U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

ENERGY EDUCATION AND WORKFORCE DEVELOPMENT

Alternative Energy Sources - An Interdisciplinary Module for Energy Education

Grades: 5-8

Topic: Energy Basics, Wind Energy, Solar

Owner: Earth Science Department at the University of Northern Iowa

This educational material is brought to you by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

ALTERNATIVE ENERGY SOURCES IN IOWA

Sample Teaching Schedule

Day 1:
Sci. - Video, Radiation and the Transfer of Energy (set up), Read pg 1 - 3
SS. - Solar and Wind Energy Around the World
L.A. - Start Researching Solar and Wind Energy

Day 2:
Sci. - Do Radiation and the Transfer of Energy
SS. - Discuss and display Solar and Wind Energy Around the World
Math - Length of Shadows
L.A. - Continue Researching Solar and Wind Energy

Day 3:
Sci. - Beaufort Wind Scale, Read pages 4, 5, and top of 6
SS. - Plotting Solar and Wind Data on US Maps
Math - Measuring Wind Speed
L.A. - Continue Research activity

Day 4:
Sci. - The Effect of Concentrating Sunlight, Read pages 6, 7, and 8
SS. - Mapping Wind Speeds Around Your School
Math - Wind Vane
L.A. - Finish Researching Solar and Wind Energy

Day 5:
L.A. - Have students present the results of Researching Solar and and Energy
L.A. - Finish the module by doing Tooning into Renewable Energy Sources

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Possible letter home:

Dear Family,
This week your student's class will be doing an integrated study of the uses of alternative energy sources in Iowa. We feel that there is a need for us all to understand how solar and wind energy can be used in the home and school. This understanding could make us more aware of current research and use of wind and solar energy in the state.
Your child will be bringing information and projects home that he/she would like to share with you. We encourage your participation. If you have any questions, do not hesitate to contact your student's teacher.

Sincerely,
Your Name

VIDEO: Alternate Energy Sources in Use Today

Teacher Directed Activity

Objectives:
1. Students will begin thinking about how wind and solar energy are used.
2. Teacher will assess prior knowledge students have about how wind and solar energy are used in Iowa and around the world.

Teaching Strategies:
1. The video lasts approximately seven minutes. Preview the video before showing it to your class. It is strongly recommended that you use the video as a start-up activity for this unit.
2. Before showing the video, ask students if anyone has ever visited a home or other building that is making use of wind or solar energy.Ask students to share their knowledge about the use of solar and wind energy.
3. Show the video to the students. The video shows four students visiting a school that uses a wind generator for electricity supply, a home that takes advantage of solar energy, and a building that is heated and cooled by using ground water.
4. After viewing the video, lead the class in a discussion about the ontent of the video. Remember, the video is primarily for motivational purposes.
5. As you move through the module, you might find it helpful to rerun various segments of the video to reinforce student learning.
6. Show the video again, before visiting an operating wind mill site or a solar home.

Materials List for Module 3 Activities

Radiation and the Transfer.....
For each group of four students: 1 lamp with 150 watt bulb or 1 sun lamp, 5 Styrofoam cups, light colored sand, dark colored dirt, water, 5 thermometers, graph paper

Beaufort Wind Scale....
No materials required

The Effect of Concentrating Sunlight.....
For each group of students: small convex hand lens, 3 Celsius or Fahrenheit thermometers, graph paper, rulers

Length of Shadows....
For each group of students: ruler, yardstick or meter stick, modeling clay, protractor

Measuring Wind Speed....
For each group of students: 1 protractor, 1 ruler, clear tape, about 9 inches or 25 cm of colored thread, 1 table tennis ball

Wind Vane....
For each student: pencil with eraser, paper or Styrofoam cups, straws, straight pins, scissors, 3 x 5 card, ruler, white glue, directional compass

Solar and Wind Energy Around the World....
magazines, catalogs, newspapers, construction paper or poster board, white glue

Plotting Solar and Wind Data on Maps....
almanacs, atlases, copies of U.S. outline map

Mapping Wind Speeds Around Your School....
wind speed measurers (from Math Activity), map of school grounds

Researching Solar and Wind Energy....
reference materials
Tooning into Renewable Energy Sources....
drawing paper, colored pencils, or crayons

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BACKGROUND INFORMATION

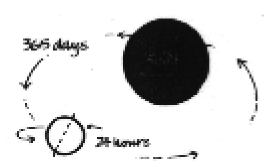
Alternative Energy Sources in Iowa

Energy From the Sun
In about forty minutes the sun sends to the earth's surface about as much energy as people use in a year. We use energy from the sun without being aware of it. The sun's energy melts snow, warms your body, and dries the laundry on a clothesline. On some days the sun makes the streets seem "hot enough to fry an egg."

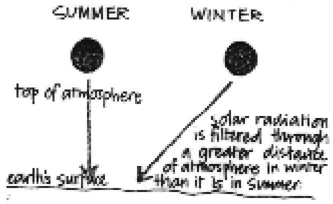
Nearly every bit of energy used by humans comes from the sun's energy -- or **solar energy**. The wood we burn for heat and the fruits and vegetables we eat come from plants. These plants use sunlight to change water, minerals and carbon dioxide into plant material and food. Fossil fuels such as coal, oil and natural gas form by the deposit and decay of plants and organisms over millions of years. We can consider coal, natural gas, and oil to be "fossilized" or stored up solar energy.

Even the wind which powers sailboats and windmills is a result of the sun heating different parts of the earth's atmosphere at different rates. Hydroelectric power also depends on the sun to evaporate water into the atmosphere. Eventually this evaporated water changes to snow and rain and falls back to earth to fill our dams and reservoirs.

The Sun in the Sky
The diagram shows the earth rotates or spins around on its axis once every 24 hours. Earth also revolves around the sun once every year. Because the earth rotates, the position of the sun in the sky changes from sunrise to sunset. Because the earth is tilted on its axis, the sun's position in the sky also changes from summer to winter as the earth moves around the sun.



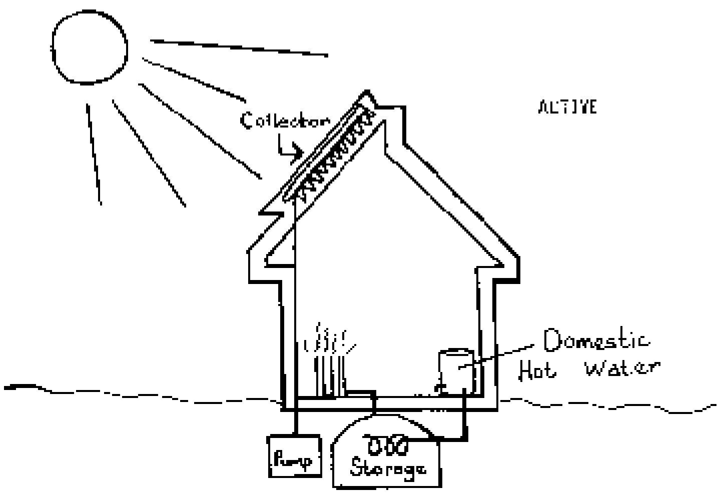
The tilt of the earth on its axis also explains why sunlight is less strong in winter than in summer. The tilt causes the suns rays to reach the ground at a shallower angle in winter. This spreads the solar energy more thinly over the ground. In summer when the sun is more nearly overhead, more solar energy strikes the ground. In all of the United States except Hawaii, the sun appears in the southern half of the sky all year. Devices used to collect solar energy, or windows designed to let in solar energy must face the southern sky to make the best use of the sun's energy throughout the year.



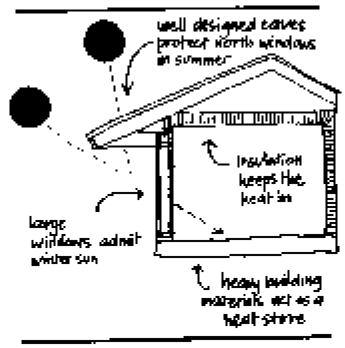
Using Solar Energy to Heat Homes

Solar energy can heat homes in two ways: **active** and **passive systems**. **Active** solar heating systems use working (or active) parts such as pumps, fans, and solar collectors to collect and move solar heat around the home. The sketch below shows a house using an active solar heating system. To use solar energy, we must first find a way to collect it. The solar house in the sketch uses a metal solar collector. Dark-colored sheets of metal are placed on the roof of the house. The metal heats quickly, and the dark color helps absorb energy from the sun. The solar collector faces the direction that gets the most sunlight. In the Northern Hemisphere, you would have a solar collector face south. You also can see in the sketch that a liquid circulates through pipes in a solar house. Solar energy heats the liquid as it moves through the solar collectors. The heated liquid then circulates to a water tank. There, the heat from the liquid is used to heat the water in the tank. Then, the cooled liquid returns to the solar collectors to absorb more solar energy. The heated water from the water tank is used to warm the air that moves through the house.

We can collect solar energy only when the sun shines. At night and on cloudy days, solar houses must use stored solar energy. You know that in the summer, rocks and stones get hot quickly and stay warm even when the sun sets. These materials store heat from the sun. A solar house has cement walls and floors that store heat. Also, the water tank stores water heated by solar energy. In these ways, stored solar energy can help keep the house warm even on a cloudy day. But after a few days of cool, cloudy weather, other energy sources must be used to keep the solar house warm.



Passive solar heating takes advantage of special design features of houses. These passive solar houses use the changing position in the sky. Specially designed solar homes let in the winter sun but exclude the hot summer sun. Using these special design features can reduce heating costs in the winter and air conditioning bills in the summer. The diagram shows the features of a passive solar house. They have large areas of glass facing south to allow sunlight to enter in winter. Heavy building materials such as brick and concrete store the heat and gradually release it inside the house. The walls and ceilings are well insulated. The insulation prevents heat from escaping outside in the winter, or entering in the house in summer. Wide eaves or other shading devices protect the south facing windows from the sun when it is high in the sky in summer. One of the good things about passive solar houses is that they need not cost any more to build than a regular house.



Active and Passive Solar Heating in Iowa

Solar energy already has an important place in the lives of many Iowans. As traditional energy sources become more expensive, and concern for the environment increases, solar energy might well play a growing role in Iowa's energy future.

There are more than 6,000 passive solar residential structures in Iowa. The amount that a structure benefits from the sun's energy depends on the structure's design. If all new single family homes were built to take advantage of solar energy, it is estimated that nearly $3,000,000 could be saved annually on natural gas used to heat homes. The number of active solar systems in Iowa is not known. There is potential for active solar systems to provide all the heat, or to help heat houses and small commercial buildings.

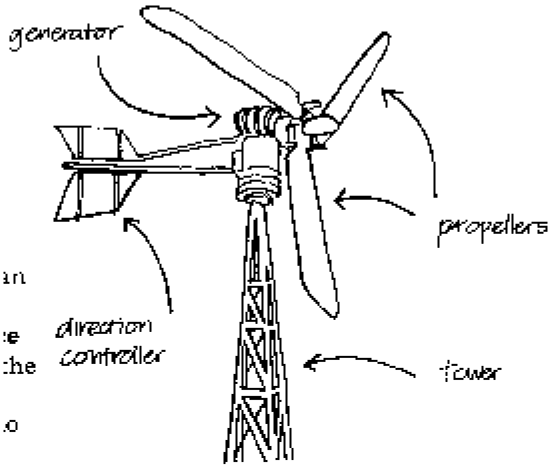
Think About It:

1. How do solar houses collect and store solar energy?
2. Why is solar energy a good energy source to use?
3. **Challenge** What might happen to the water in a garden hose if the hose lies in the sun all day?

Energy From the Wind

The wind can do work. People have used wind for centuries as an energy source for sailing ships, pumping water and grinding grain. More recently, wind has become an important energy source for generating electricity. Interest in the use of wind energy is increasing as fossil fuels become more expensive. Environmental pollution caused by fossil fuels is also a very serious concern. Some scientists think windmills can someday produce almost one-tenth of our electricity. They are studying ways we can use windmills to meet more of our energy needs.

Wind machines like the one shown in the diagram are made up of three basic parts. The propeller is made up of a number of blades that catch the wind, causing the propeller to spin. The spinning blades turn a shaft connected to an electric generator. The generator makes electricity when there is enough wind to turn the propeller. The electricity can be used immediately or stored away in batteries to be used later. A tail device is used on smaller windmills to swing the propeller into the wind. Larger wind generators sometimes use motors to do this.



Like solar energy, the wind can be considered to be free. However special equipment is needed to use the energy from the wind. So, although the energy supply may be free, the cost of using wind energy is not.

The wind might be clean and free, but it is not a perfect energy source. When the wind is calm, windmills cannot produce electricity. Windmills are sometimes noisy and take up a lot of space that can be used for homes or farms. Some wind generators send out signals that interfere with radios and televisions. People living in different places will have to decide whether the wind is a good energy source for them to use.

Wind Energy in Iowa

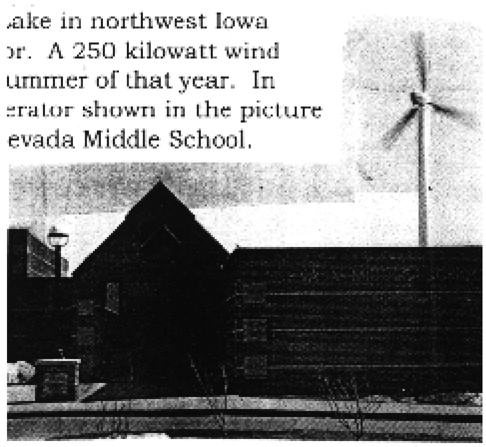
The wind blowing over the hills and plains of Iowa might prove to be one of the state's most practical renewable energy resources. Wind energy was used largely on farms to pump water from wells. But in the 1930s and 1940s rural electrification led to the end of that era of wind energy systems. Several things have led to an increased interest in the research and development of a new generation of wind technology. These include public interest in clean fuels, the rising cost of fossil fuel generated electricity, and increased awareness of environmental pollution.

Current wind systems do not produce electricity at rates that are as low in cost as fossil fuel generated electricity. On a large scale present day wind systems are providing many millions of watts of electricity.

California's wind energy farms like the one pictured here have been in operation for many years. But are such wind farms practical in Iowa? Researchers are currently collecting highly accurate wind speed data from key sites around the state. Highly detailed and accurate wind records measured 100 to 150 feet above the ground are needed. This information will help determine whether successful planning of wind farms in Iowa can take place.

In 1993, the Waverly, Iowa, Light and Power Company became the first municipal utility company in the Midwest to own and operate a wind turbine. This demonstration project will help Midwest utility companies determine if the cost of operating wind turbines is practical.

Two Iowa school districts have recently joined the list of users of wind generated electricity. In 1993, Spirit Lake in northwest Iowa became the first district to install a generator. A 250 kilowatt wind turbine was put into operation during the summer of that year. In December of 1993, a 250 kilowatt wind generator shown in the picture below was installed on the grounds of the Nevada Middle School.



Since that time the Nevada district has also installed a 200 kilowatt wind generator. School district estimate that Nevada's two generators will save the district about half of the annual electricity bill of $90,000. The two Nevada generators represent a gift worth about $500,000. Had the district purchased the generators on their own, it would have taken about ten years for the savings to pay for the turbines. Information learned about using wind generators at the Spirit Lake school and the Nevada schools is shared with the public. Studying these wind generator systems provides valuable information about the efficiency and cost of operation.

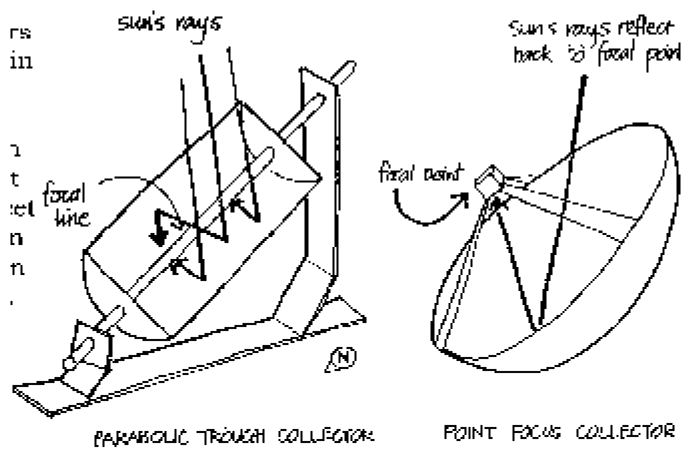
New technology is expected to produce a new generation of wind energy systems. These new wind energy systems are expected to generate electricity at low cost per kilowatt-hour. If these new wind generator systems get developed, then we might see wind farms in Iowa, alongside of agricultural crop farms.

Think About It:
1. What are the three essential parts of a wind machine?
2. What are several advantages of using wind energy? Several disadvantages?
3. **Challenge** What areas in your community might make good locations for a wind turbine? Explain why you picked these locations.

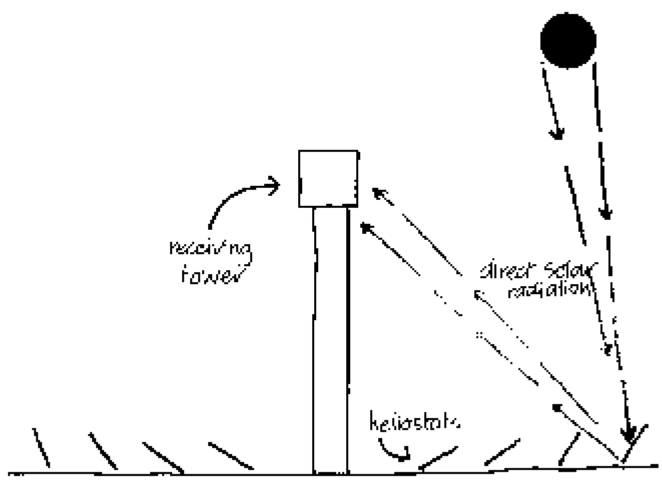
Who in the World Uses Solar and Wind Energy?
Some solar projects being studied in different parts of the world might someday generate electricity for many thousands of homes. Concentrating sunlight is one area of current research. Properly concentrating sunlight on a central point produces extremely high temperatures. These temperatures range from hundreds to several thousand degrees Fahrenheit. This type of solar energy collector is called a **concentrating collector**. Two types of concentrating collectors are illustrated here. Trough collectors and point focus collectors use curved sheets of reflective metal or mirrors. These materials reflect and concentrate sunlight onto a central pipe or point called the focal point. Trough collectors are being used in Australia to produce hot water in homes and industry. Research on point collectors continues in

various locations around the world.

Concentrating collectors are being used to cook food in developing countries where firewood and electricity for cooking is scarce. A common type of solar cooker is a point focus collector about three feet across. It is aimed at the sun with a frying pan or saucepan suspended at the focal point. On a sunny day these solar cookers can boil a quart of water in about 15 minutes.



On a very large scale, a field of huge mirrors called **heliostats** reflect solar energy. Study the diagram below. Notice that the sun's energy reflects onto a central receiving tower or power tower. The reflected and concentrated sunlight boils water in the power tower. Steam from the boiling water turns the blades of a turbine. The turbine operates a generator that makes electricity. Power tower projects have been set up in Europe, Japan and near Albuquerque, New Mexico, in the United States.



Many new wind turbines are being developed to generate electricity. Many people live in remote areas of the world, far away from electric generating plants. Wind generators provide electricity for a lot of these people. Of course there must be a reliable source of wind energy for these wind generators to be practical.

Large individual wind generators are being developed in many countries including Great Britain, Sweden, Denmark, Germany, Canada and the United States. These generators add to existing electricity supplies. In the USA, the National Aeronautics and Space Administration (NASA) developed a 22,500 kilowatt machine in the state of Washington. The propeller is about 300 feet across and is attached to a tower that is nearly 200 feet high. New wind machines with propellers nearly 400 feet across have been developed!

Wind farms are large areas of land dotted with hundreds of wind generators. Current wind farms exist in 13 countries. The electricity produced on wind farms is usually fed directly into existing electric networks. The Altamont Pass, Tehachapi Mountains and San Gorgio Pass wind farms are the biggest and best known wind farms in the USA. Together they are able to produce more than 1,200,000 kilowatts of electricity from more than 1400 wind turbines. At times they supply enough electricity for 200,000 average homes in California.

Ebeltoff in Denmark built the first sea-based wind farm. It has sixteen 55 kilowatt wind turbines built on a jetty almost a half-mile long, plus a 100 kilowatt unit on the shore. These wind machines catch the wind as it blows from the sea. The sea-based wind farm supplies enough electricity for about 600 homes.

Think About It:
1. Describe how concentrating solar collectors work.
2. Why do you think very large wind turbines are being developed?
3. **Challenge** Solar collectors will not work very efficiently if they are not aimed directly at the sun. Think about what you know about the sun's position in the sky and how it changes. Use this knowledge to explain why a "tracking system" is used with concentrating collectors and heliostats.

Answers to In-Text Questions

Active and Passive Solar Heating in Iowa
1. Solar houses collect solar energy with solar collectors and large windows. Solar energy is stored in the cement walls of the house, along with being stored as hot water in a storage tank.
2. It is renewable and there is no pollution associated with its use.
3. The water will heat up.

Wind Energy in Iowa
1. The propellor, generator, and tail device.
2. Advantages -- clean and renewable. Disadvantages -- Noisy, not always practical or cost-efficient.

Who Uses Solar and Wind Energy?
1. Collect the sun's rays by reflecting them off of metal or mirrors onto a central line or focal point. It heats quickly.
2. Very large wind turbines can catch more wind to generate more electricity.
3. To be aimed directly at the sun, the collectors need to follow it as it moves from the eastern to the western sky. The tracking device allows this to happen.

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SCIENCE ACTIVITIES

Radiation and the Transfer of Energy

Teacher's Notes

Objective:
Students gain an understanding that dark colored objects absorb energy faster than light colored objects.

Background:
While solar energy can be used immediately to warm a house, it is often stored as heat to be released slowly into an area to be heated. Solar collectors are usually dark, as dark colors absorb heat more rapidly than light objects. Water is often heated by solar energy and used to store the energy. Water warms slowly, but holds its heat and cools slowly. This allows the slow release of stored solar energy. In this activity students not only determine the fastest absorbers of solar energy, but the slowest releasers of solar energy.

Materials:
Lamp with 150 watt bulb, or sun lamp
Bottom 3 cm of 5 styrofoam cups
Light colored sand
Dark colored dirt
Thermometers
1 sheet graph paper (coordinate paper)

Teaching Suggestions:
1. Caution students to handle the thermometers with care. Use alcohol thermometers for this activity as they present less of a hazard if broken than mercury thermometers.
2. This activity could be done outside on a sunny day when the sun is high in the sky. The procedure is the same as far as recording temperatures for 5 minutes and then remove the cups from the sun. Record the cooling rates of each cup as in the listed procedure.

Extended Activities:
Have students relate any experiences of their own to support the difference in absorption of solar energy. Examples might be walking on hot sand to get to cool water, or dark clothes get warm in the sun, while light colored clothes don't seem to get as warm.

Radiation and the Transfer of Energy

Introduction:
One of the most interesting things about the transfer of energy by radiation is how the characteristics of the material which is absorbing the energy affects the amount of energy transferred. In this activity we will compare the ability of different substances to absorb and lose energy to change temperature.

Materials:

Lamp with 150 watt bulb, or sunlamp
Bottom 3 cm of 5 styrofoam cups
Light colored sand
Dark colored dirt
Thermometers
graph paper

Follow These Procedures:
Part A: Determine the change in temperature from the absorption of radiant energy in five different substances:
Water
Dry light sand
Wet light sand
Dry dark dirt
Wet dark dirt

1. Use five cups, one with each of the materials listed above.
2. Arrange the cups in as small a circle as possible without having them touch each other.
3. Place a thermometer in each cup so the bulb is 0.5 cm below the surface of the material. (You will need to hold or clamp the thermometer in that position in the water.)
4. Place a lamp 20 cm above the containers and directly over the center of the circle.
5. Read and record the temperature of each material just before turning on the lamp. Turn on the lamp and record the temperature at regular intervals of one minute for 5 minutes. Then turn off the lamp and continue to record the temperature at regular intervals of one minute for 5 more minutes. Record your results in a table. Think about what you will measure and design a good table in which to record your results.

Part B: Graph the data from the investigation. Label the lines showing the temperatures of the five different materials.

Answer These Questions:
1. During the five minutes the light was on, where did the energy come from to change the temperature of the substances in the cups?
How was this energy transferred to the cups?

2. Of the two wet solids, which warmed the fastest?
If the two wet solids have the same heat capacity, the one that warmed more must have absorbed more energy. What characteristic caused it to absorb more radiant energy?

3. Which two materials warmed the fastest?
Explain why they warmed up more rapidly than the other materials.

4. Where did the heat energy go when the materials cooled?
How long was the energy transferred away from the cups during the cooling?

5. Which material cooled off most rapidly after the light was turned off?
Explain why it cooled most rapidly.

Beaufort Wind Scale

Teacher's Pages

Objective:
Students estimate wind speed by observing the wind's effect on lake or pond surfaces or on flexible objects such as trees, flags, and rising smoke plumes.

Background:
Wind speed can be estimated by observing the wind's effect on lake or ocean surfaces or on flexible objects such as trees. Such observations are the basis of the Beaufort scale, which is a graduated sequence of wind strength. These graduations range from 0 for calm conditions to 12 for hurricane strength winds. The scale carries the name of Sir Francis Beaufort, who developed the scale in the early 1800s. Beaufort served as a ship's commander in the British Navy. His goal was to standardize terms used by sailors in describing the state of the sea under various wind conditions. In 1838, after some revision, the British Navy adopted the Beaufort scale. In 1853 the scale was sanctioned for international use by sailors. Later, when the scale was extended from sea to land, it was necessary to develop wind speed equivalents for each Beaufort number. This development was done in 1926. The Beaufort scale is still in use today.

Materials:
No materials needed

Teaching Suggestions:
1. Have students practice using the Beaufort Scale individually. Then have the students compare their results. Try to arrive at a consensus on the wind speeds at various times during the school day.
2. If students have already made the Ping-Pong ball-protractor wind speed measurer, have them compare their Beaufort estimates to measurement obtained with the wind speed tool.
3. Your students and you might wish to convert the Beaufort scale to wind speeds in miles per hour rather that using km/hr. To do this remember that 1 kilometer = 0.61 mile. Therefore 50 km/hr = 30.50 miles per hour.

Extended Activities:
1. Students can research the Beaufort Scale and its development. You do not have to give them the background material provided above.
2. Some libraries have Almanacs of Weather. Students can research information about wind such as the windiest places on earth, the strongest wind gust ever recorded, etc.

Beaufort Wind Scale

Problem:
At what time of day is there enough wind to make electricity where you live?

Background Information:
This is the Beaufort wind scale. It is used to measure wind speeds. It relies on human observations, not mechanical devices, to estimate the speed of the wind. It gives the Beaufort Number, the description of the wind speed, and the observation of the wind.

0 -- calm (0-1 mph) -- smoke rises vertically

1 -- light air (2-3 mph) -- smoke drifts slowly
2 -- slight breeze (4-7 mph) -- leaves rustle; wind vane moves
3 -- gentle breeze (8-12 mph) -- twigs move; flags extended
4 -- moderate breeze (13-18 mph) -- branches move; dust and paper rise
5 -- fresh breeze (19-24 mph) -- small trees sway
6 -- strong breeze (25-31 mph) -- large branches sway; wires whistle
7 -- moderate gale (32-38 mph) -- trees in motion; walking difficult
8 -- fresh gale (39-46 mph) -- twigs break off trees
9 -- strong gale (47-54 mph) -- branches break; roofs damaged
10 -- whole gale (55-63 mph) -- trees snap; damage evident
11 -- storm (64-72 mph) -- widespread damage
12 -- hurricane (73-82 mph) -- extreme damage

Activity:
1. Measure the wind using the above scale. Measure it on three different days at three different times during the day, preferably in the morning, midday, and afternoon or evening. Record your observations.

2. At what time of day do the fastest winds usually occur? the slowest winds?

3. Any wind over 8 mph can be used to generate electricity. Currently, though, it only makes economic sense to build wind turbines in areas where the wind exceeds 15 mph most of the time. Could you generate electricity in your area?

The Effect of Concentrating Sunlight

Teacher Notes

Objective:
1. Students will use thermometers to measure temperature of sunlight in direct sunlight, focused sunlight, and shadow.
2. Students will construct a line graph of the data collected.

Background:
CAUTION: If the temperature recorded by thermometer A reaches 105 degrees C, remove from the sunlight.

CAUTION: Tell the students not to use the lenses to burn holes in paper or start paper on fire.

The last section of the student text material discusses concentrating solar collectors. The illustrations in the text shows reflective materials used to make concentrating collectors. This activity uses a lens rather than a reflector. The results are the same -- concentrating sunlight can produce significant increases in temperature.

Materials:
1. Double convex lens (small hand lens about 5 cm in diameter)
2. Three Celsius thermometers (Fahrenheit thermometers are OK)
3. Graph paper
4. Rulers

Teaching Suggestions:
1. Make sure that students understand the tables before starting to collect data. Go over what .5 min. means in time
(.5 min. = 1/2 min. = 30 seconds).
2. Have students do #'s 1 - 4 on Procedure.
3. Go over how to make a line graph.
4. Have students complete Think It Over.

Extended Activities:
1. Use filters such as cellophane paper to see the effects of filtering.
2. Place thermometers in liquid and measure temperature changes of focused sunlight and shadow.

The Effect of Concentrating Sunlight

Problem:
What are some effects of concentrating sunlight?

Materials:
1. Double convex lens (5 cm or more in diameter)
2. Three Celsius or Fahrenheit thermometers
3. Graph paper
4. Rulers

Follow This Procedure:
1. Examine Table 1 and make sure you understand where you will be recording your data. Read this procedure before doing the activity.
2. Work either outdoors or at a window through which the sun shines. Label the thermometers "A", "B",and "C".
3. Read each thermometer in the shade. Record the starting temperatures in Table 1. Place thermometer B so that the bulb is in the shade -- possibly the shadow cast by your arm. Place thermometer C in direct sunlight. Then use the lens to bring sunlight to a sharp focus on thermometer A.
4. Read each thermometer every 30 seconds for 5 minutes and record their temperatures in the table.

Think It Over:
1. Make a line graph of your data. Plot time on the horizontal axis and temperature on the vertical axis. Use a dotted line for normal sunlight temperatures, a dashed line for focused sunlight temperatures, and a solid line for shadow area temperatures.
2. Compare the changes in temperature for normal sunlight, focused sunlight, and shadow. State possible reasons for the difference you notice.
3. Describe another way you could concentrate sunlight in one area.

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MATHEMATICS ACTIVITIES

Length of Shadows

Teacher's Pages

Objective:
Students will discover, through accurate measurement, that the length of a shadow is shortest around noon when the sun is at its highest in the sky.

Background:
Every day the sun appears to cross the sky from east to west because of the earth's rotation. For thousands of years people have noticed that shadow length changes during the day. People have also noticed that the length of shadows increases after the summer solstice and decreases after the winter solstice. This change happens because the sun's position in the sky changes with the seasons. The sun is lowest in the sky in winter and highest in summer. On a daily basis, the length of shadows decreases from a maximum at sunrise to a minimum at noon. From noon to sunset, the shadows become progressively longer again. A common misconception is that at noon the sun is directly overhead and there are no shadows. A little investigation will dispel that notion. In fact, the sun is never directly overhead anywhere at anytime in the continental United States.
In winter months the sun is low in the southern sky and shadows cast will be longer than those made in the summer. After the winter solstice, the sun slowly gets higher in the southern sky and shadows cast at noon slowly get shorter until the summer solstice in June.
When designing passive solar homes in the United States, builders take into account the sun's changing position in the sky. In winter the sun is low in the southern sky and south facing windows can let the sunshine in and contribute to warming the house. During summer when the sun is high in the sky, overhangs or awnings over the windows block the suns rays, preventing solar energy from warming the house too much.

Materials:
ruler, clay, yardstick, protractor

Teaching Suggestions:
1. Encourage your students to make the ruler as vertical as possible. Allow them to use a protractor if they wish.
2. Have the students make the observations so that noon (standard time) measurements are included. It would be good if you could start the activity early in the morning and continue until close to the end of the school day.
3. If you have students measure to the nearest 1/16 of an inch instead of using metric units, they will get practice adding and subtracting fractions with uncommon denominators.
4. Encourage students to look for patterns in the shadow lengths, i.e. they grow shorter as noon approaches and grow longer after noon.

Extended Activities:
Have students pretend they live on a planet that has two suns. Write a story about how shadows change

on such a planet.

Length of Shadows

Problem:
How does the length of a shadow change during the day?

Materials:
12 inch ruler
Clay
Yardstick

Follow This Procedure:
1. Find a sunny, flat area around your school. Use pieces of clay to support a 12-inch ruler straight up and down.
2. Measure the length of the ruler's shadow with a yardstick. Record the length of the shadow and the time of day in a table.
3. Predict when the shadow will be shortest.
4. Measure the shadow's length, in inches, every 30 minutes for three hours. Record the time and shadow length after each measurement.
5. Estimate and then calculate the change in the shadow's length since the last measurement. Look for a pattern.

Think About It:
1. How does the shadow length change from morning to afternoon?
2. When was the shadow shortest?
3. What is the difference in length between the longest and shortest shadow you measured?
4. Why do you think shadow length changes?

Measuring Wind Speed

Teacher's Pages

Objective:
Students will measure and record wind speed by observing the wind's effect on a suspended Ping-Pong ball.

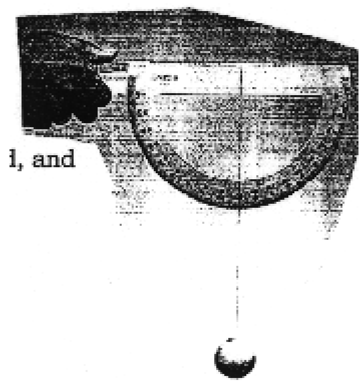
Background:
Wind is air in motion. Our air is composed of molecules and atoms of gases, mainly nitrogen, oxygen and argon. When these small particles move and strike an object, a force is exerted. Students know that strong winds can knock down power lines, break branches from trees and remove roofs from houses. Wind speed increases with increased distance above the ground. This is because objects on the earth's surface such as trees and buildings exert friction on moving air particles and actually slow the wind.
In this activity a table tennis ball is suspended vertically and exposed to the wind. Wind displaces the ball an amount dependent on the wind speed. Students observe the angle of deflection and use a table to relate the angle to wind speed.

Materials:
protractor, ruler, clear tape, 25 cm red thread, table tennis ball

Teaching Suggestions:
1. Large protractors with a hole at the measuring center work very well for this activity. It is important to suspend the string from the protractor's measuring center.
2. Winds swirl around buildings and trees, changing speed and direction. Students can investigate this phenomenon if you wish. However students should measure actual wind speed in an open area.

Extended Activities:
Have students convert the wind speeds from kilometers per hour to miles per hour, a more common measurement for them. One kilometer per hour is equivalent to 0.61 miles per hour. For example, 10 kilometers per hour = 6.1 miles per hour.

Measuring Wind Speed



Problem:
How can you build a tool for measuring wind speed, and measure wind speed?

Materials:
protractor, ruler, clear tape, 25 cm red thread, table tennis ball

Follow This Procedure:
1. Use a table to record your observations.
2. Tape the protractor to the ruler as shown in the picture.
3. Tape one end of the thread to the table tennis ball. Tape the other end of the thread to the protractor as shown. The thread should hang down the middle of the protractor.
4. Take your measuring tool outside. Hold it still using the ruler as a handle. Point the ruler into the wind. Be sure the ruler is level with the ground.
5. When the wind blows the ball, it will move the thread on the protractor. Record the highest number on the protractor that the thread reaches.
6. Find the wind speed number in kilometers per hour under this number in the chart below. Record the wind speed in your table.
7. Measure and record the wind speed 3 times during the day.

Number on protractor and corresponding wind speeds:
90: 0 km/hr; 95: 9; 100: 13; 105: 16; 110: 19; 115: 21; 120: 24; 125: 26; 130: 29; 135: 31; 140: 34; 145: 37; 150: 41; 155: 46; 160: 52

Think About It:
1. What was the highest wind speed you measured?
2. How can you use a number on a protractor to find wind speed?
3. For a windmill to make electricity, wind speed must be at least 13 kilometers per hour. Could windmills be used where you live? Explain your answer.

Wind Vane

Teacher's Pages

Objective:
Students will use area of polygon formulas to find that the area of a wind vane's tail must be larger than the area of the pointer in order for the wind vane to work properly.

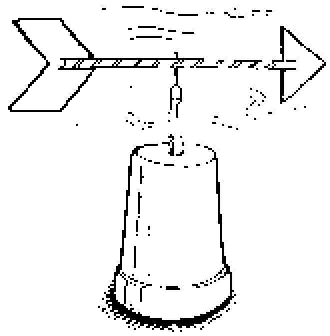
Background:
A wind vane is used to determine the direction of the wind. Wind vanes are usually made with a large tail to catch slight breezes. They turn to point into the direction the wind is coming from. The directional markings on a vane must be aligned with north, south, east, and west using a compass. A wind is named for the direction it is coming from. For example, a north wind is blowing from the north. A west wind comes from the west and blows towards the east.

Materials:
pencil with eraser, paper or polystyrene cup, straw, straight pin, scissors, 3" x 5" cards, ruler, glue, and a directional compass

Teaching Suggestions:
1. Make sure you remind students to be careful with the straight pins. Remind them also not to jab each other with the pins.
2. Encourage students to use regular polygons for the shapes of their tails and pointers to simplify finding areas. They can use shapes that are combinations of regular polygons, but these will have to be divided off in order to calculate area.
3. Some helpful area formulas:
Rectangle: A = l x w
Triangle: A = 1/2bh
Parallelogram: A = bh
4. If students are not familiar with these formulas, have them estimate the area by placing the shapes on graph paper that has squares of a known area. Then the students can count the squares to find the total area.
5. You might wish to place a fan in your classroom for students to test their wind vanes. The fan's blades will provide a steady air flow.

Extended Activities:
1. Take the class outside and allow them to determine wind direction.
2. Have students research the history of wind vanes. If you know of a local collector of wind vanes, invite them to visit your classroom.

Wind Vane



Problem:
How can you make a working wind vane?

Materials:
Paper or polystyrene cup, Pencil, Straight pins, Scissors, 3 x 5 inch index cards

Follow This Procedure:
1. With a pencil, make a hole in the bottom of a paper cup. Push the pencil through the hole as shown in the picture. Cut slits about 1 cm long in each end of a straw. Push a straight pin through the center of the straw and into the eraser of the pencil so that the slits in the straw are vertical.
2. Predict whether the wind vane will work better when the tail is larger than the pointer or when the tail is smaller than the pointer.
3. Cut the pointer and the tail for your vane from 3 x 5 inch cards. Estimate and then calculate the area of each. Insert the pointer and tail into the slits in the straw and glue them in place.
4. Test your wind vane to see how it works. Experiment with tails and pointers of different sizes. Calculate the area of each. Record your results in a table.

Think About It:
1. On what basis could you rate the performance of a wind vane?
2. How do your results compare to your prediction?

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SOCIAL STUDIES ACTIVITIES

Solar and Wind Energy Around the World

Teacher's Notes

Objective:
Each student 1) decides upon uses for solar and wind energy; 2) designs and constructs an energy collage; and 3) titles the collage.

Teaching Suggestions:
1. Students are given magazines, catalogs, and newspapers to cut out pictures for an energy collage.
2. After the collage is complete, a title should be given. A contest could be held to see which collage shows the most ways of using solar or wind energy.
3. Winners could be rewarded with a solar powered clothes dryer (clothes line and pins).

Extend the Activity:
Have students write the "message" their collage represents and present their products to the class.

Solar and Wind Energy Around the World

Problem:
How does our world use wind and solar energy?

Materials:
1. Magazines, catalogs, and newspapers
2. Construction paper or poster board
3. Glue

Activity:
1. On paper, list uses of wind or solar energy.
2. Look through magazines, catalogs, and newspapers for pictures depicting the use of solar and wind energy. Cut out these pictures.
3. Glue pictures onto poster board or construction paper to make a collage.
4. After the collage is finished, decide upon a title for it.

Use What You Learned:
Write a message or short story about your collage and what it represents.

Plotting Solar and Wind Data on Maps

Teacher's Pages

Objectives:
Students will locate data in almanacs or other resources regarding wind velocity and number of sunny days for various cities in the United States. The students will accurately display this data on a map of the United States. Students will decide which regions of the continental United States seem to be best suited for wind/solar energy development.

Background:
Solar energy is the oldest form of energy and the original source of almost all forms of energy. There are more than 6000 passive solar residential structures estimated to exist in Iowa. The extent to which a residence benefits from the sun's energy depends on the structure's efficiency, orientation and landscaping. No reasonable estimate exists at this time on the number of active solar energy systems in use in Iowa. It is known that the number of active solar energy systems dramatically declined after the expiration of the federal tax credit in 1985. Along with the loss of the tax credit, mechanical failures and lack of a support industry have been typical problems.
Even wind energy is derived from solar energy. The uneven heating of the earth's surface by the sun gives rise to large scale circulation within the atmosphere and also to small scale or local winds. Obviously areas of the continental United States that receive the most sunlight and areas having sufficient average wind speeds are the prime areas for development of solar and wind energy use. In this activity students plot wind speed data and also solar data to identify areas of the U.S. they think seem to be good areas for wind and solar energy use. There are typical wind speeds or classes of wind throughout the U.S. Classes range from 1 (the lowest) to 7 (the highest), with Iowa falling in the range of Classes 2, 3, and 4. Studies have shown that the northwest corner of Iowa has the most consistent winds and highest average wind speeds. The cost of generating electricity in this area of Iowa with wind turbines has been estimated to cost as much as 12 cents per kilowatt hour. This is not a competitive rate when compared with fossil fuel generated electricity. But new technology in wind generation is expected to result in turbines which can efficiently generate electricity at a competitive rate. These turbines might be usable in other areas of the state where wind speed averages are lower.

Materials:
Almanacs or other resources showing wind and solar data in the U.S.
Copies of continental United States map outline
Atlas, or U.S. road map

Teaching Suggestions:
1. Have students use current almanacs to find data on average wind speeds and also the number of sunny days for U.S. cities.
2. Students should then locate each city for which data is given on the blank U.S. outline map and display the data. They could use one color for wind velocity and another color for number of sunny days. Also they could use two separate maps.
3. If data is sufficient, students could draw lines around areas of the U.S. that appear to have the highest number of sunny days and the highest wind speeds.
4. Ask students to summarize in paragraph form what they found out about the sunniest and windiest areas.

Extended Activities:
Have students obtain data on average wind speed for various cities in Iowa. Contact your nearest National Weather Service office to obtain the data. The state forecast office in Des Moines should have some wind data for the state.

Mapping Wind Speeds Around Your School

Teacher's Pages

Objectives:
Students collect wind speed data at different locations on the school grounds and correctly display the data on a map of the school grounds.

Background:
One of the problems with wind power is the inconsistency of wind strong enough to generate electricity. Placement of windmills has to be in an area that is clear of buildings and trees that might make the wind slow down or constantly change direction. Winds near the ground swirl and change because of trees, hills, and buildings. In this activity students gather data about wind speeds at various locations on the school ground. The side of the school facing the wind is called the windward side, the opposite side is called the leeward side. Of course as general wind direction changes, so do the sides of the building receiving wind and the protected sides. Students should notice that the wind seems to change direction and swirls around buildings. Tree rows and shrubs can serve as effective windbreaks, reducing wind speeds to near zero, even on fairly windy days.
Windmills have to be built in open areas, away from the blocking effects of trees and buildings. The top of a hill is usually a good place for locating a windmill. The other alternative is to build the windmill on a tower that is high enough above the ground so that the effects of trees and buildings are minimized. Current wind research in Iowa is identifying wind speeds in key locations around the state and at heights of about 150 feet above the ground. At these heights, ground interference with the wind is minimized. Properly placed trees and large shrubs can provide protection from the summer sun, reducing demand on air conditioners. Also, properly planted trees can reduce the strength of winds blowing against a building on cold winter days. This reduces the heat loss from the building and consequently lowers heating demand.

Materials:
Wind speed devices from Math Activity -- Measuring Wind Speed.
Copy of school ground map

Teaching Suggestions:
1. This activity should be done on a fairly breezy day.
2. Assign pairs of students to start their observations at different locations around the school grounds. Give them an amount of time you think reasonable to collect the data around the school.
3. You can make a rough sketch of your school building on graph paper. Leave room on the paper for students to sketch location of trees, shrubs and other objects that might interrupt wind flow.
4. Have the class create a large map of the school grounds placing their data in the appropriate locations.
5. Students should discuss reasons why winds speeds might vary at different locations around the school.
6. Conduct the activity on more than one windy day to check for consistency of data. Also they can contrast data collected on days when the general wind direction has changed.

Extended Activities:
Many farms have windbreaks protecting the main buildings. Have students contact a local extension agent to come into class to discuss the reasons for windbreaks and their placement around farm houses. Most wind breaks are plantings of several rows of trees, especially tall evergreens, that protect the west and north sides of buildings.

Mapping Wind Speeds Around Your School

Problem:
How does wind speed vary at different locations outside your school?

Materials:
Wind speed measurer, Sketch of school grounds showing outline of school building.

Follow This Procedure:
1. Your teacher will assign you to teams and starting locations.
2. Use the wind-speed measurer to observe the wind speed in different locations around the school. Also record the direction the wind is from.
3. On your map record your wind speed observations and the locations at which they were observed.
4. Note on your map the location of trees and shrubs that might interrupt wind flow.
5. Following your teachers directions, place your data on the large classroom map of the school grounds.

Think About It:
1. What differences in wind speeds or directions did you notice around the building?
2. If your class observed changes in wind speed and direction in different locations, discuss possible reasons for these changes.

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LANGUAGE ARTS ACTIVITIES

Researching Solar and Wind Energy

Teacher's Pages

(Note: this is a long activity and should be started early in the Unit)

Objective:
Students will research use of solar and/or wind power in history and present the information in the form of a speech, skit, model or diorama.

Background:
The History of Solar Energy
Ancient civilizations were well aware of the changing position of the sun and discovered many ways to use it. For thousands of years, African, Mediterranean, Asian, and other cultures used the Sun to dry clothes and animal skins, preserve meat, dry crops, and evaporate sea water to produce salt.
Around 500 BC a shortage of local firewood led the ancient Greeks to use the changing angle of the Sun's rays to heat their homes. Famous Greek philosophers, such as Socrates and Aristotle, advised city planners to position buildings so that sunlight entered them in winter, but not in summer. Heavy building materials stored the solar energy let in during the day. Window shutters were closed at night to retain the heat inside. Buildings were also clustered together to provide shelter from cold winds. Six hundred years later, the Romans added to the design of solar buildings. They faced transparent mica windows towards the Sun, and used heavy, dark-colored floors to absorb and store heat. The Romans were also the first civilization to use greenhouses to grow vegetables and other plants.
In the 18th century, the Swiss scientist, Horace Benedict de Saussure, built the first solar water heating collector. It was simply a wooden box with a glass top and a black base. By trapping solar energy, this collector reached a temperature of 88o Celsius.
In 1774, the French scientist Lavoisier focused sunlight through a series of high powered lenses to produce heat. Also in France, in 1878, a dish-shaped mirror was used to focus solar energy onto a steam boiler which powered a printing press. At about the same time, in Chile, a solar distilling operation produced over 20,000 liters of fresh water a day from salt water.

The History of Wind Energy
Wind energy was used as early as 5000 years ago, when it provided the power for mechanical tasks such as pumping water for irrigation, grinding grain, and sailing ships. The first wind machines had cloth sails, and were fixed in one position to face the prevailing wind. In the 1300's, a tailpole was attached to the machine so that the operator could turn the propeller to face winds coming from any direction. This was soon replaced by a fantail, which allowed the propeller to automatically face into the wind.
In the 1800's, wind generators were developed to generate electricity in remote areas. Installed across the Nullabor Plain in Australia, they provided power for radio communication between Eastern and Western states. Many rural homesteads were provided with electricity from wind generators also. By the mid 1900's, large wind generators were linked in with existing electricity supply networks to supplement conventional electricity supplies. Today, large wind machines are being experimented with in the USA. And in the USA and Europe, "wind farms", made up of hundreds of wind generators, feed electricity

into existing electricity supply networks. Remote areas too, are turning away from expensive diesel-powered generators to wind power for their electricity.

Materials:
Reference materials in classroom or library

Teaching Suggestions:
1. Have students work in pairs or small groups to research one of the historical uses of solar or wind power. Here are some suggested research topics/people:
Solar Power
Samuel Langley -- a pioneer of solar energy
Louis XIV of France -- his reign saw an era of solar experiments
Archimedes --used mirrors to concentrate solar energy on invading ships
Georges Buffon -- used parabolic reflectors to concentrate solar energy
Antoine Lavoisier -- built a solar furnace
Eastern Sun Power Company, Cairo, Egypt -- world's largest solar power plant in 1900s
Anasazi Indians -- Mesa Verde National Park, Colorado, cliff dwellings were a sort of solar home.
Ancient Greeks -- built entire cities to take advantage of the sun
Ancient Romans -- heated villas and bath houses with solar energy
Horace Benedict de Saussure -- built the first solar water-heating collector
Wind Power
Ancient Egyptians -- used wind power to sail their ships on the Nile
Persia (now Iran) -- earliest known windmills
Dutch -- improved the design of windmills
U.S. colonists -- used windmills for grinding grain, pumping water, and cutting wood
Sir Francis Beaufort -- developed the Beaufort Wind Scale
Australia -- 1800s wind generators provided power for radio communications.

2. Students can present their findings to the class as a skit, a first-person speech, as an interview, a model or diorama with a written explanation.

Extended Activities:
Have students find pictures or make drawings to compare the features of windmills used in the historical past to modern windmills and wind generators. The same can be done for past solar energy devices and modern ones.

Researching Solar and Wind Energy

Problem:
How have ideas on using wind power or solar energy developed throughout history?

Materials:
Classroom or library reference materials

Follow This Procedure:
According to your teacher's instructions collect information about any of the following topics or people:
Solar Power
Samuel Langley
Louis XIV of France
Archimedes

Georges Buffon
Antoine Lavoisier
Eastern Sun Power Company, Cairo, Egypt
Anasazi Indians
Ancient Greeks
Ancient Romans
Horace Benedict de Saussure
Wind Power
Ancient Egyptians
Persia (now Iran)
Dutch
U.S. colonists
Sir Francis Beaufort
Australia

Think About It:
Use the information you collect to write a skit, a first-person speech, a diorama with explanation, or a 'Talk Show' interview.

"Tooning" into Renewable Energy Sources

Teacher Notes

Objective:
Each student will draw a "solartoon" or "windtoon" with an appropriate caption depicting a concept about solar or wind energy.

Background Information:
Class discussion over solar and wind energy using student text for background material.

Materials:
1. Drawing paper
2. Colored pencils

Teaching Strategies:
1. Read and discuss background information about wind and solar energy.
2. Choose one concept learned from the information to draw in cartoon form.
3. Students need to decide between a one frame and a multiple frame format.
4. Each frame needs captions developed.

Activity Results:
"Windtoons" and "solartoons" will demonstrate wind and solar energy concepts.

"Tooning" into Renewable Energy Sources

Problem:
How can a cartoon illustrate a concept about solar or wind energy?

Materials:
1. Drawing paper
2. Colored pencils

Follow This Procedure:
1. Choose one concept learned from the information to explain and illustrate in cartoon format. You need to develop an appropriate caption. Decide between one frame and multiple frame format. Call cartoons about the wind a "windtoon" and cartoons about solar energy a "solartoon."

Think It Over:
1. If you lived in the western section of the country, what type of energy would you use to heat your home?
2. What type of renewable energy in Iowa is the most practical from your viewpoint?

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