce health risks

Grades: 6-10

Subjects: Science, Social Studies, Health

Objectives:

1. Determine the Average Vehicle Occupancy in your community.
2. Develop, administer, and analyze a survey to determine attitudes toward air pollution and transportation.

Materials:

City street map, pencil, paper

Background:

Many states in the U.S., and many countries around the world, have serious air quality problems. And, while the pollution may start in a particular geographic area, winds carry these clouds of pollution to other regions. As cities grow in size, air pollution problems often grow as well.

Many laws have been passed to force polluters to clean up their business, most notably the Clean Air Act in the U.S. Industries such as paper mills, steel foundries, and chemical plants must adhere to strict emission guidelines and undergo regularly scheduled smokestack tests to make sure that unhealthy levels of pollution are not blown into the air. These laws have helped significantly in improving our air.

One of the biggest sources of pollution is gas-powered vehicles - notably cars, trucks, buses, motorcycles, and other engines that need gasoline in order to run. As the population has increased, so, too, has the number of vehicles. Travel data from the 1997 U.S. Census has shown a 39 percent increase since 1980 in the number of miles driven in our vehicles. In other words, for every 100 miles traveled by cars in 1980, cars in 1997 traveled 139 miles. In the same census, people carpooled for only 9 percent of their trips, took transit only four percent of the time, and biked or walked for only 6.5 percent of the trips.

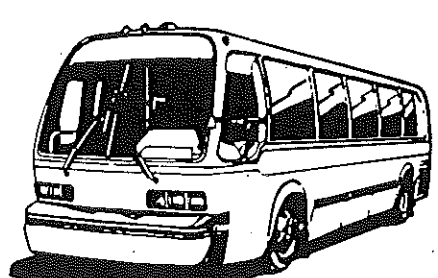
While it is true that cars are "cleaner" than in the past, the rapid rise in the number of vehicles on the highways still creates pollution. One way to get everyone where they're going with fewer vehicles is to use alternative means of travel such as buses, trains, bicycles, and carpools. The more people a single gas-powered engine can transport, the better it is for the environment. Not only does this reduce air pollution, it helps make our highways last longer, saves gasoline and oil, reduces stress associated with traveling in heavy traffic, and slows down the need to build bigger and longer superhighways.

The number of people traveling divided by the number of vehicles gives us an "Average Vehicle Occupancy" or AVO. For example, according to the Federal Highway Administration, as of 1997 the United States had an AVO of 1.59. This is the same as saying that 159 people are getting to their destinations by using 100 vehicles:

$$\frac{159 \text{ people}}{100 \text{ vehicles}} = 1.59 \text{ AVO}$$

The Clean Air Act Amendment of 1990 requires the counties in the most polluted regions of each U.S. State to monitor specific air pollutants and to take action to reduce air pollution. One way to reduce air pollution and traffic congestion is by promoting alternative ways of traveling. Employers can play a big role by encouraging their employees to carpool, use the bus, walk, or bike to work, and offering special benefits for those employees who participate.

For more information, visit *<u>The Library</u>* on the Easy Breathers Web site.



Procedure:

1. Using a street map of your community highlight the "commuter roadways." These are the major roadways that people use to travel to or from work. From this map determine the best locations to conduct a survey of traffic and the number of people traveling in each vehicle. Before conducting the survey, inspect each observation point and carefully select a safe place to stand.
2. Students should predict what they think the average vehicle occupancy will be. Then, using a tally sheet, have students determine the number of vehicles and the number of people in each vehicle. Counters should make very specific comments to the recorder. Example: "car-one person," "truck-two people." Students should keep a separate count of any walkers or bikers. Have students survey for 10 minutes. If possible, have them conduct the survey during the hours of 6 A.M. and 10 A.M. when most people are traveling to work. Compare the different sites in your community. Calculate the AVO for your community.
3. Have students develop a <u>written or oral survey</u> to determine commuters' attitudes toward trip reduction. The survey should target why people decide to carpool or take transit. The survey should also focus on reasons drivers have for driving alone.

   After analyzing the survey responses, have your students come up with ideas that promote carpooling, bicycling, bus riding, and walking.

Extension:

1. Students can survey vehicles entering the school parking lot to determine AVO of the students and teachers. A school survey could be completed that determines the number of miles that students and teachers drive to school and back each day. Based on the results, the students could develop a trip reduction program for their school.
2. Students can survey businesses in the area to learn more about their efforts to encourage carpooling, use of mass transit and biking.

Submit your AVO results to the Easy Breathers project via our Web site:
www.easybreathers.org