ACTIVITIES

CROSS-CURRICULAR EXTENSIONS

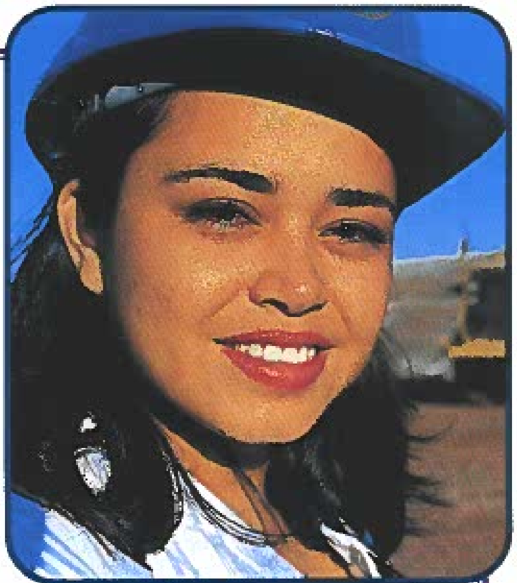
1. **SCIENCE** Design an underground house that uses the earth for insulation. What kinds of special materials or construction techniques would an underground house need?

2. **MATHEMATICS** Design housing that you think people would like to live in for a city with a large, crowded population.

3. **COMMUNICATION** Take pictures of storefronts in a business district of your town. Cut and glue the pictures together to show an entire block of storefronts. Place tracing paper over the pictures, and design a new front for each store that would make the business area more attractive. Show your design to a city planner or zoning committee.

EXPLORING CAREERS

Technology helps people build things faster, cheaper, and with fewer flaws. Here are two careers that involve building things.



Construction and Building Inspector

Construction and building inspectors inspect buildings, bridges, and highways while they are being built and after they are finished. They have a good eye for detail. They use their engineering skills to make sure that structures are built properly and safely and that they conform to the building code. A strong background in mathematics and good communication skills are needed.

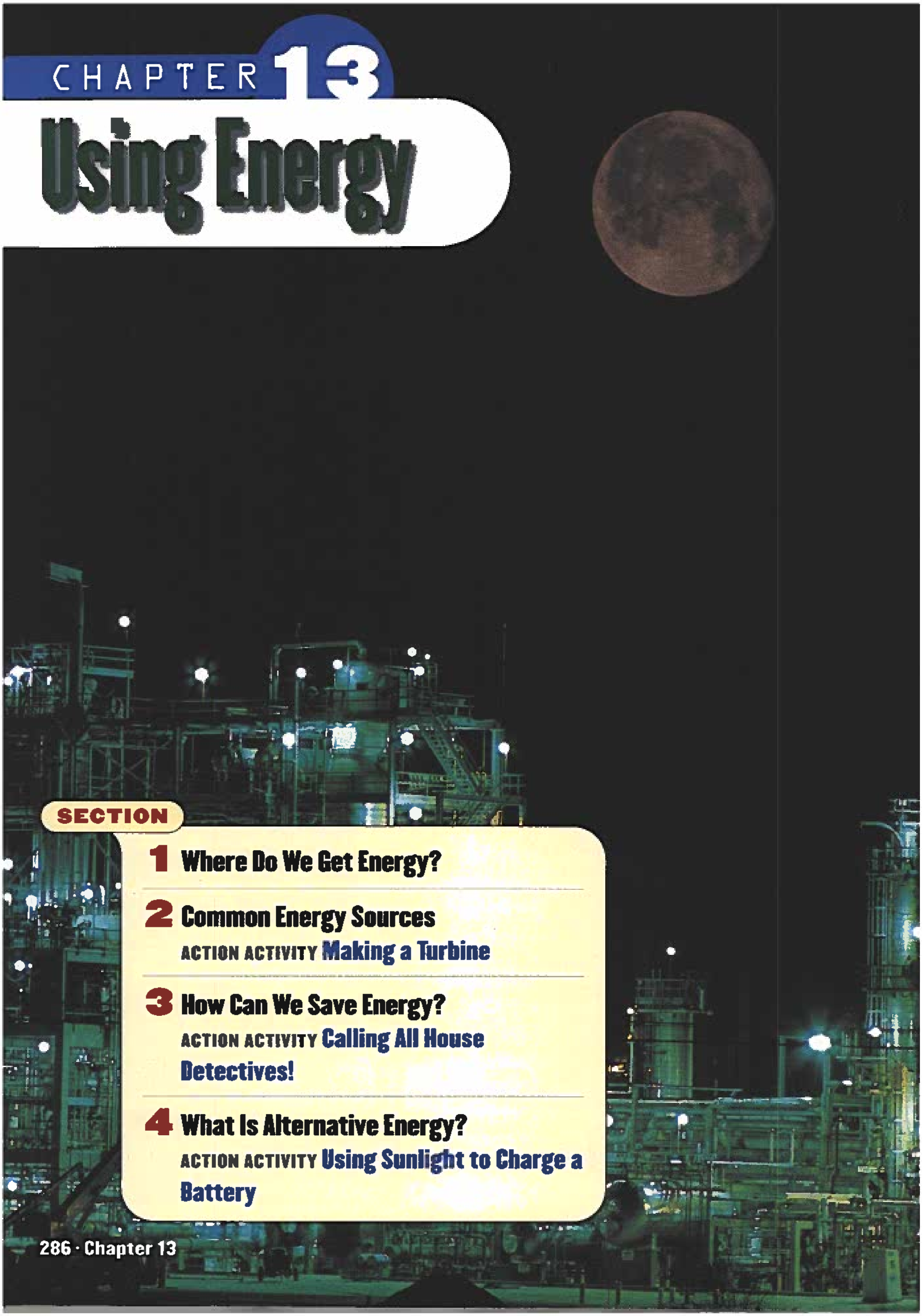
Operating Engineer Operating engineers operate power construction equipment, such as cranes, tractors, and derricks, used to move earth and erect structures. They must have good mechanical skills since they often repair and maintain the equipment. Operating engineers need to be in good physical condition. They should enjoy working outside and be able to follow instructions.

ACTIVITY

Suppose you are planning to build a home on a vacant lot. Make a list of job titles for all the workers you will need to build your home from start to finish.

CHAPTER 13

Using Energy



SECTION

Where Do We Get Energy?

SECTION 1

THINGS TO EXPLORE

- Tell what energy is and give examples of potential and kinetic energy.
- Explain where energy comes from.
- Tell how we depend on energy.

TechnoTerms

energy
kinetic energy
potential energy
power
precipitation

Did you ever stop to think of the ways you use energy in a day? Every time you pick up a pencil or blink an eye, you are using energy provided by the food you eat. The bus or car you might ride to school in every day uses the chemical energy stored in gasoline. Fig. 13-1. When you flip on a light switch, you use electrical energy to produce light. What is energy, and where does it come from?

What Is Energy?

The definition of **energy** is the ability to do work. Some people confuse power and energy. They are related, but they are not the same. Simply having the energy to do work doesn't mean work gets done. **Power** is the amount of work done in a certain time period, or the *rate* of doing work.

Energy is never lost or destroyed, but it can be changed from one form to another. For example, a battery changes chemical energy to electrical energy. Fig. 13-2. A solar-powered car turns light energy into electrical energy. Technological processes often change one form of energy into another, more useful, form to do work for us.

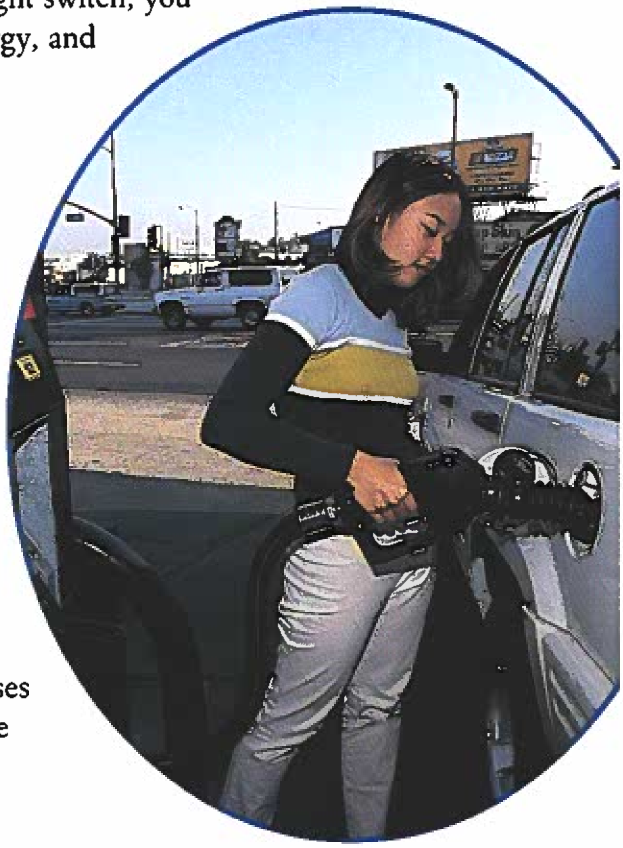


Fig. 13-1. The oil used to make gasoline was produced over time from decayed plant and animal matter.

OPPOSITE At this refinery, oil is changed to gasoline. The energy from gasoline is used to power cars, planes, and other vehicles.

TechnoFact

ENERGY AND POLLUTION Besides being expensive, burning fossil fuels for energy produces 500 million tons of carbon dioxide a year. That's about two tons of carbon dioxide for every person in the United States. Think about what that does to your environment!

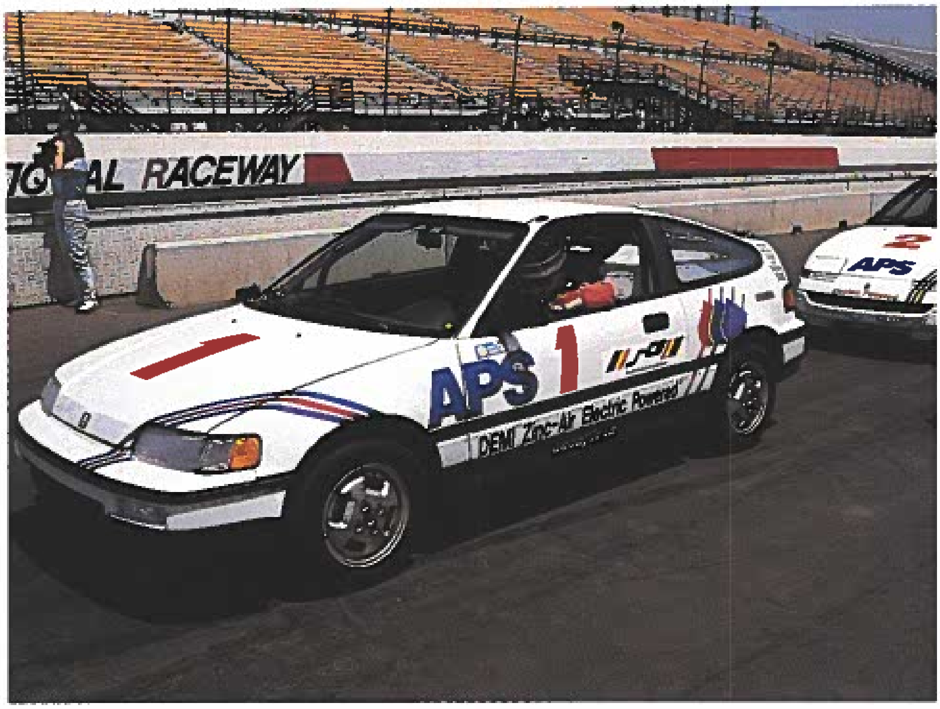


Fig. 13-2. These racing cars are powered by electrical energy from batteries. Find out what other alternative fuels are being tried in automobiles. Report your findings to the class.

MATHEMATICS CONNECTION

Electricity Costs!

Your local electric company keeps track of the electricity you use at home with an electric meter. When you turn on any electric appliance, the dials of the meter start moving.

Kinds of Energy

There are two kinds of energy. **Potential energy** is energy at rest waiting to do work. A book about to fall off the edge of the table has potential energy. So does a compressed or coiled spring, like a spring on a pinball game.

When you release a spring the spring has kinetic energy. **Kinetic energy** is energy of motion. A moving bicycle also has kinetic energy. Can you think of some other examples of kinetic and potential energy?

The sun is the ultimate source of Earth's energy. There's more energy packed into one hour of sunshine than we use in an entire year.

Where Does Energy Come From?

Did you know that nearly all of the Earth's energy comes from the sun? The sun creates wind energy, water energy, energy for living things, and even fossil fuels.

Winds are a kind of kinetic energy caused by uneven heating of the Earth's atmosphere by the sun. The hot air rises and the colder, heavier air moves in under it. Sometimes the resulting winds are strong enough to power electric generators.

You can find out how much energy is used by an electrical device over a certain period. This is done by multiplying the power it requires by the amount of time it uses that power.

electrical energy used = power x time

The unit of electrical power is the kilowatt-hour (kWh). One kilowatt-hour equals 1000 watts of power used for one hour. The electric company charges you for each kilowatt-hour you use. For example, a hair dryer requires about 1000 watts per hour. If you use it 6 hours total in one month, you will have used 6000 watt hours or 6 kilowatt-hours. If your electricity costs you $.09 per kilowatt-hour, then it costs you about $.54 per month to use your hair dryer.

ACTIVITY

If the average power needed to run your color TV is 200 watts each hour and you use the TV 80 hours in one month, how many kWh did you use? If the electricity rate is $.09 for each kWh, how much would you pay to use your television?

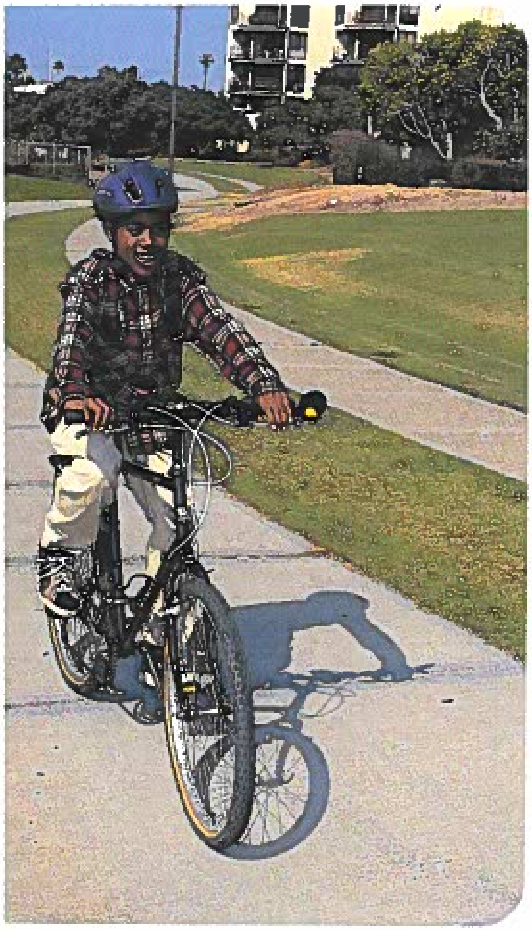


Fig. 13-3. The energy you use to power a bicycle comes from the food you eat. Find out what unit is used to measure food energy. Report your findings to the class.

Most living things on Earth needs solar (sun) energy. Plant cells store solar energy during photosynthesis. Animals like us eat plants for energy needs. Fig. 13-3. Some decayed plant and animal materials become fossil fuels after millions of years.

The sun also keeps Earth's water cycle going. The sun heats water in a lake or ocean until it evaporates (changes to a gas). As the water vapor rises, it cools and forms clouds. As the vapor cools even more, it becomes liquid again and falls as **precipitation** (rain, snow, or sleet).

We Depend on Energy for Technology

Without energy our technology wouldn't be what it is today. Technology processes and systems depend on energy. Primitive people used muscle power as their main source of energy. They did only the things they themselves were strong enough to do. Then they discovered that animals could be tamed and used as energy sources, too. For thousands of years, most technologies depended on animal energy.

Then people learned how to use other sources of energy, such as the wind and falling water, to do work. Eventually, adding power to tools and machines made it possible to do work faster and more easily. Today, we depend on energy to be there when we want it. What would your life be like without advances in energy and power?

SECTION 1 TechCHECK

1. What is energy and where does it come from?
2. How is potential energy different from kinetic energy?
3. Tell how you depend on energy in your daily life.
4. **Apply Your Knowledge.** Choose a form of energy and tell how it can be changed to another form of energy to do a specific job for you.

SECTION 2

Common Energy Sources

THINGS TO EXPLORE

- Identify common energy sources used in developed countries.
- Identify the major sources of energy used today.
- Build a working model of a turbine generator.

TechnoTerms

conventional
electric generator
nuclear fission
turbine

Today's **conventional** (most common) energy sources used in developed countries include the following:

- **Electricity.** Most electricity is produced by an **electric generator**, a machine that converts mechanical energy to electrical energy. You might have a portable generator on your bicycle that you power by pedaling.
- **Fossil fuels.** Coal, oil, and natural gas are fossil fuels. Fig. 13-4. These are the major sources of energy used today. They are produced deep in the Earth over time from decayed animals and plants. Burning fossil fuels produces a lot of heat energy that we can use. Fossil fuels are nonrenewable (cannot be replaced) in our lifetime.

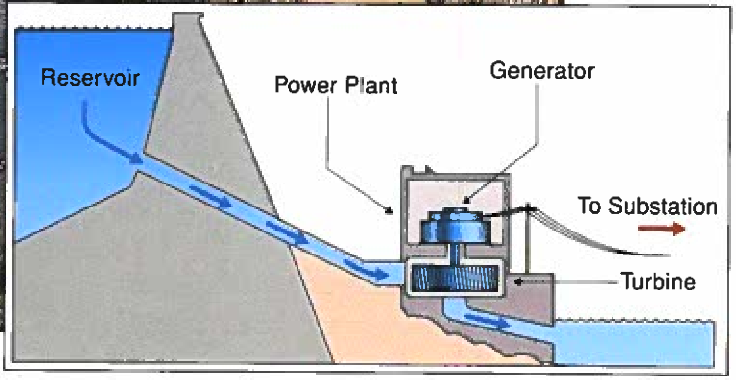
INFOLINK

See Chapter 7 for more information about the use of fossil fuels.

- **Nuclear energy.** Nuclear energy is the energy found in atoms. In **nuclear fission**, atoms of materials such as uranium are split, releasing huge amounts of heat energy that is used to heat water. The steam from the hot water then spins a **turbine**. A turbine is a type of fan that can operate under high pressures and sometimes high temperatures. It is turned by the force of a gas or liquid striking its blades.

Fig. 13-4. Natural gas and oil come from wells deep in the ground. Find out where gas and oil deposits are found in the U.S. Report your findings to the class.

Fig. 13-5. Turbines inside a dam like this one in Arizona create hydroelectric power. Look up the prefix hydro. What does it mean?



TechnoFact

WASTED ENERGY

Almost half of the electricity produced at a power plant is wasted as it is moved from the plant to where it is used. Experts say that if we did everything right and used the most efficient methods available, we would lose as little as 6 percent. Does that make you wonder why we are still doing things the inefficient way?

- **Hydroelectric power.** This power is made when water stored behind a dam passes through a turbine. Fig. 13-5. A generator working with the turbine produces electrical energy from mechanical energy.

One of our biggest challenges today is to find ways to use these conventional energy sources more efficiently. In the activity that follows, you will build a turbine generator that demonstrates how hydroelectricity and other forms of conventional electricity are produced.

SECTION 2 TechCheck

1. Name four conventional energy sources used in developed countries.
2. What are the main sources of energy used?
3. What form of energy is changed in a generator to make electricity?
4. **Apply Your Knowledge.** With your teacher's help, contact your local power company. Ask a representative to speak to your class. Ask questions about the future of the power plant. How will it keep up with the growing need for electricity?

ACTION ACTIVITY

Making a Turbine

Be sure to fill out your TechNotes and place them in your portfolio.

Real World Connection

What would your life be like without electricity? Stereos, televisions, irons, toasters, and computers would be useless. Almost all of the electricity we use involves a turbine blade turning a generator. In this activity, you will make your own model turbine and put it to work creating electrical energy.

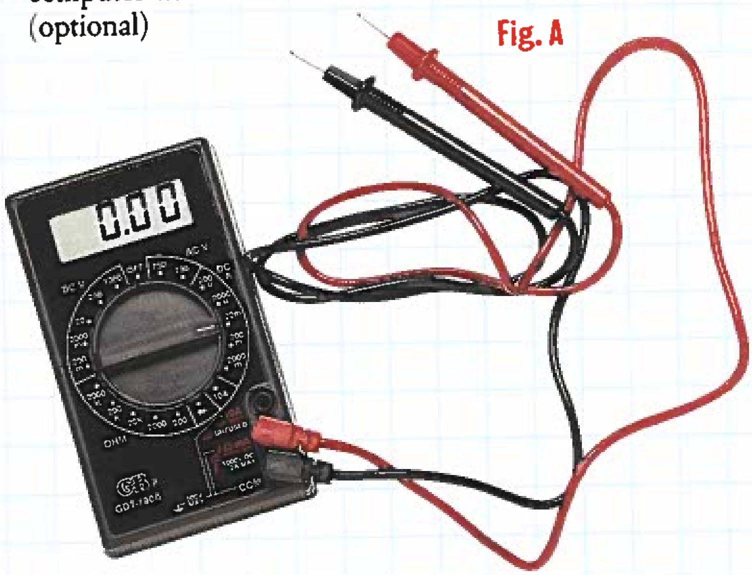
Design Brief

Build a working model of a turbine generator to demonstrate how conventional forms of electricity are produced. Your model will include a turbine blade that harnesses the energy of moving water or air. The turbine will be connected to a generator to change mechanical energy into electrical energy.

Materials/Equipment

- polycarbonate plastic (Lexan), 1/8" thick
- 1/8" steel welding rod
- epoxy glue
- 1 1/2- to 3-volt DC motor
- hookup wire
- 1/8"-ID (inside diameter) plastic shrink tubing
- wood, 1" x 2" x 6" (optional)
- rubber cement
- drill press and 1/8" drill bit
- scissors
- scroll saw
- measurement tools
- plastic strip heater
- compass
- 45° triangle
- pliers, bolt cutters
- digital multimeter, Fig. A
- heat gun
- compressed-air gun
- computer with CAD software (optional)

Fig. A



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Procedure

1. Work with two or three other students to make your turbine blade and generator. First, draw the plan for the turbine blade on a sheet of paper. Fig. B. Use a compass and a 45° triangle or a computer and CAD software to make your plan.
2. Cut out the finished paper design with scissors. With rubber cement, glue the design to a piece of 1/8" thick polycarbonate plastic. (Polycarbonate is a very strong thermoplastic.) The proper way to use rubber cement is to coat both surfaces lightly and let them dry. When the glue is dry, press the two surfaces together.

SAFETY FIRST

- Wear eye protection.
- Follow the general safety rules on pages 42-43 and specific rules for the machines you are using.
- Remember to ask your teacher for help.

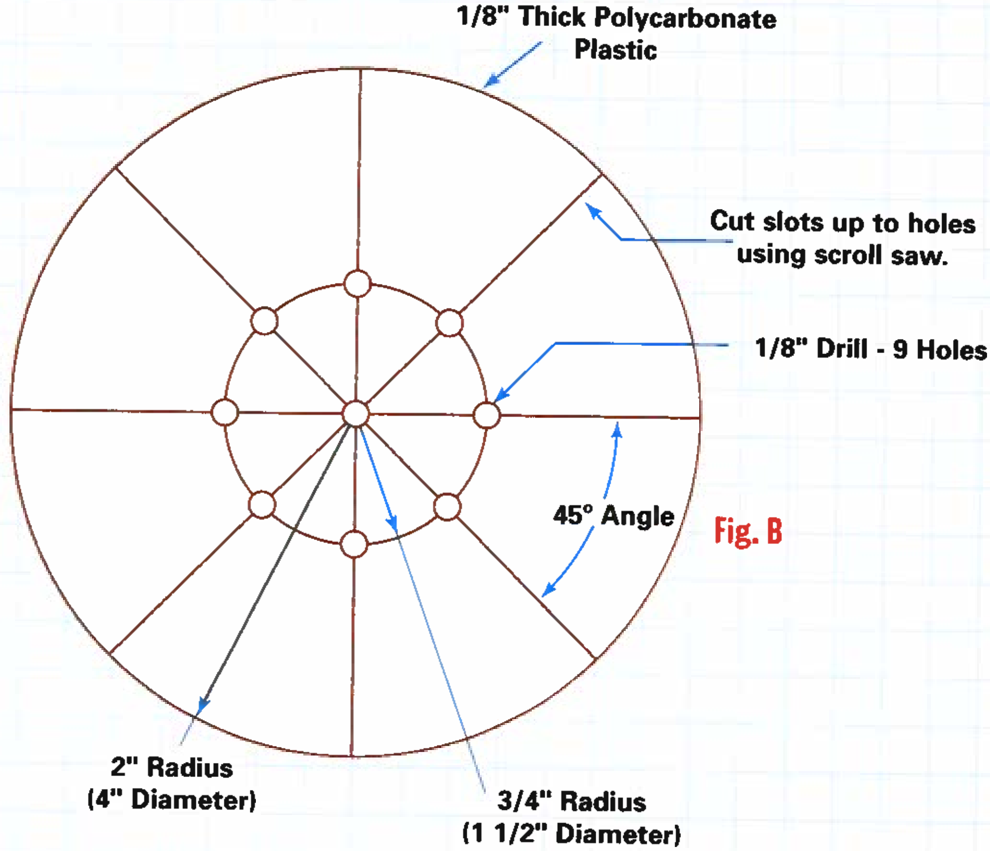

Fig. B

3. Drill the eight 1/8"-diameter holes around the inside circle and another in the center. The holes will help prevent the plastic from cracking. Heat the plastic between the holes with a heat gun with your teacher's help. Use pliers to bend each fin of the turbine blade to a 45° angle.

SAFETY FIRST

The plastic must reach a temperature of 350° to 400° before it will bend. Do not touch the hot plastic or the heating element of the strip heater.

4. Using bolt cutters, cut an 8"-long piece of 1/8"-diameter steel welding rod. Be careful not to bend the welding rod because it will become the axle for your turbine.
5. Glue the turbine blade to the middle of the welding rod using epoxy glue. Follow the directions on the tube of glue carefully. Mix the two parts of epoxy together to start the chemical reaction that will make it harden. Be sure to read the label to see how long you have to wait for the glue to cure (harden). Ask your teacher for help.
6. After the epoxy has cured, attach the axle to the shaft of a 1 1/2- to 3-volt DC motor. This connection will be made flexible using a 1'-long piece of 1/8"-ID (inside diameter) plastic shrink tubing. The tubing can be shrunk to fit tightly around the shaft of the motor by applying heat. Ask your teacher for help in shrinking tubing.
7. The motor you are using has permanent magnets inside so it will also work as a generator. Instead of using a battery to run the motor, you will use the turbine to turn the generator to produce electricity. Connect the terminals of the motor to a digital multimeter. The multimeter should be set to read 0-3 volts DC.
8. In the first test of your turbine generator you will simulate a hydroelectric power plant. You will use the force of water running out of a water faucet to turn the turbine blade. Hold the motor/generator in a sink so it will be out of the water stream and low enough to prevent splashing. Watch the multimeter reading and see what voltage your turbine will produce. If the meter shows a negative number, reverse the positive and negative wires.
9. The test will simulate the use of a turbine being run by high-pressure steam. In a real power plant, steam would be generated by burning coal, oil, or natural gas to boil water. Nuclear power plants use radioactive fuel rods to boil water and make steam. High-pressure steam is very dangerous. Instead of using steam to spin your turbine, you will use compressed air from a compressed-air gun. Fig. C.

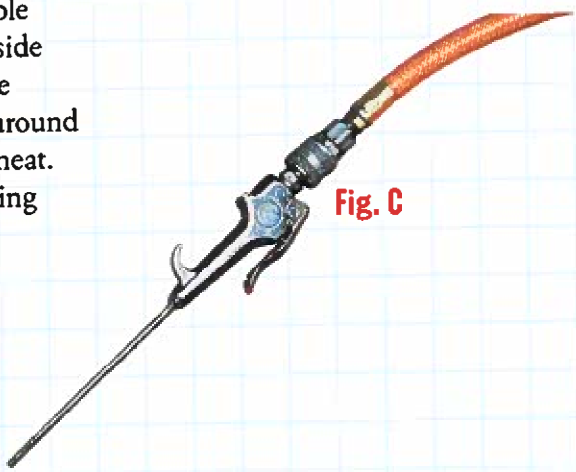

Fig. C

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10. Design and build a stand to hold the turbine blade. Your stand might be made of plastic or wood. Fig. D.

11. Connect the multimeter to the generator terminals as before. With your teacher's help, use a compressed-air gun to spin the turbine blade.

SAFETY FIRST

Compressed air can be dangerous. Do not point the gun at anyone or put your finger over the end of the gun. Keep your fingers and any long hair away from the spinning turbine blade. Do not exceed 20 psi.

12. Watch the multimeter reading to see how many volts your turbine generator can produce.

Evaluation

1. What was the voltage reading in the hydroelectric test? What was the reading using compressed air? Why was there a difference? Explain.

2. Where does the electricity you use come from? How is it produced?

3. How many generators like yours would it take to run a house outlet that drew 120 volts?

4. **Going Beyond.** Design and make a modification (change) of your turbine blade so that you could use wind energy to make electricity.

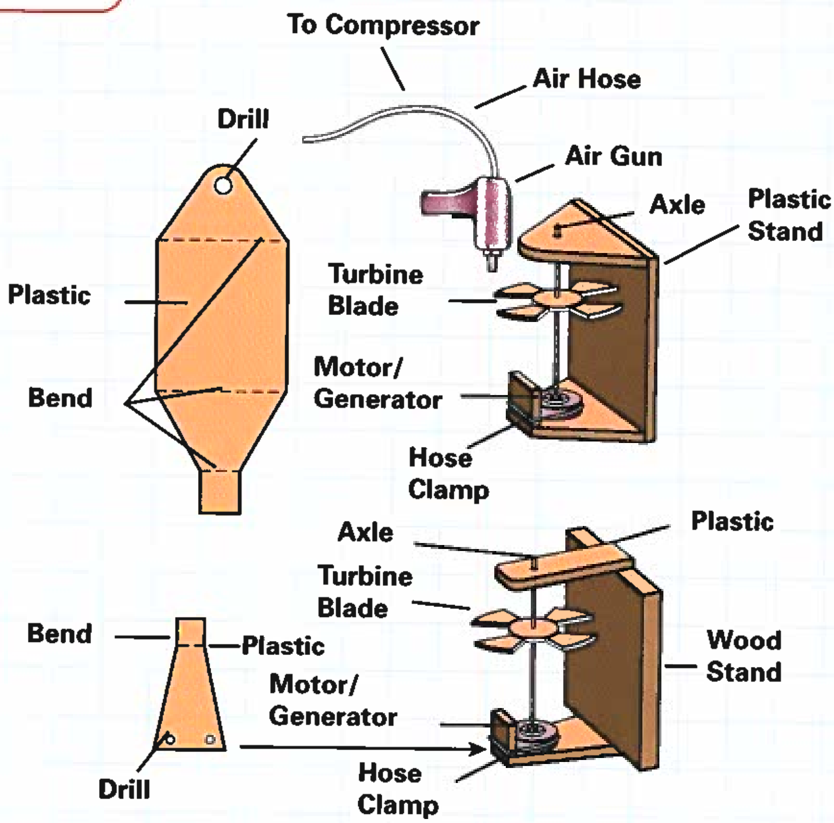


Fig. D

How Can We Save Energy?

SECTION 3

THINGS TO EXPLORE

- Explain why we need to conserve energy.
- Identify ways technology can help save energy.
- Investigate a house or apartment for air leaks.

TechnoTerms
energy-intensive
insulated

Did you ever leave a light on in a room when you left? Have you seen people leave their cars running while they go into a store? Do you turn the heat up in your house but leave a window open for fresh air? These are some habits that we need to change in order to *conserve*, or save, our energy resources. Conservation can take many forms.

People are trying to find ways to conserve energy because many of our resources are nonrenewable. Even those like electricity, which we think will always be there, count on other energy sources for their production. In some places, power plants use coal or oil to make electricity. Both of these fossil fuels are running out. We must use our energy supplies more wisely and efficiently.

You live in an **energy-intensive** world. That means many of the things you do daily require energy. Every day more products that use energy are being developed to meet your needs. Sometimes these products make life easier, but they are not needed for your survival. Do you really need an electric can opener? How about an electric pencil sharpener? Some of the ways you can save energy are simple, but others are not so easy.

Making Things More Energy-Efficient

What can we do to save energy? We can make products that require less energy to operate. For example, one company has produced a new fluorescent light bulb that uses less energy than conventional bulbs and lasts longer. We can also make cars that burn less fuel. Using plastics for many parts instead of metals makes cars lighter. Not as much fuel is needed to move them.

TechnoFact

BRIGHT IDEA Can you imagine how reducing the size of the bulb used in a car's headlights by one inch could result in a new shape for cars of the future? The new light bulb will be far more durable and energy-efficient than the bulbs used now. It doesn't have a heated filament. It uses an electronically controlled spark to heat gases. The smaller bulb produces more light and less heat. Since the bulb itself is cooler, the assembly that holds it can be smaller, lighter, and made from plastics. That means cars can be more streamlined, or aerodynamic, and therefore have improved gas mileage.

Fig. 13-6. **Wrapping a water heater with insulation saves energy.** Stop at an appliance store and look at the EnergyGuide stickers that show how much energy a large appliance saves. Describe the stickers to the class.

In addition, we can change products so they waste less energy. Up to now, no machine can make total use of all the energy put into it. All products that use energy waste some. For example, about half of the energy in fossil fuels burned in engines is lost in the form of heat that doesn't do any useful work. This is true for all types of engines. Automobile manufacturers are trying to make car engines more efficient. Also, furnaces are now being produced that are twice as energy-efficient as the ones made five years ago.

Even home appliances can be more efficient. For example, water heaters can be better **insulated** so that heat stays in. Fig. 13-6. Maybe your dishwasher has a special energy-saving setting that doesn't use energy to dry your dishes. Many large buildings and schools have special switches that automatically lower room temperatures and turn lights off at night or on weekends when most people are not working. Your walls, ceilings, doors, and windows can be better insulated to prevent heat loss during cold weather. That saves a lot of energy.

Recycling

Have you been recycling cans, bottles, plastic, and newspaper? Recycling is another way to save energy because it takes less energy to recycle a used material than to process a raw material. Throwing away one aluminum can is like throwing away one-half gallon of gasoline!

SECTION 3 TechCHECK

1. What does *conserve* mean?
2. Why do we need to conserve energy?
3. How can technology help us save energy?
4. **Apply Your Knowledge.** List five ways you can conserve energy at school and at home. Share your list with your classmates.

ACTION ACTIVITY

Calling All House Detectives!

Be sure to fill out your TechNotes and place them in your portfolio.

Real World Connection

In cold climates, cool air leaking in from outside can add a great deal to the heating bill. Fig. A. In warm climates, hot air coming in adds to the cooling bill. The places where air enters can be found and fixed easily. In this activity you will investigate how finding air leaks in a house or apartment can save energy.

Design Brief

Draw a floor plan of your house or apartment. Investigate your home for air leaks and mark them on the floor plan. Then help correct any problems.

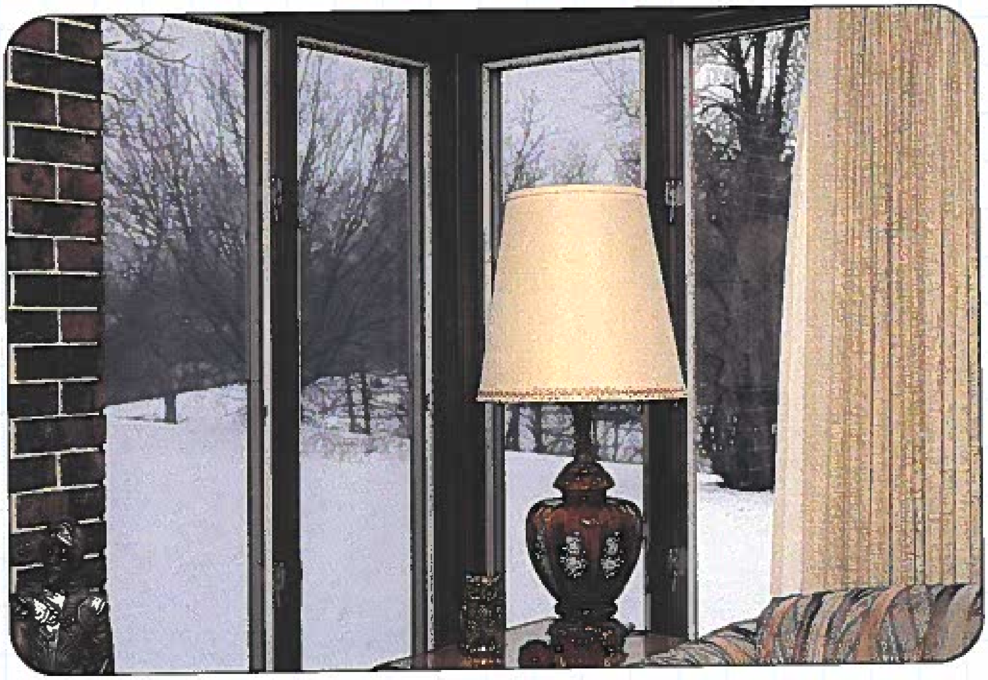
Materials/Equipment

- graph paper with 1/4" squares
- weather stripping (optional)
- thermometer
- flashlight
- screwdriver

SAFETY FIRST

Follow the safety rules listed on pages 42-43 and the specific rules provided by your teacher for tools and machines.

Fig. A



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ACTION ACTIVITY

Procedure

1. Sketch a floor plan of your house or apartment on graph paper. Use a scale of 1/4" = 1'. Use the architectural symbols from Chapter 12 to mark walls, windows, and doors.

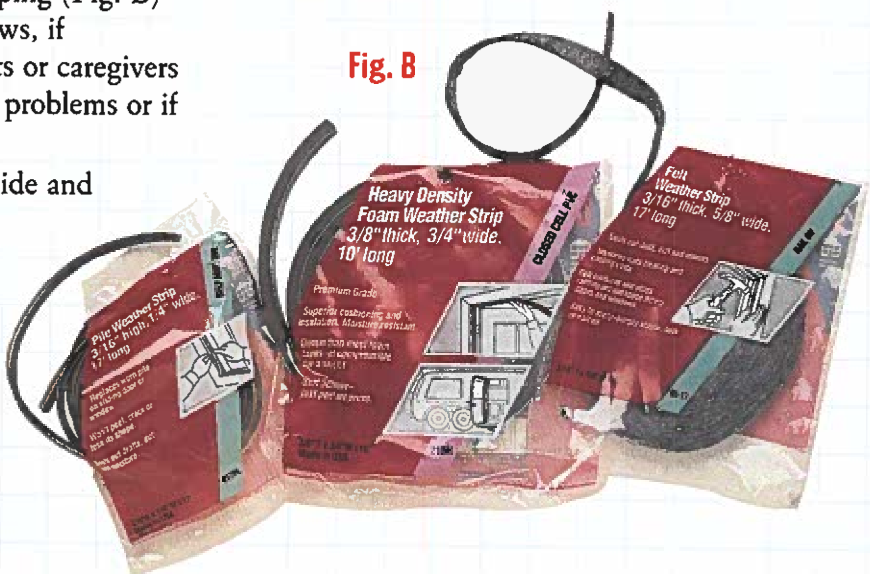
> **INFOLINK**
> See Chapter 12 for more information about architectural symbols.

2. Check your home for air leaking inside through cracks and spaces around doors or windows. Wait until night and turn off the lights. Ask someone to go outside and shine a flashlight around windows and exterior (outside) doors. Then you watch from the inside to find any spots where the light shines through. If you live above the ground floor, ask your teacher what you should do.
3. Mark on your floor plan any areas where you saw light. These problems can be corrected using weatherstripping (Fig. B) or by installing storm windows, if appropriate. Ask your parents or caregivers if you can help correct these problems or if someone else can do it.
4. Measure the temperature inside and outside. Record the temperature difference.
5. Write a paragraph that explains your investigation and the steps you took to fix any problems. If possible, use a computer and word processing software.

Evaluation

1. Did you find any areas where air was leaking into your home? If you did, how did you correct the problem?
2. Find out what type of heat your house or apartment has. How could the heating bill be reduced?
3. What is the maximum temperature difference anyone in your house can remember between the inside and outside of your home?
4. **Going Beyond.** With your teacher's help, organize a group to test and weatherize the homes or apartments of poor or elderly people in your neighborhood. Ask local building suppliers if they would either donate the materials needed or sell them at a discount to the disadvantaged.
5. **Going Beyond.** Research how electronics will help conserve energy in the smart houses of the future.

Fig. B



What Is Alternative Energy?

SECTION 4

THINGS TO EXPLORE

- Identify alternative energy sources.
- Explain why alternative energy sources are important to us.
- Design, build, and test a photovoltaic battery charger.

TechnoTerms

alternative energy
biomass
geothermal energy
photovoltaic cell
solar cell

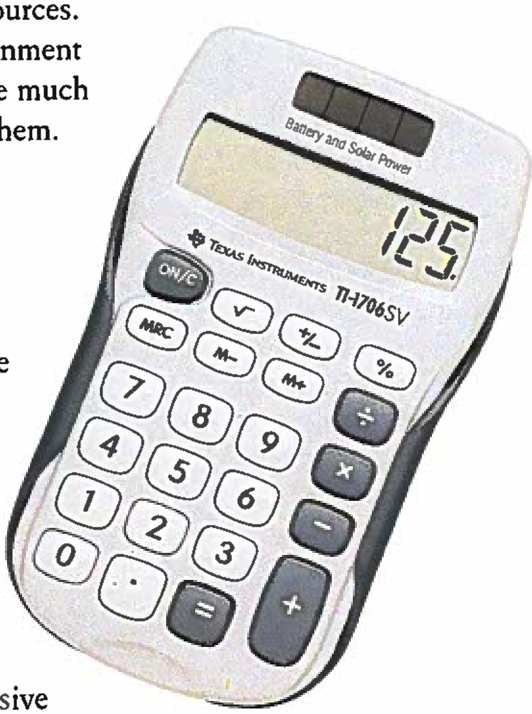
Besides trying to conserve our current energy sources, we need to look at **alternative energy** sources. They are also called *renewable resources* because we will not run out of them. They are constantly renewed through natural processes caused by the sun's energy. Alternative energy sources are important to you. Can you name some of them?

Solar energy, wind energy, biomass, tidal energy, and geothermal energy are examples of alternative energy sources. They provide energy with far less damage to the environment than nuclear or fossil fuel sources. They do not produce much waste or pollution. We need to find more ways to use them. They may replace or be added to nonrenewable energy supplies to do work for us.

Solar Energy

The sun provides the Earth with lots of energy, some of which can be used for heating purposes and to produce electricity.

Solar cells, or **photovoltaic cells**, make electricity directly from sunlight. Solar cells were developed to use on satellites in the 1950s, and they were very expensive then. Do you have a solar-powered calculator? Solar cells are now much cheaper to make, and calculators that contain them are inexpensive and powerful.



Solar-powered calculators change light energy into electricity.

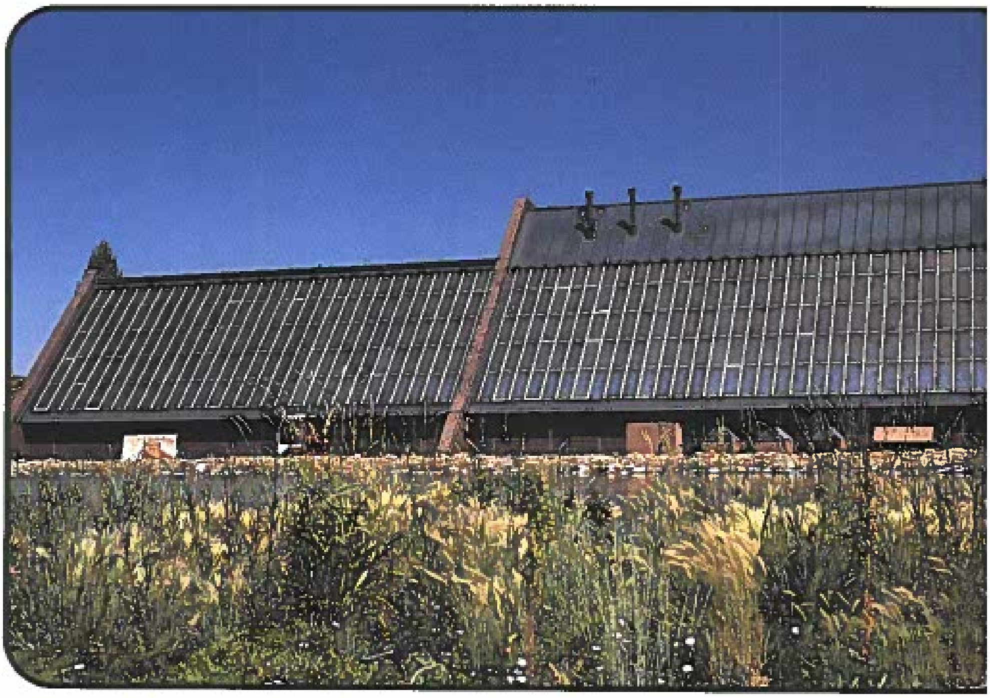


Fig. 13-7. This building uses the sun's energy for heating. Solar collectors are built into the roof. Look for solar collectors on homes in your neighborhood. How many can you find?

TechnoFact

HERE COMES THE SUN Did you know that if we could figure out a way to better use energy from the sun, all our energy problems would be solved? The average amount of solar radiation striking the Earth over a year's time is equal to 178,000 terawatts (10^{12} watts)!

Another direct use of solar energy is using solar collectors to heat water. The hot water is then used to heat homes. Fig. 13-7. Some solar collectors produce temperatures high enough to be used in industry and for generating electricity. Active solar heating is much more effective in sunny climates.

Wind Energy

Wind is one of the most promising alternative energy sources. Many countries, especially those that get a lot of wind, are developing wind power technology.

The most important use of wind energy is to produce electricity. The wind turns a turbine shaft that is hooked to a generator. The turbine depends on a steady supply of wind averaging 10 miles per hour or more. Medium-sized wind-driven turbines have been the most efficient so far. In some places, batteries are used to store the energy for times when the wind isn't blowing. More than 20,000 wind turbines are now producing electricity around the world.

Wind energy can generate electricity at the same price as fossil fuels and nuclear power, but it is safer and doesn't cause pollution. "Wind farms," or collections of wind generators, in California have the power of two nuclear power plants but cost half as much as conventional power stations to operate. Fig. 13-8.

Fig. 13-8. Wind "farms" like this one in California use windmills to capture wind energy. What were early windmills used for?

Biomass

Biomass is living or dead plant or animal matter. Its main sources are wood, crops, animal wastes, and organic materials found in garbage. Almost half of the world's population depends on biomass to supply energy for cooking, heating, and light.

The energy in biomass can be released and used in many different ways. Garbage can be burned to produce lots of heat. Most poorer nations get much of their energy from burning wood or from animal waste when wood is scarce or expensive.

Biomass can be used to produce biofuels such as methane, methanol, and ethanol. Processes also exist that can change it into petroleum. Fig. 13-9.

Fig. 13-9. Ethanol is a type of alcohol produced from corn or other biomass. Check the pumps at a local gas station. Does the station sell gasoline mixed with ethanol? If so, what is the percentage of ethanol contained in the mixture?

Tidal Energy

Ocean tides have mechanical energy that can be changed to a form you can use. Turbines can produce electricity from the rising and falling tides. The water is first trapped and then released through the turbine. The energy available depends on the difference between the heights of high and low tides.

Special generators can also change the energy in waves into electric power. This source of energy has lots of potential. But high waves and strong winds pose problems that scientists must first solve.

Geothermal Energy

Geothermal energy is heat from beneath the Earth's crust. Fig. 13-10. When it is brought up to the surface as steam or hot water, it can be used directly to heat water. It can also be used to drive generators or steam turbines. The geothermal resources in the upper three miles of the Earth's crust are estimated to contain more energy than all the world's natural gas and crude-oil reserves. Until now we have used only a small percentage of this energy.

Fig. 13-10. This geyser is at Yellowstone National Park in Wyoming. Geysers are hot springs that erupt into columns of steam and hot water. Find out if geothermal energy is used at Yellowstone and report your findings to the class.

You can see that many energy resources are available to us. We will have to start using some alternative energy supplies because the nonrenewable ones are running out. Could you live with less energy? Most of us can, because we waste so much. We need to find more efficient ways to use and conserve our energy sources and, at the same time, to keep looking for new sources.

SECTION 4 TechCHECK

1. What is alternative energy?
2. List five types of alternative energy.
3. Why do we need to use alternative energy?
4. **Apply Your Knowledge.** Research other devices that are powered by solar cells besides calculators. Share your information with the class.

ACTION ACTIVITY

Using Sunlight to Charge a Battery

Be sure to fill out your TechNotes and place them in your portfolio.

Real World Connection

Wouldn't it be great if we could change sunlight directly into usable energy? Well, we can, thanks to a thin slice of silicon called a photovoltaic cell. Fig. A. In this activity, you will build a solar battery charger. This simple electrical circuit will change sunlight directly into electricity that you can use while the sun shines or store in a battery for use at night or on cloudy days.

Design Brief

Design, build, and test a photovoltaic battery charger. Your charger should produce approximately 1.5 volts DC. It must be able to charge a nicad battery.

Materials/Equipment

- silicon solar cells
- silicon diode
- hookup wire, rubber cement
- AA nicad battery, AA battery holder
- 1/16"-acrylic plastic (Plexiglas)
- aluminum foil
- electronic soldering pencil
- band or scroll saw
- drill press
- digital multimeter
- strip heater (optional)
- 1 1/2-volt DC motor, 1/16"-steel welding rod, gears, belts, pulleys, from machine dissection activity in Chapter 8 (optional)

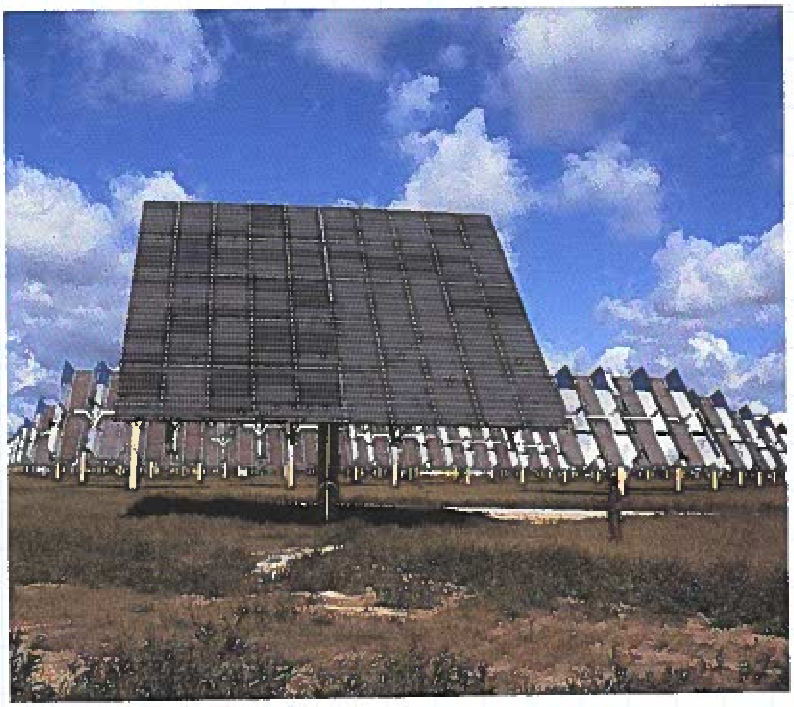


Fig. A. Here, large groups of photovoltaic cells convert solar energy into electrical energy. "Solar farms" like this may become major sources of electricity in the future.

(Continued on next page)

Procedure

1. In this activity, you can work individually or in a group to make a solar battery charger. You will need to use the problem-solving steps you learned in Chapter 1 to solve the problems.

> **INFOLINK**
>
> See Chapter 1 for more information about problem solving.

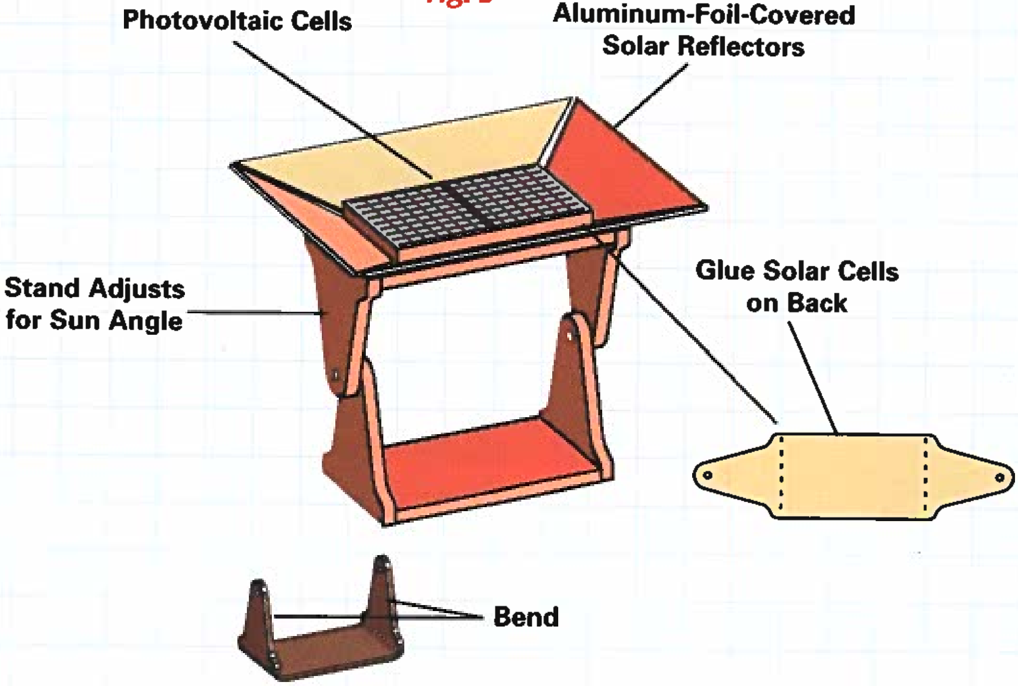
2. A solar collector must be pointed at the sun to be able to produce electricity. You will need a way to adjust the collector so it will gather enough light to charge a battery. You may also need to help gather sunlight by using reflectors to direct the sunlight to the solar cells. Brainstorm ideas for how you will meet this need. Some possibilities are illustrated for you in Fig. B.

3. Refine your design and start construction. Think about the goals of your solar collector. It must

- be adjustable
- gather enough sunlight to operate at 1.5 volts or more
- be lightweight enough for a solar-powered car

> **SAFETY FIRST**
>
> **Wear eye protection. Follow the general safety rules on pages 42-43 and specific rules for the machines you are using. Remember to ask your teacher for help.**

Fig. B



4. With the help of your teacher, solder the hookup wires to the solar cells according to the directions on the package. Handle the solar cells carefully. They are very thin and fragile. (They are also expensive.) Solder the hookup wires together to make a series circuit called a *solar array*. This arrangement will add the voltages of all the solar cells together. Solder the positive lead to a diode before it is connected to the battery holder. The diode will let electrons flow in only one direction. Fig. C.

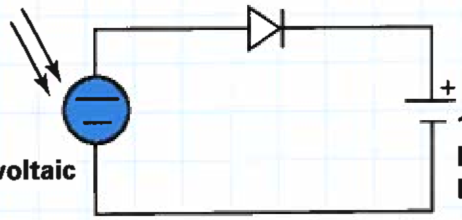


Fig. C

5. Carefully glue the solar cells to your collector using rubber cement. Do not press hard on the solar cells. They will crack easily if handled roughly.
6. Test your solar generator by pointing it toward the sun. Connect the leads of a digital multimeter to the positive (+) and negative (-) terminals of the battery holder. If you get a negative reading on the multimeter, you must reverse the battery holder. It is important that the polarity (+ or -) be correct for the charger to work.

SAFETY FIRST

Do not look directly into the reflections from the mirrors.

Evaluation

1. How many volts of electricity did your solar charger produce?
2. How did you use reflectors to trap more light? Measure the voltage output with and without the reflectors. What is the difference?
3. Try using your solor charger indoors. What is the difference in results?
4. **Going Beyond.** Use the solar collector as a part of a solar-powered car. You might decide to team up with another group to solve this problem. You will need to apply knowledge about mechanical systems, covered in Chapter 8, to connect a motor to the wheel or axle of your car. If your first attempt does not make the car move, can you connect two or more solar collectors together to get more power? If your class is successful in making more than one solar-powered car, set up a race to see which car goes the fastest or the farthest.
5. **Going Beyond.** Research the development of photovoltaic cells. What has happened to the efficiency and cost of producing solar cells? Where are they commonly used today?
6. **Going Beyond.** Research the solar-powered car made by General Motors called the *Sunraycer*. How is this car designed differently from an ordinary car? Do you think you will be able to buy a solar-powered car some day? Explain.

CHAPTER 13 REVIEW &

CHAPTER SUMMARY

SECTION 1

- Energy is the ability to do work; power is the amount of work done in a certain period of time.
- There are two kinds of energy, potential energy (energy at rest) and kinetic energy (energy of motion).
- Most of the Earth's energy comes from the sun.

SECTION 2

- Conventional energy sources used in developed countries are electricity, fossil fuels, nuclear energy, and hydroelectric power.
- One of our biggest challenges today is to find ways to use these conventional energy sources more efficiently.

SECTION 3

- Technology is helping find ways to make machines and other products more efficient so they don't use or waste so much energy.

SECTION 4

- Alternative energy sources are being developed to replace nonrenewable energy supplies.
- Solar energy, wind energy, biomass, tidal energy, and geothermal energy are some alternative energy sources.

REVIEW QUESTIONS

1. What were solar cells originally developed for?
2. How are fossil fuels produced?
3. What is the difference between energy and power?
4. Does a coiled spring have potential or kinetic energy?
5. Name ways energy is wasted in your home or school.
6. What is biomass?

CRITICAL THINKING

1. Research the cost of electricity in your area. Find out how much the electricity used in your house costs every month. List ways you could reduce the electricity bill.
2. Design your own experiment that demonstrates conservation of energy. Ask your teacher for help in making a procedure for your idea.
3. Ask your teacher to show you plans for a super-insulated house. How are super-insulated houses built differently from normal houses? How long do you think it would take to pay for the additional cost of materials by saving energy?
4. Make a sketch of a hydroelectric power plant. Label the turbine, generator, dam, and reservoir.