SECTION 2

Alternative Energy and Conservation

Objectives

- Describe three alternative energy technologies.
- Identify two ways that hydrogen could be used as a fuel source in the future.
- Explain the difference between energy efficiency and energy conservation.
- Describe two forms of energy-efficient transportation.
- Identify three ways that you can conserve energy in your daily life.

Key Terms

alternative energy
ocean thermal energy conversion (OTEC)
fuel cell
energy efficiency
energy conservation

To achieve a future where energy use is sustainable, we must make the most of the energy sources we already have and develop new sources of energy. **Alternative energy** describes energy sources that are still in development. Some renewable energy sources that we use now, such as geothermal power, were once considered alternative energy. For an alternative energy source to become a viable option for the future, the source must be proven to be cost effective. Also, the environmental effects of using the energy source must be acceptable. Government investment is often the only way to research some of these future energy possibilities.

Tidal Power

Tides are the movement of water in the oceans and seas caused by gravitational attraction between the sun, Earth, and moon. The tides, which happen twice each day, are marked by the rising and falling of the sea level. The energy of the tides was used nearly a thousand years ago to power mills in France and Britain. Today, tidal power is used to generate electricity in countries such as France, Russia, and Canada.

As **Figure 13** shows, a tidal power plant works much like a hydroelectric dam. As the tide rises, water flows behind a dam; when the sea level falls, the water is trapped behind the dam. When the water in the reservoir is released, it turns a turbine that generates electricity. Although tidal energy is renewable and nonpolluting, it will not become a major energy source in the future. The cost of building and maintaining a tidal power plant is high, and there are few locations that are suitable.

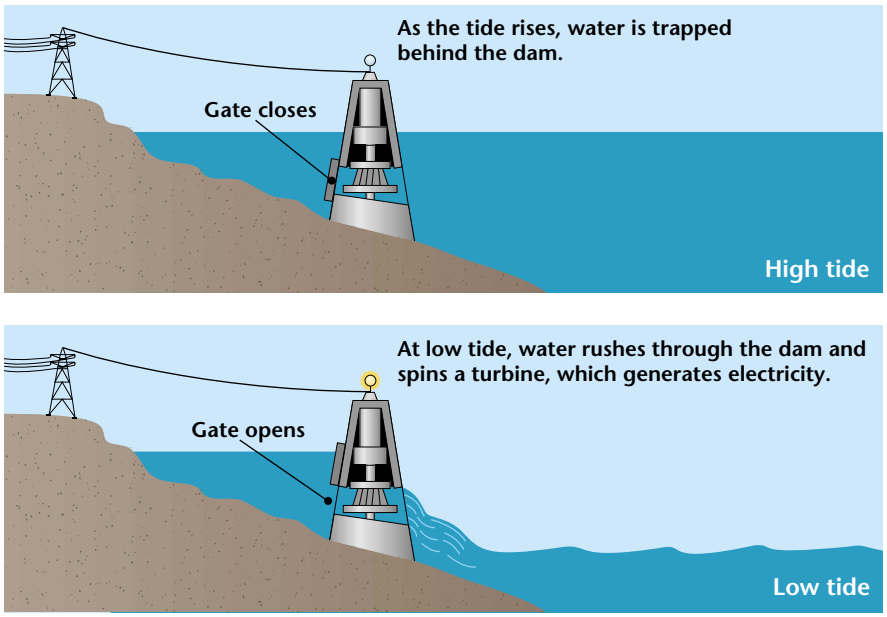


Figure 13 ▶ As the tide rises, water enters a bay behind a dam. The gate then closes at high tide. At low tide, the gate opens and the water in the bay rushes through, spinning a turbine that generates electricity.

Ocean Thermal Energy Conversion

In the tropics, the temperature difference between the surface of the ocean, which is warmed by solar energy, and deep ocean waters can be as much as 24°C (43°F). An experimental power station off the shores of Hawaii uses this temperature difference to generate electricity. This technology, which is shown in **Figure 14,** is called **ocean thermal energy conversion (OTEC).** In this system, warm surface water is used to boil sea water. This is possible because water boils at low temperatures when it is at low pressure in a vacuum chamber. The boiling water turns into steam, which spins a turbine. The turbine runs an electric generator. Cold water from the deep ocean cools the steam, turning the steam into water that can be used again.

Japan has also experimented with OTEC power, but so far, no project has been able to generate electricity cost effectively. One problem with OTEC is that the power needed to pump cold water up from the deep ocean uses about one-third of the electricity the plant produces. Therefore, the OTEC plants are inefficient. The environmental effects of pumping large amounts of cold water to the surface are also unknown.

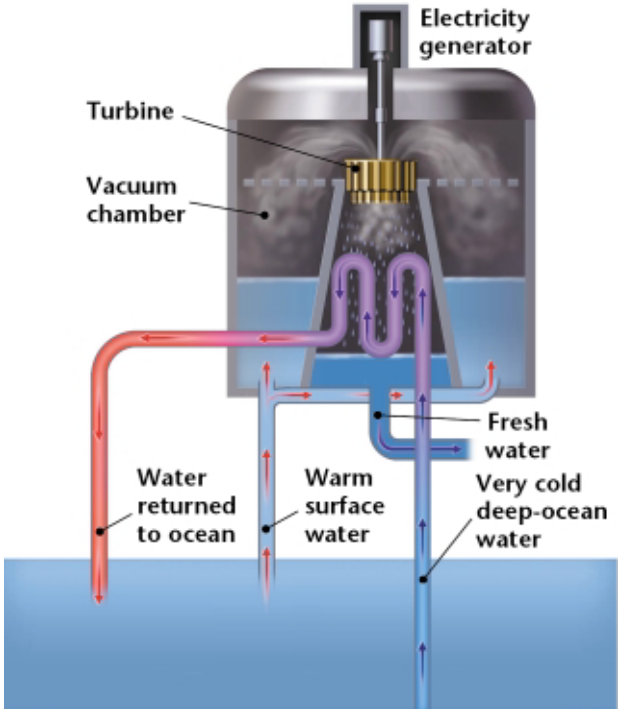


Figure 14 ▶ In an open cycle OTEC plant, warm surface water is brought to boil in a vacuum chamber. The boiling water produces steam to drive a turbine that generates electricity. Cold deep-ocean water is pumped in to condense the steam. Fresh water is a byproduct of this type of OTEC plant.

Hydrogen—A Future Fuel Source?

The fuel of the future might be right under our noses. Hydrogen, the most abundant element in the universe, can be burned as a fuel. Hydrogen is found in every molecule of living things, and it is also found in water. Hydrogen does not contain carbon, so it does not release pollutants associated with burning fossil fuels and biomass. When hydrogen is burned, it combines with oxygen to produce water vapor, a harmless byproduct, and small amounts of nitrogen oxides. Hydrogen gas (H_2) can be produced by using electricity to split molecules of water (H_2O). Or, in the future, we may also be able to grow plants to produce hydrogen cost effectively, as shown in **Figure 15.**

Figure 15 ▶ Hydrogen fuel can be made from any material that contains a lot of hydrogen, including the experimental plot of switchgrass shown here.

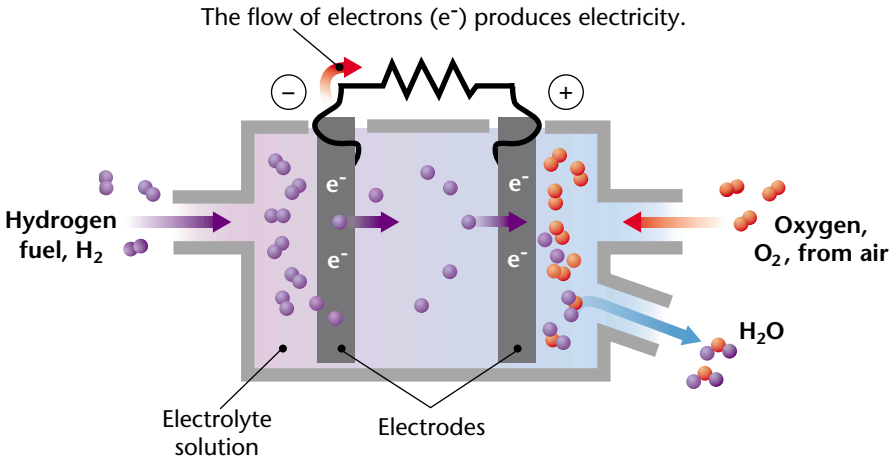


Figure 16 ▶ This diagram shows how a fuel cell produces electrical energy.

QuickLAB

Hydrolysis

Procedure

1. Coat a **9 V cell** with **petroleum jelly.** Be careful not to get any on the terminals.
2. Mix **1 Tbsp** of **salt** in a **600 mL beaker** of **water.**
3. Fill **two test tubes** with the saltwater solution, and invert them in the beaker, making sure to cover the ends of the test tubes. No air should be trapped in the test tubes.
4. Place the 9 V cell upright in the beaker. Position a battery terminal under the open mouth of each test tube. You will observe hydrogen gas collecting in the test tube located over the negative terminal and oxygen gas collecting over the positive terminal.

Analysis

1. Did you collect the same volume of hydrogen as oxygen? Explain why or why not.

The Challenge of Hydrogen Fuel So why is hydrogen the fuel of the future and not the fuel of today? One difficulty is that hydrogen takes a lot of energy to produce. If this energy comes from burning fossil fuels, generating hydrogen would be expensive and polluting. One alternative is to use electricity from solar cells or wind power to split water molecules to produce hydrogen. Hydrogen could then be stored in pressurized tanks and transported in gas pipelines. Or hydrogen might not be stored at all—it might be used as it is produced, in fuel cells.

Fuel Cells Fuel cells, like the one in **Figure 16,** may be the engines of the future. Like a battery, a **fuel cell** produces electricity chemically, by combining hydrogen fuel with oxygen from the air. When hydrogen and oxygen are combined, electrical energy is produced and water is the only byproduct. Fuel cells can be fueled by anything that contains plenty of hydrogen, including natural gas, alcohol, or even gasoline. The space shuttles have used fuel cells for years. In the change from cars powered by internal combustion engines to those powered by fuel cells, vehicles may get hydrogen from gasoline so that they can be refueled at existing gas stations. By 2010, portable devices such as phones and video-game players may be powered by micro fuel cells. These fuel cells would be fueled with alcohol and may end the problem of charging or changing batteries.

Energy Efficiency

There are two main ways to reduce energy use—lifestyle changes and increases in energy efficiency. Lifestyle changes might include walking or biking for short trips and using mass transit. **Energy efficiency** is the percentage of energy put into a system that does useful work. Energy efficiency can be determined using this simple equation: energy efficiency (in %) = energy in/energy out × 100. Thus, the efficiency of a light bulb is the proportion of electrical energy that reaches the bulb and is converted into light energy rather than into heat. Most of our devices are fairly inefficient. More than 40 percent of all commercial energy used in the

United States is wasted. Most of it is lost from inefficient fuel-wasting vehicles, furnaces, and appliances and from leaky, poorly insulated buildings. We could save enormous amounts of energy by using fuel cells instead of internal combustion engines in cars, and by changing from incandescent to fluorescent light bulbs, as shown in **Table 1.** However, many increases in efficiency involve sacrifices or investments in new technology.

Efficient Transportation Nothing would increase the energy efficiency of American life more than developing efficient engines to power vehicles and increasing the use of public transportation systems. The internal combustion engines that power most vehicles use fuel inefficiently and produce air pollution. The design of these engines has hardly changed since 1900, but they may change radically in the next 50 years. However, in the United States, gasoline prices are currently so low that there is little demand for fuel-efficient vehicles, which are more common in other countries.

Hybrid Cars Hybrid cars, such as the one shown in **Figure 17,** are examples of energy-efficient vehicles currently in use. You have probably seen hybrid cars on the road. Hybrid cars use a small, efficient gasoline engine most of the time, but they also use an electric motor when extra power is needed, such as while accelerating. Hybrid cars feature many other efficient technologies. They convert some of the energy of braking into electricity and they store this energy in the battery. To save fuel, hybrid cars sometimes shut off the gasoline engine, such as when the car is stopped at a red light. Hybrid cars are also designed to be aerodynamic, and they are made of lightweight materials so that they need less energy to accelerate. Hybrid cars do not cost much more than conventional vehicles, they cost less to refuel, and they produce less harmful emissions. These benefits are leading several top auto makers to design many hybrid car models, including hybrid trucks and SUVs.

Table 1 ▼

Energy Efficiency of Common Conversion Devices

Device	Efficiency
Incandescent light bulb	5%
Fluorescent light bulb	22%
Internal combustion engine (gasoline)	10%
Human body	20%–25%
Steam turbine	45%
Fuel cell	60%

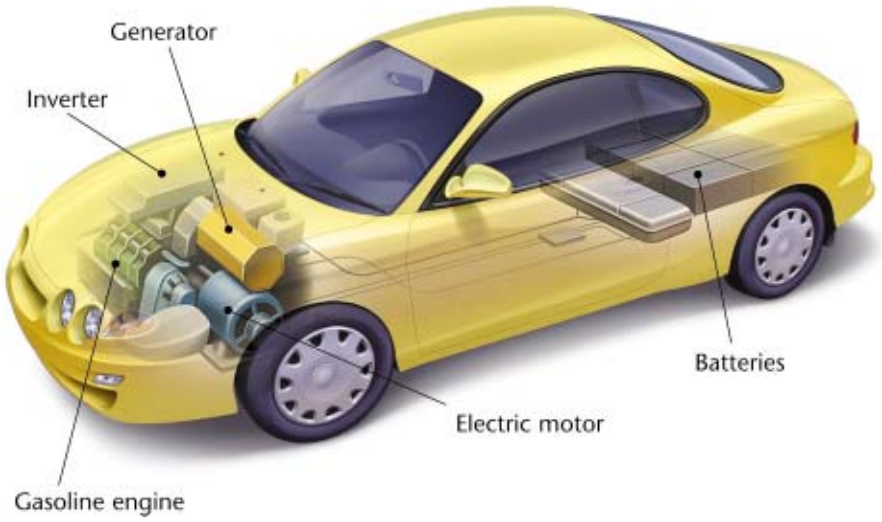


Figure 17 ▶ A hybrid car has a gasoline engine and an electric motor.

Cogeneration

One way to use fuel more efficiently is *cogeneration*, the production of two useful forms of energy from the same fuel source. For example, the waste heat from an industrial furnace can power a steam turbine that produces electricity. The industry may use the electricity or sell it to a utility company. Small cogeneration systems have been used for years to supply heat and electricity to multiple buildings at specific sites. Small units suitable for single buildings are now available in the United States.

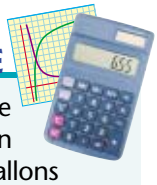
Energy Conservation

Energy conservation means saving energy. It can occur in many ways, including using energy-efficient devices and wasting less energy. The people in **Figure 18** are conserving energy by bicycling instead of driving. Between 1975 and 1985, conservation made more energy available in the United States than all alternative energy sources combined did.

Cities and Towns Saving Energy The town of Osage, Iowa, numbers 3,600 people. You might not think that a town this small could make much of a difference in energy conservation. Yet the town adopted an energy conservation plan that saves more than $1 million each year. The residents plugged the leaks around windows and doors where much of the heat escapes from a house. In addition, they replaced inefficient furnaces and insulated their hot water heaters. Businesses in Osage also found ways to conserve energy. In addition to saving energy, the town has greatly improved its economy through energy conservation. Businesses have relocated to the area in order to take advantage of low energy costs. Unemployment rates have also declined. This small town in Iowa is just one example of the dramatic benefits of energy conservation.

Conservation Around the Home The average household in the United States spends more than $1,200 on energy bills each year. Unfortunately, much of that energy is wasted. Most of the energy lost from homes is lost through poorly insulated windows, doors,

MATHPRACTICE



Energy Efficiency In the United States, each person uses an average of 459 gallons of gasoline per year. In Germany, each person uses an average of 140 gallons a year. Auto manufacturers estimate that vehicles would use 2 percent less gasoline if everyone kept their tires inflated to the correct pressure. How much gasoline would a person in the United States save and a person in Germany save each year if their tires were kept inflated to the correct pressure?

Figure 18 ▶ In Copenhagen, Denmark, companies provide free bicycles in exchange for publicity. Anyone wishing to use a bike is free to borrow one after paying a refundable deposit. The program helps cut down on pollution and auto traffic.

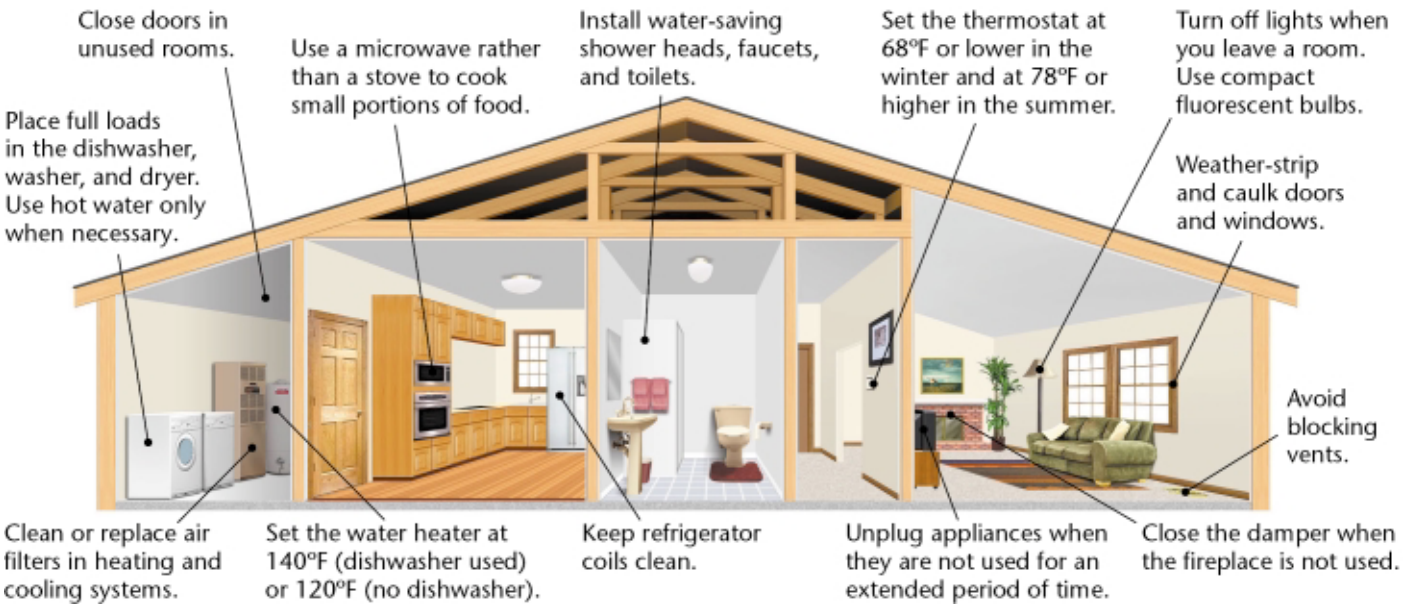
walls, and the roof. So a good way to increase energy efficiency is to add to the insulation of a home. Replacing old windows with new high efficiency windows can reduce your energy bill by 15 percent. Two of the best places to look for ways to conserve energy are doors and windows. Much of the energy lost from a house escapes as hot air in winter or cold air in summer passes through gaps around doors and windows. Hold a ribbon up to the edges of doors and windows. If it flutters, you've found a leak. Sealing these leaks with caulk or weather stripping will help conserve energy. There are dozens of other ways to reduce energy use around the home. Some of these are shown in **Figure 19.**

Conservation in Daily Life There are many simple lifestyle changes that can help save energy. First, remember that using less of any resource usually translates into saving energy. For example, washing your clothes in cold water uses only 25 percent of the energy needed to wash your clothes in warm water. **Table 2** lists a few ways that you can conserve energy every day. Can you think of other ways?

Table 2 ▼

Energy Conservation Tips
• Walk or ride a bicycle for short trips.
• Carpool or use public transportation whenever possible.
• Drive a fuel-efficient automobile.
• Choose ENERGY STAR® products.
• Recycle and choose recycled products whenever possible.
• Set computers to "sleep" mode when they are not in use.

Figure 19 ▶ Ways to Save Energy Around the House



SECTION 2 Review

1. **Describe** three alternative energy technologies, and identify two ways that hydrogen could be used as a fuel source in the future.
2. **List** as many ways as you can for individuals and communities to conserve energy.
3. **Describe** the difference between energy conservation and energy efficiency.

CRITICAL THINKING

4. **Making Inferences** What factors influence a person's choice to conserve energy?
5. **Making Comparisons** Read the description of hydrogen fuel cells and explain why hydrolysis (splitting water molecules with electricity to produce hydrogen and oxygen) is the opposite of the reaction that occurs in a hydrogen fuel cell. READING SKILLS

CHAPTER 18

Highlights

1 Renewable Energy Today

Key Terms

renewable energy, 457
passive solar heating, 458
active solar heating, 460
biomass fuel, 462
hydroelectric energy, 463
geothermal energy, 464

Main Ideas

- Renewable energy sources are forms of energy that are constantly being formed from the sun's energy.
- Solar energy can be used to heat a house directly or to heat another material, such as water, which can then be used to heat a house. Solar cells can also be used to generate electricity.
- Wind power is the fastest growing source of energy in the world.
- Many people in developing countries get most of their energy from biomass such as fuelwood. Biomass is increasingly used in developed countries to generate electricity.
- Hydroelectric energy is electricity generated by the energy of moving water.
- Geothermal energy, the heat within the Earth, can be used to generate electricity.

2 Alternative Energy and Conservation

alternative energy, 466
ocean thermal energy conversion (OTEC), 467
fuel cell, 468
energy efficiency, 468
energy conservation, 470

- Alternative energy sources are energy sources that are still in development.
- Ocean thermal energy conversion (OTEC) uses the temperature difference between layers of ocean water to generate electricity.
- Hydrogen may be one of the fuels of the future. It can be made from any organic material and produces only water as a waste product when burned.
- Hydrogen fuel cells may be the engines of the future. Many experiments with them are now underway.
- Energy efficiency is the percentage of energy put into a system that does useful work. Energy conservation means saving energy.

CHAPTER 18 Review

Using Key Terms

Use the correct key term to complete each of the following sentences.

1. Much of the energy needs of the developing world are met by _____, such as fuelwood.
2. A _____ converts the potential energy of a reservoir into the kinetic energy of a spinning turbine.
3. Turning off the lights when you leave a room is an example of _____.

Use each of the following terms in a separate sentence.

4. *renewable energy*
5. *geothermal energy*
6. *alternative energy*
7. *energy conservation*

STUDY TIP

Get Some Exercise Ride a bike, go for a walk, or play Frisbee or basketball. Try to get at least a half hour of exercise before you begin studying. Then when you study you will be more relaxed and you will be able to focus on the subject you want to learn. As you study, take a moment to notice if the exercise helped. Scientists have proven that regular physical exercise helps fight memory loss.

Understanding Key Ideas

8. Which of the following forms of renewable energy uses the sun's energy most directly?
   a. biomass fuel
   b. passive solar heating
   c. geothermal energy
   d. a hydrogen fuel cell
9. Which of the following energy sources is useful in most parts of the world?
   a. tidal power
   b. OTEC
   c. geothermal energy
   d. active solar energy
10. A house that uses passive solar heating in the Northern Hemisphere will
    a. be built of a material such as concrete or adobe that stores heat well.
    b. have little insulation.
    c. have large north-facing windows.
    d. have an overhang to shade the house from direct winter sun.
11. A passive solar house in the Southern Hemisphere will face
    a. north.
    b. south.
    c. east.
    d. west.
12. Photovoltaic cells convert the sun's energy into
    a. heat.
    b. fuel.
    c. electricity.
    d. light.
13. In a developing country, you are most likely to find biomass used
    a. to generate electricity.
    b. for manufacturing.
    c. for heating and cooking.
    d. as a source of hydropower.
14. Which of the following is *not* true of fuel cells?
    a. They produce electricity.
    b. They will work with many different fuels.
    c. They are more energy efficient than most engines used today.
    d. They cannot be fueled by hydrogen.
15. Which renewable energy source is the fastest growing energy source in the world?
    a. oil
    b. wind
    c. biomass
    d. photovoltaic cells
16. Which statement describes why geothermal heat pumps work?
    a. They are located in areas with abundant geothermal energy.
    b. The ground is warmer than the air in summer and colder than the air in winter.
    c. The ground is colder than the air in summer and warmer than the air in winter.
    d. They run on hydrogen fuel cells.

CHAPTER 18 Review

Short Answer

17. Rivers are recharged by the water cycle, so what is the original source of hydroelectric energy?

18. Salt water corrodes metals rapidly. What effect is this likely to have on the cost of electricity produced from tidal power?

19. Why is it likely that hydroelectric energy will be generated increasingly by micro-hydropower plants rather than by large hydroelectric dams?

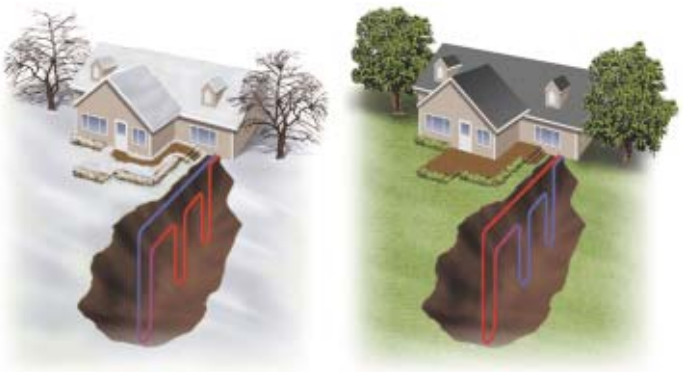
Interpreting Graphics

Use the information in the figure below to answer questions 20–22.

20. Describe the path of the water in the loop during winter. Where is the water warmed? Where is the water cooled?

21. Describe the path of the water in the loop during summer. Where is the water warmed? Where is the water cooled?

22. What is the difference in the temperature between the house, the closed loop, and the air in the summer? What is the temperature difference in the winter?



Concept Mapping

23. Use the following terms to create a concept map: *sun*, *hydroelectric energy*, *solar energy*, *passive solar heating*, *active solar heating*, *water cycle*, *biomass fuel*, *wind energy*, *photovoltaic cell*, and *electric current*.

Critical Thinking

24. Making Comparisons Read the description of energy efficiency and energy conservation in this chapter. How are the two concepts related? Give several examples. READING SKILLS

25. Analyzing Ideas Does the energy used by fuel cells come from the sun? Explain your answer.

26. Analyzing Ideas Explain whether you think the most important advances of the 21st century will be new sources of energy or more efficient use of sources that already exist.

27. Drawing Inferences Don Huberts of Shell Hydrogen said, "The Stone Age didn't end because the world ran out of stones." He was talking about the future of fossil fuels. Write a short essay that explains what he meant. WRITING SKILLS

Cross-Disciplinary Connection

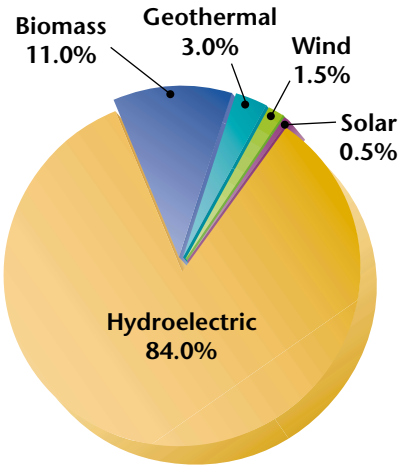
28. Geography Create a world map that shows at least 10 renewable energy or alternative energy projects currently in operation. Annotate your map with details and photographs of each project.

Portfolio Project

29. Energy Timeline The first energy source used by human societies was human muscle. It was used to build houses, make clothing, and shape tools that could be used to dig up plants and kill animals for food. What was the next source of energy? Make a timeline of the energy sources that humans began to use at various times in history. Add interesting facts and images that relate to each energy source on your timeline. Continue your timeline into the future. What energy sources do you think we will use in the future?

MATH SKILLS

The pie graph below shows electric generating capacity from renewable sources in the United States in 1998. Use the data to answer questions 30–31.



30. **Making Calculations** How much generating capacity came from biomass, geothermal, wind, and solar combined?

31. **Making Calculations** In 1998, the United States had a total of 94,822 MW of electric generating capacity from renewable energy. How much of that capacity came from biomass? How much came from wind power?

WRITING SKILLS

32. **Communicating Main Ideas** Explain why scientists are working to reduce the use of the two main sources of energy people use today—fossil fuels and biomass.

33. **Writing Persuasively** Write a guide that encourages people to conserve energy and offers practical tips to show them how.

READING FOLLOW-UP

Now that you have read the chapter, take a moment to review your answers to the **Reading Warm-Up** questions in your ***EcoLog.*** If necessary, revise your answers.

STANDARDIZED TEST PREP

Read the passage below, and then answer the questions that follow.

Aluminum is refined from the ore *bauxite*, which is deposited in a thin layer at the Earth's surface. Worldwide, bauxite strip mines cover more of the Earth's surface than any other type of metal ore mine. Aluminum production uses so much electrical energy that the metal has been referred to as "congealed electricity." Producing six aluminum cans takes the energy equivalent of 1 L of gasoline. For this reason, aluminum smelters are located close to cheap and reliable energy sources, such as hydroelectric dams the in the Pacific Northwest, Quebec, and the Amazon. When the environmental effects of producing new aluminum are considered, the importance of recycling becomes clear. Recycling one aluminum can saves enough energy to run a television set for 4 hours! Currently, the United States obtains about 20 percent of its aluminum from recycling.

1. Why is aluminum referred to as "congealed electricity"?
   - **a.** Smelting aluminum requires a different form of electrical energy.
   - **b.** Aluminum has an electric charge.
   - **c.** Like electrical energy, aluminum can also be recycled.
   - **d.** So much electrical energy is required to produce aluminum that it is almost as if aluminum were solidified electricity.

2. Which of the following statements describes the author's main point?
   - **a.** Hydroelectricity is a cheap, reliable source of energy.
   - **b.** Recycling aluminum can make a significant contribution to energy conservation.
   - **c.** Aluminum is available in many places, so there is no need to conserve it.
   - **d.** The environmental effects of hydroelectric dams are not related to the consumption of aluminum.

CHAPTER 18

Inquiry Lab: MODELING

Objectives

- USING SCIENTIFIC METHODS **Prepare** a detailed sketch of your solution to the design problem.
- **Design and build** a functional windmill that lifts a specific weight as quickly as possible.

Materials

blow-dryer, 1,500 W
dowel or smooth rod
foam board
glue, white
paper clips, large (30)
paper cup, small (1)
spools of thread, empty (2)
string, 50 cm

optional materials for windmill blades: **foam board, paper plates, paper cups, or any other lightweight materials**

Blowing in the Wind

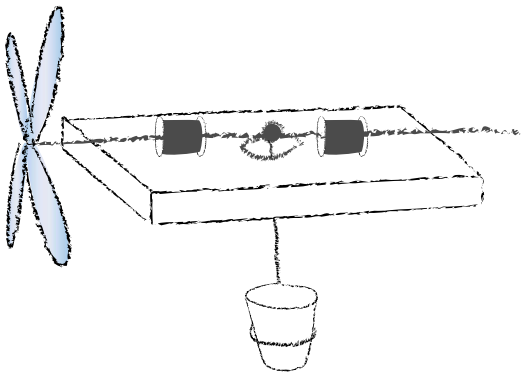
MEMO

To: Division of Research and Developers

Quixote Alternative Energy Systems is accepting design proposals to develop a windmill that can be used to lift window washers to the tops of buildings. As part of the design engineering team, your division has been asked to develop a working midel of such a windmill. Your task is to design and build a prototype of a windmill that can capture energy from a 1,500 W blow-dryer. Your model must lift 30 large paper clips a vertical distance of 50 cm (approximately 2 ft) as quickly as possible.

Procedure

1. Build the base for your windmill (shown below). Begin by attaching the two spools to the foam board using the glue. Make sure the spools are parallel before you glue them.
2. Pass a dowel or a smooth rod through the center of the spools. The dowel should rotate freely. Attach one end of the string securely to the dowel between the two spools.
3. Poke a hole through the middle of the foam board to allow the string to pass through.
4. Attach the cup to the end of the string. You will use the cup to lift the paper clips.
5. Place your windmill base between two lab tables or in any other area that will allow the string to hang freely.



▶ **Windmill Base** Your windmill base should allow the dowel to spin as freely as possible. The pinwheel shown at the end of the dowel is a suggested design for your windmill blades.

6. Prepare a sketch of your prototype windmill blades based on the objectives for this lab. Include a list of the materials that you will use and safety precautions (if necessary).
7. Have your teacher approve your design before you begin construction.
8. Construct a working prototype of your windmill blades. Test your model several times to collect data on the speed at which it lifts the paper clips. Record your data for each trial.
9. Vary the type of material used for construction of your windmill blades. Test the various blades to determine whether they improve the original plan.
10. Vary the number and size of the blades on your windmill. Test each design to determine whether the change improves the original plan.

Analysis

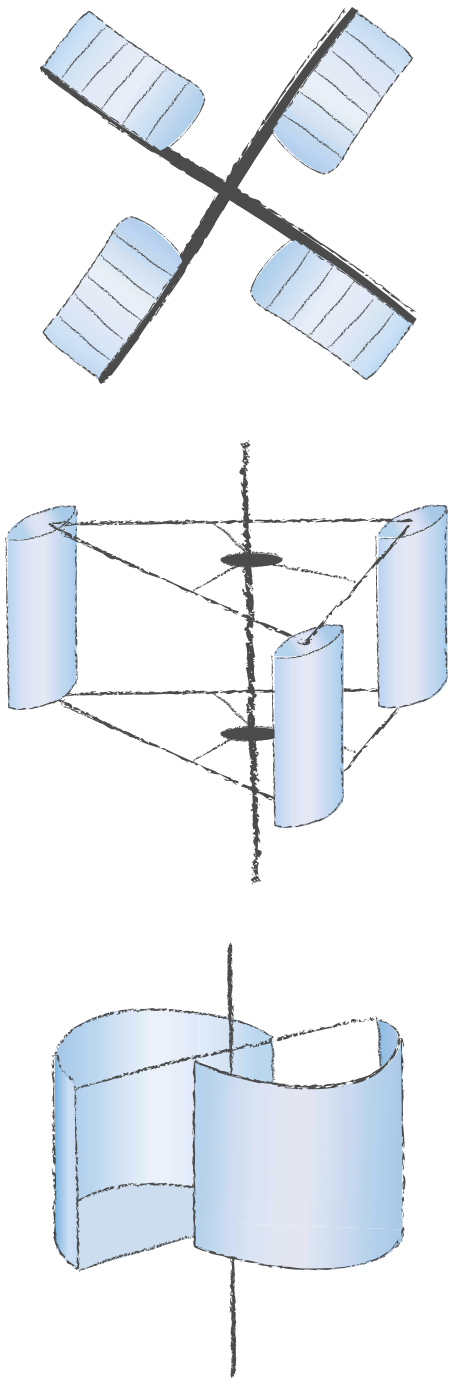
1. **Summarize Results** Create a data table that lists the speed for each lift for several trials. Include an average speed.
2. **Graphing Data** Prepare a bar graph that shows your results for each blade design.

Conclusions

3. **Evaluating Methods** After you observe all of the designs, decide which ones you think best solve the problem and explain why.
4. **Evaluating Models** Which change improved your windmill the most—varying the materials for the blades, varying the number of blades, or varying the size of the blades? Would you change your design further? If so, how?

Extension

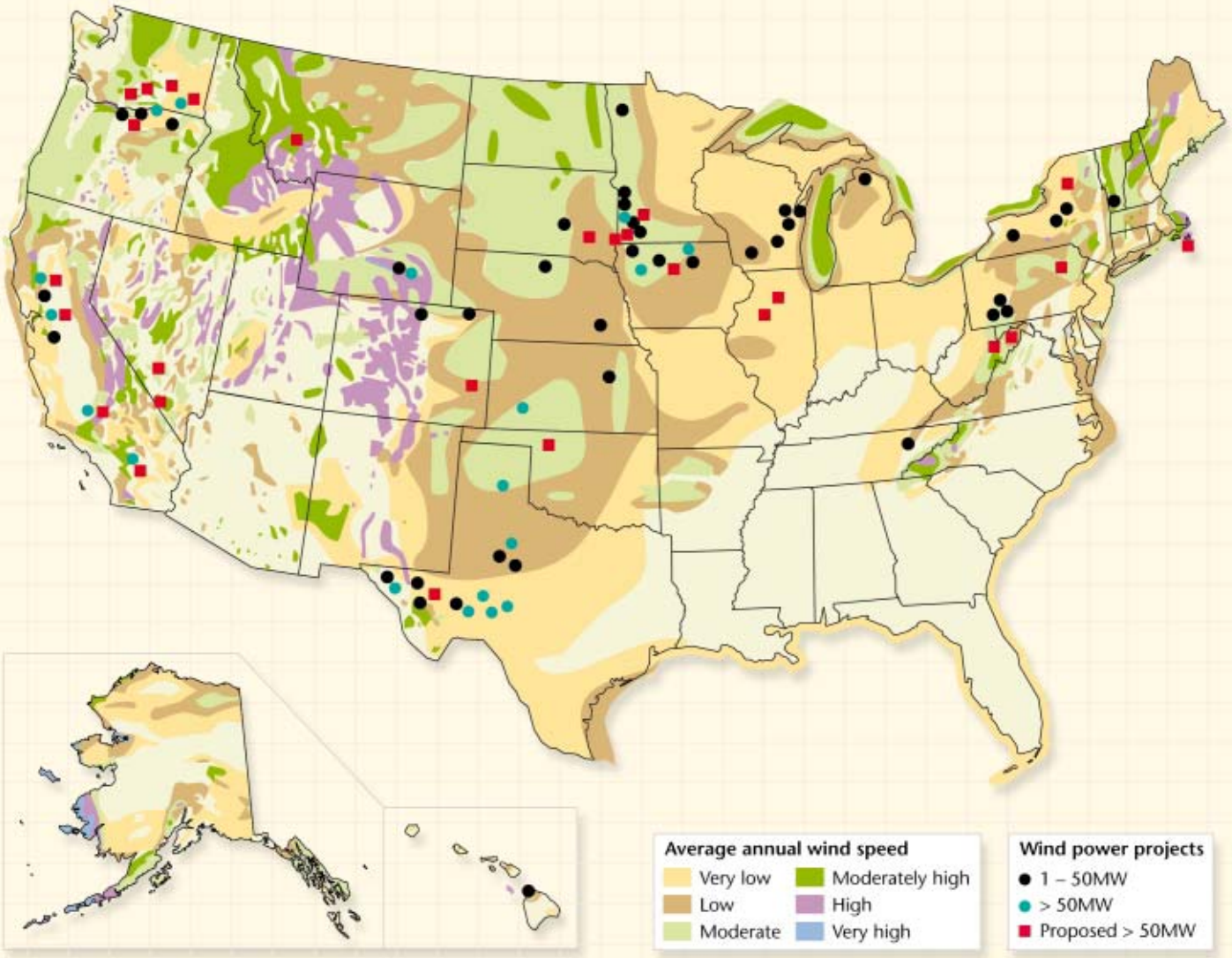
1. **Research** Windmills have been used for more than 2,000 years. Research the three basic types of vertical-axis machines and the applications in which they are used. Prepare a report of your findings.
2. **Making Models** Adapt your design to make a water wheel. You'll find that water wheels can pull much more weight than a windmill can. Find designs on the Internet for micro-hydropower water wheels such as the Pelton wheel, and use the designs as inspiration for your models. You can even design your own dam and reservoir.



▶ **Sample Windmill Blade Designs**

MAPS in action

WIND POWER IN THE UNITED STATES



Alaska and Hawaii are not drawn to scale.

Note: Locations of wind power projects are approximate.

MAP SKILLS

1. **Analyzing Data** Why are most of the wind farms located in the western and central United States and not in the eastern United States?
2. **Understanding Topography** Examine Idaho, Wyoming, Montana, and Colorado. What landscape feature might account for the strong winds in those states?
3. **Using the Key** Use the wind power key to locate where you would plan five wind power projects that are larger than 50 MW.
4. **Using the Key** The Great Plains states have been called the "Saudi Arabia of wind energy." Use the key to explain what this statement means.
5. **Finding Locations** The first offshore wind farm in the United States is proposed off the East Coast. Find where the proposed wind farm will be located, and describe the wind conditions in that area.
6. **Using the Key** Use the map to determine which state has the greatest unused potential for wind energy. Explain your reasoning.

BACK TO MUSCLE POWER AND SPRINGS

In 2001, U.S. forces dropped radios into remote parts of Afghanistan so that people could hear news broadcasts. The radios did not contain batteries, and there are few electrical outlets in rural Afghanistan. So how were people supposed to power the radios? The answer is surprisingly simple. The radios use our oldest form of energy—human muscle. Thirty seconds of cranking a handle on one of these radios stores enough energy for an hour of listening.

All Wound Up

The windup radios were invented by Trevor Bayliss in a London garden shed. They were first marketed in 1995 by Freeplay Energy. Now there are also flashlights and electric generators powered by cranks. Some people use them for boating and camping trips and for times when the power goes out. In developing countries, these devices are used in areas where there is no power supply.

These windup devices have several advantages over battery-powered devices. One main advantage is that there is no hazardous waste to dispose of in the form of used batteries. Also, batteries are heavy. Replacing batteries with longer-lasting, lighter sources of electricity has long been a goal of inventors.

The Secret Is in the Design

The first Freeplay radios worked like clockwork toys. The user would turn the handle, winding up a long spring, which then slowly unwound, releasing energy. In a newer model, cranking drives an alternator that charges a tiny battery.

How are these devices different from older clockwork devices, such as the first record players? They are much lighter and much easier to crank. The secret, says Freeplay, is enormously strong, lightweight components that survive for a long time.

An Inspiring Invention

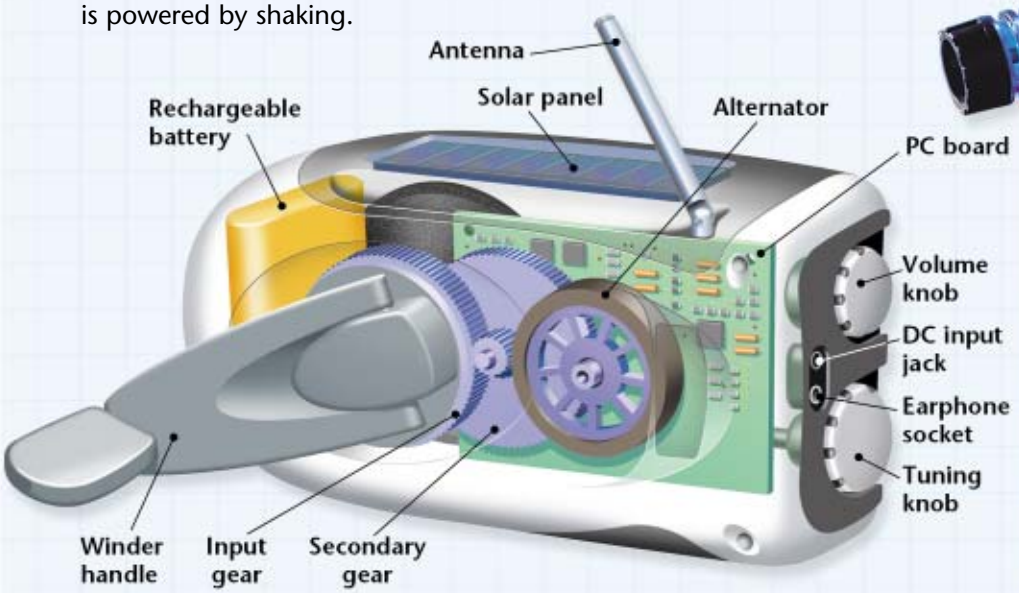
This new technology has captured the imagination of many groups with different goals. There are dozens of experiments going on all over the world. A new line of windup generators will power everything from computers and mobile phones to land-mine detectors and water purification systems.

Watchmakers have developed watches whose batteries never need to be changed. These watches are powered by movement of the wrist. Typing your term paper or playing volleyball powers your watch. Another watch is powered by the heat of your body.

A shoe company is investigating ways to charge small batteries by walking. One design contains a material that generates electricity every time your heel hits the ground.

Defense agencies are studying ways to convert mechanical energy and heat energy into electricity. The goal is to make lighter versions of equipment that has to be carried. Soldiers would no longer have to carry heavy batteries in their packs. The possible applications for these new energy technologies are almost endless.

▶ The Freeplay Radio (below) was invented in a London garden shed, and now the idea is being used all over the world. The flashlight (right) is powered by shaking.



What Do You Think?

Can you think of any other lightweight gadgets that could be powered by human muscle or body heat instead of by batteries? In what ways are the devices described here more environmentally friendly than the devices they replace?