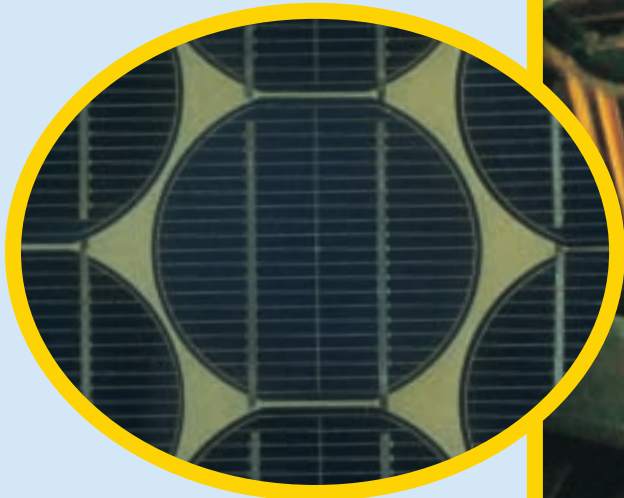


Energy Sources

It takes energy to build a car. The welding torches use energy. The robots that operate the torches require energy. The assembly line runs on energy. And the car, when it is finished, will need energy to be driven. Energy heats and cools your home, refrigerates and cooks your food, pumps your water, and turns on your lights. Where does all that energy come from? How does it get to your home? Will we ever run out of energy? In this chapter, you will learn about different energy sources, how they produce energy, and how they affect the environment.

What do you think?

Science Journal Look at the picture below with a classmate. Discuss what you think this is or what is happening. Here's a hint: *It can be used to operate a calculator.* Write your answer or best guess in your Science Journal.



EXPLORE ACTIVITY

The Sun constantly bathes our planet with enormous amounts of energy, and this energy can be captured and used to make electricity, heat homes, and provide hot water. In this activity, you will explore a way to capture the Sun's energy to heat water.

Observe solar heating

1. Use scissors to poke a small hole in the center of two coffee can lids.
2. Fill a coffee can that has been painted black with water at room temperature. Snap on the lid and push a thermometer through the hole in the lid. Record the temperature.
3. Repeat step 2 using the coffee can that has been painted white.
4. Place both cans in direct sunlight. After 15 min, record the temperature of the water in both cans again.



Observe

Write a paragraph in your Science Journal explaining why the temperature change differed between the two cans.

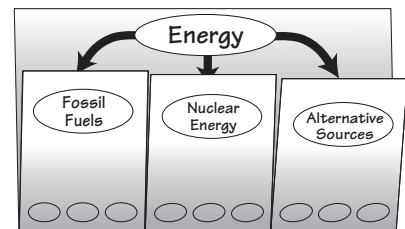
FOLDABLES Reading & Study Skills



Before You Read

Making a Concept Map Study Fold Make the following Foldable to help you organize information by diagramming ideas about energy sources.

1. Place a sheet of paper in front of you so the long side is at the top. Fold the bottom of the paper up, stopping about four centimeters from the top.
2. Draw an oval above the fold. Write *Energy* in the oval.
3. Fold both sides in. Unfold. Through the top thickness of the paper, cut along each of the fold lines to form three tabs. Draw an oval on each tab and draw arrows from the large oval to the smaller ovals.
4. Write *Fossil Fuels*, *Nuclear Energy*, and *Alternative Sources* in the ovals. Draw three smaller ovals at the bottom of each tab, but don't write in them yet.
5. As you read the chapter, write about each source of energy under the tabs.



Fossil Fuels

As You Read

What You'll Learn

- **Discuss** properties and uses of the three main types of fossil fuels.
- **Explain** how fossil fuels are formed.
- **Describe** how the chemical energy in fossil fuels is converted into electrical energy.

Vocabulary

fossil fuels
petroleum
nonrenewable resource

Why It's Important

Fossil fuels are widely used to generate electricity.

Using Energy

How many different ways have you used energy today? You can see energy being used in many ways, throughout the day, such as those shown in **Figure 1**. Furnaces and stoves use thermal energy to heat buildings and cook food. Air conditioners use electrical energy to move thermal energy outdoors. Cars and other vehicles use mechanical energy to carry people and materials from one part of the country to another.

Transforming Energy According to the law of conservation of energy, energy cannot be created or destroyed. Energy can only be transformed, or converted, from one form to another. To use energy means to transform one form of energy to another form of energy that can perform a useful function. For example, energy is used when the chemical energy in fuels is transformed into thermal energy that is used to heat your home.

Sometimes energy is transformed into a form that isn't useful. For example, when an electric current flows through power lines, about 10 percent of the electrical energy is changed to thermal energy. This reduces the amount of useful electrical energy that is delivered to homes, schools, and businesses.

Figure 1
Energy is used in many ways.



A A steel plant uses energy to make steel products.



B Automobiles burn gasoline to provide energy.



C Power lines like these carry the electrical energy you use every day.

Energy Use in the United States

More energy is used in the United States than in any other country in the world.

Figure 2A shows how energy is used in the United States. About 20 percent of the energy is used in homes for heating and cooling, to run appliances, and to provide lighting and hot water. About 27 percent is used for transportation to power vehicles such as cars, trucks, and aircraft. Another 16 percent is used by businesses to heat, cool, and light stores, shops, and office buildings. Finally, about 37 percent of this energy is used by industry and agriculture to manufacture products and produce food.

Figure 2B shows the main sources of the energy used in the United States. Almost 85 percent of the energy used in the United States comes from burning petroleum, natural gas, and coal. Nuclear power plants provide about eight percent of the energy used in the United States.

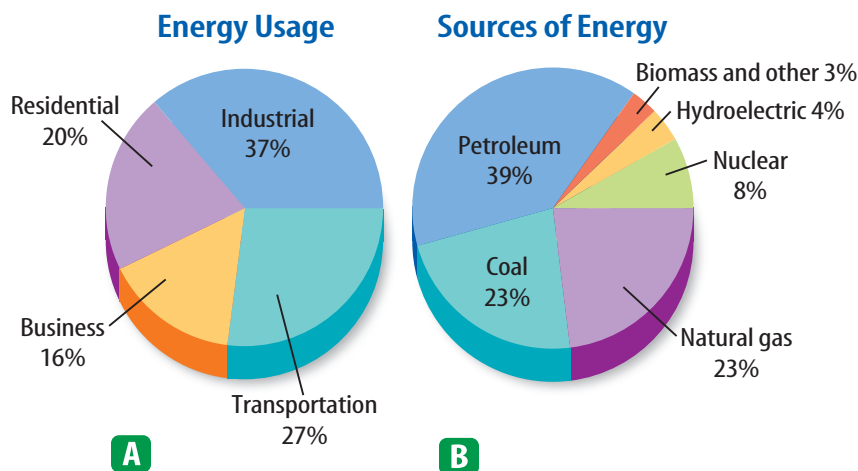


Figure 2

A This circle graph shows the percentages of energy in the United States used by homes, businesses, transportation and industry. **B** This circle graph shows the sources of the energy used in the United States.

Making Fossil Fuels

In one hour of freeway driving a car might use several gallons of gasoline. It may be hard to believe that it took millions of years to make the fuels that are used to produce electricity, provide heat, and transport people and materials. **Figure 4** on the next page shows how coal, petroleum, and natural gas are formed by the decay of ancient plants and animals. Fuels such as petroleum, or oil, natural gas, and coal are called **fossil fuels** because they are formed from the decaying remains of ancient plants and animals.

Concentrated Energy Sources When fossil fuels are burned, carbon and hydrogen atoms combine with oxygen molecules in the air to form carbon dioxide and water molecules. This process converts the chemical energy that is stored in the chemical bonds between atoms to heat and light. Compared to other fuels such as wood, the chemical energy that is stored in fossil fuels is more concentrated. For example, burning 1kg of coal releases two to three times as much energy as burning 1 kg of wood. **Figure 3** shows the amount of energy that is produced by burning different fossil fuels.

Figure 3

The bar graph shows the amount of energy released by burning one gram of four different fuels.

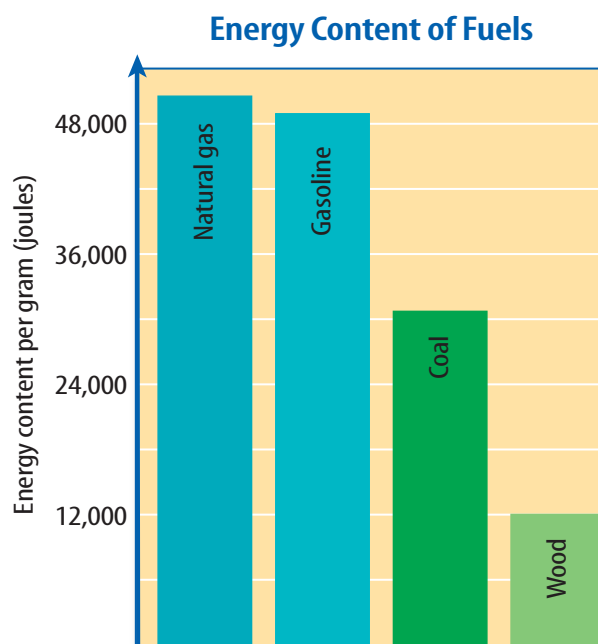
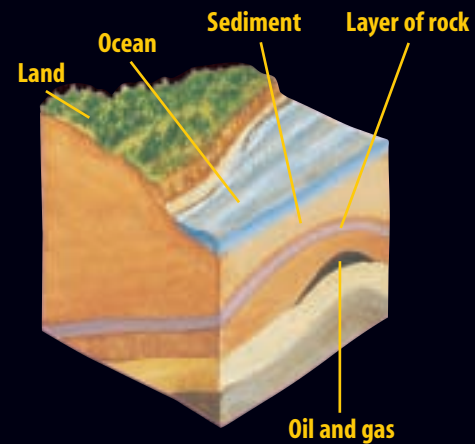
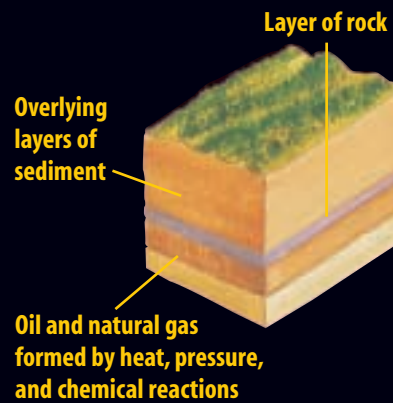
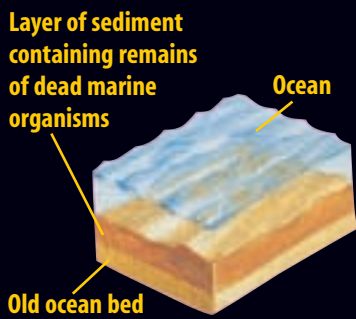


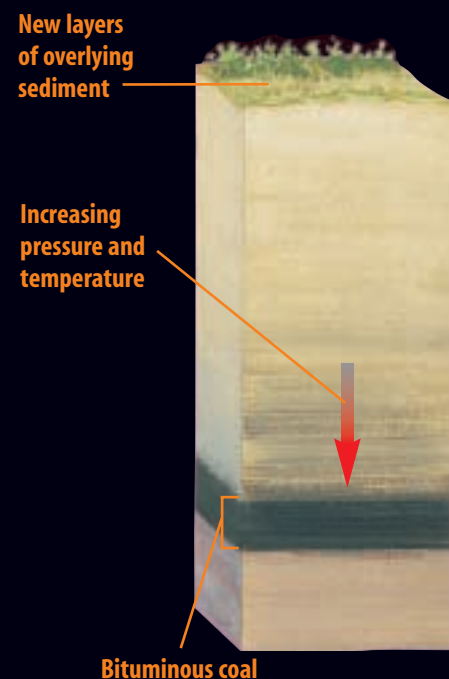
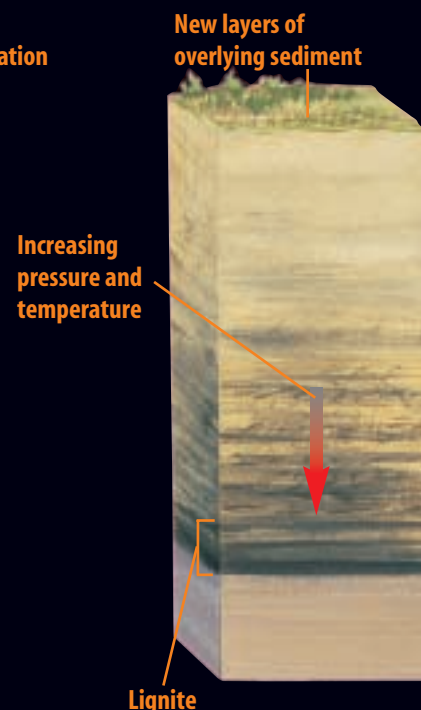
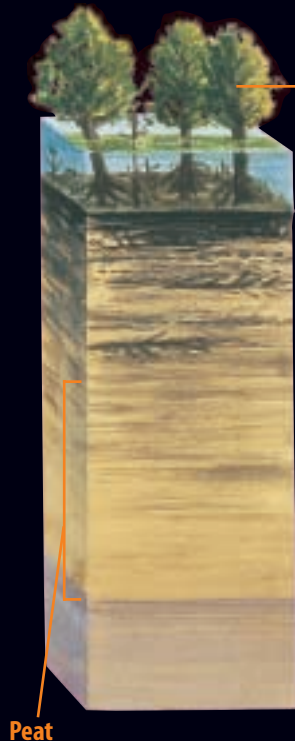
Figure 4

Oil and natural gas form when organic matter on the ocean floor, gradually buried under additional layers of sediment, is chemically changed by heat and crushing pressure. The oil and gas may bubble to the surface or become trapped beneath a dense rock layer. Coal forms when peat—partially decomposed vegetation—is compressed by overlying sediments and transformed first into lignite (soft brown coal) and then into harder, bituminous (buh TYEW muh nus) coal. These two processes are shown below.

HOW OIL AND NATURAL GAS ARE FORMED



HOW COAL IS FORMED



Petroleum

Millions of gallons of petroleum, or crude oil, are pumped every day from wells deep in Earth's crust. **Petroleum** is a highly flammable liquid formed by decayed ancient organisms, such as microscopic plankton and algae. Petroleum is a mixture of thousands of chemical compounds. Most of these compounds are hydrocarbons, which means they contain only carbon and hydrogen.

Separating Hydrocarbons The different hydrocarbon molecules found in petroleum have different numbers and arrangements of carbon and hydrogen atoms. The composition and structure of hydrocarbons determines their properties.

The many different compounds that are found in petroleum are separated in a process called fractional distillation. This separation occurs in the tall towers of oil-refinery plants. First, crude oil is pumped into the bottom of the tower and heated. The chemical compounds in the crude oil boil and vaporize according to their individual boiling points. Materials with the lowest boiling points rise to the top of the tower as vapor and are collected. Hydrocarbons with high boiling points, such as asphalt and some types of waxes, remain liquid and are drained off through the bottom of the tower.

 **Reading Check** *What is fractional distillation used for?*

Other Uses for Petroleum Not all of the products obtained from petroleum are burned to produce energy. About 15 percent of the petroleum-based substances that are used in the United States go toward nonfuel uses. Look around at the materials in your home or classroom. Do you see any plastics? In addition to fuels, plastics and synthetic fabrics are made from the hydrocarbons found in crude petroleum. Also, lubricants such as grease and motor oil, as well as the asphalt used in surfacing roads, are obtained from petroleum. Some synthetic materials produced from petroleum are shown in **Figure 5**.

Figure 5
The objects shown here are made from chemical compounds found in petroleum.



Mini LAB

Designing an Efficient Water Heater

Procedure   

1. Measure and record the mass of a **candle**.
2. Measure 50 mL of **water** into a **beaker**. Record the temperature of the water.
3. Use the lighted candle to increase the temperature of the water by 10°C. Put out the candle and measure its mass again.
4. Repeat steps 1 to 3 with an **aluminum chimney** surrounding the candle to help direct the heat upward.

Analysis

1. Compare the mass change in the two trials. Does a smaller or larger mass change in the candle show greater efficiency?
2. Gas burners are used to heat hot-water tanks. What must be considered in the design of these heaters?



Figure 6
Coal mines usually are located deep underground.

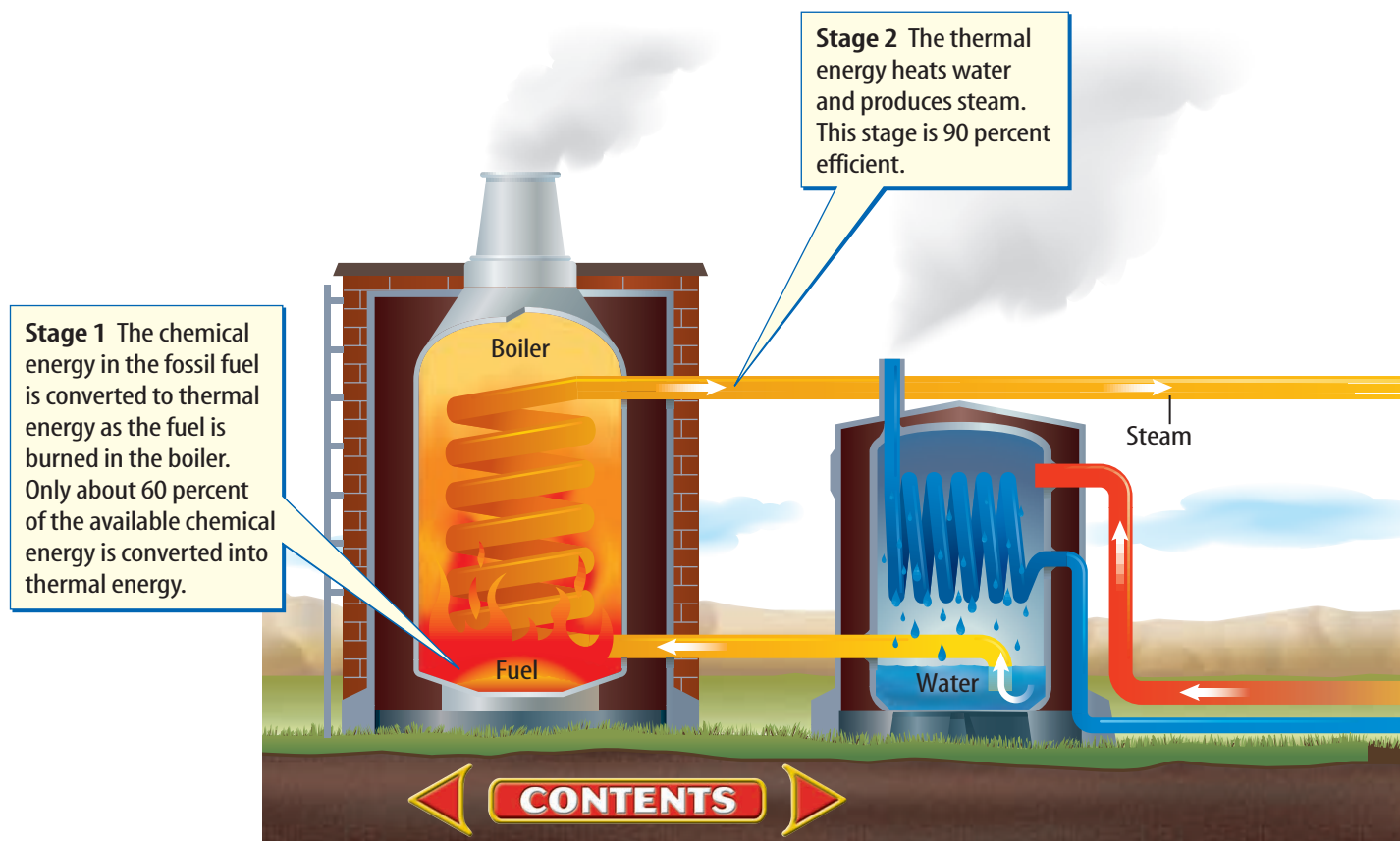
Natural Gas

The chemical processes that produce petroleum as ancient organisms decay also produce gaseous compounds called natural gas. These compounds rise to the top of the petroleum deposit and are trapped there. Natural gas is composed mostly of methane, CH_4 , but it also contains other hydrocarbon gases such as propane, C_3H_8 , and butane, C_4H_{10} . Natural gas is burned to provide energy for cooking, heating, and manufacturing. About one fourth of the energy consumed in the United States comes from burning natural gas. There's a good chance that your home has a stove, furnace, hot-water heater, or clothes drier that uses natural gas.

Natural gas contains more energy per kilogram than petroleum or coal does. It also burns more cleanly than other fossil fuels, produces fewer pollutants, and leaves no residue such as ash.

Coal

Coal is a solid fossil fuel that is found in mines underground, such as the one shown in **Figure 6**. In the first half of the twentieth century, most houses in the United States were heated by burning coal. In fact, during this time, coal provided more than half of the energy that is used in the United States. Now almost two thirds of the energy used comes from petroleum and natural gas, and only about one fourth comes from coal. About 90 percent of all the coal that is used in the United States is burned by power plants to generate electricity.



Origin of Coal Coal mines were once the site of ancient swamps where large, fernlike plants grew. Coal formed from this plant material. Worldwide, the amount of coal that is potentially available is estimated to be 20 to 40 times greater than the supply of petroleum.

Coal also is a complex mixture of hydrocarbons and other chemical compounds. Compared to petroleum and natural gas, coal contains more impurities, such as sulfur. As a result, more pollutants, such as sulfur dioxide, are produced when coal is burned.

Generating Electricity

Figure 7 shows that almost 70 percent of the electrical energy used in the United States is produced by burning fossil fuels. How is the chemical energy contained in fossil fuels converted to electrical energy in an electric power station?

The process is shown in **Figure 8**. In the first stage, fuel is burned in a boiler or combustion chamber, and it releases thermal energy. In the second stage, this thermal energy heats water and produces steam under high pressure. In the third stage, the steam strikes the blades of a turbine, causing it to spin. The shaft of the turbine is connected to an electric generator. In the fourth stage, electric current is produced when the spinning turbine shaft rotates magnets inside the generator. In the final stage, the electric current is transmitted to homes, schools, and businesses through power lines.

Sources of Electricity

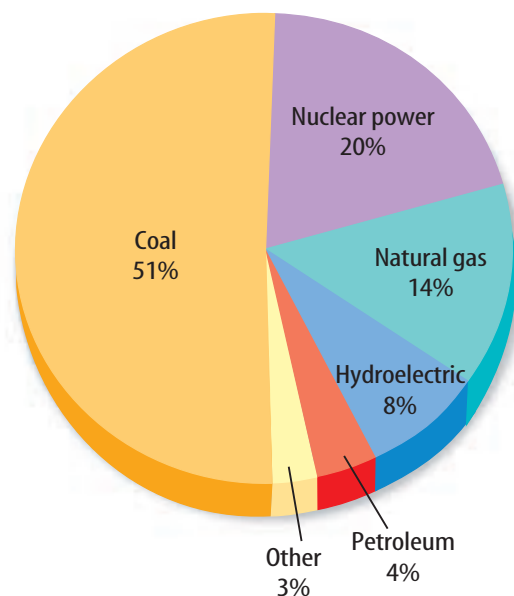


Figure 7
This circle graph shows the percentage of electricity generated in the United States that comes from various energy sources.

Figure 8
Fossil fuels are burned to generate electricity in a power plant.

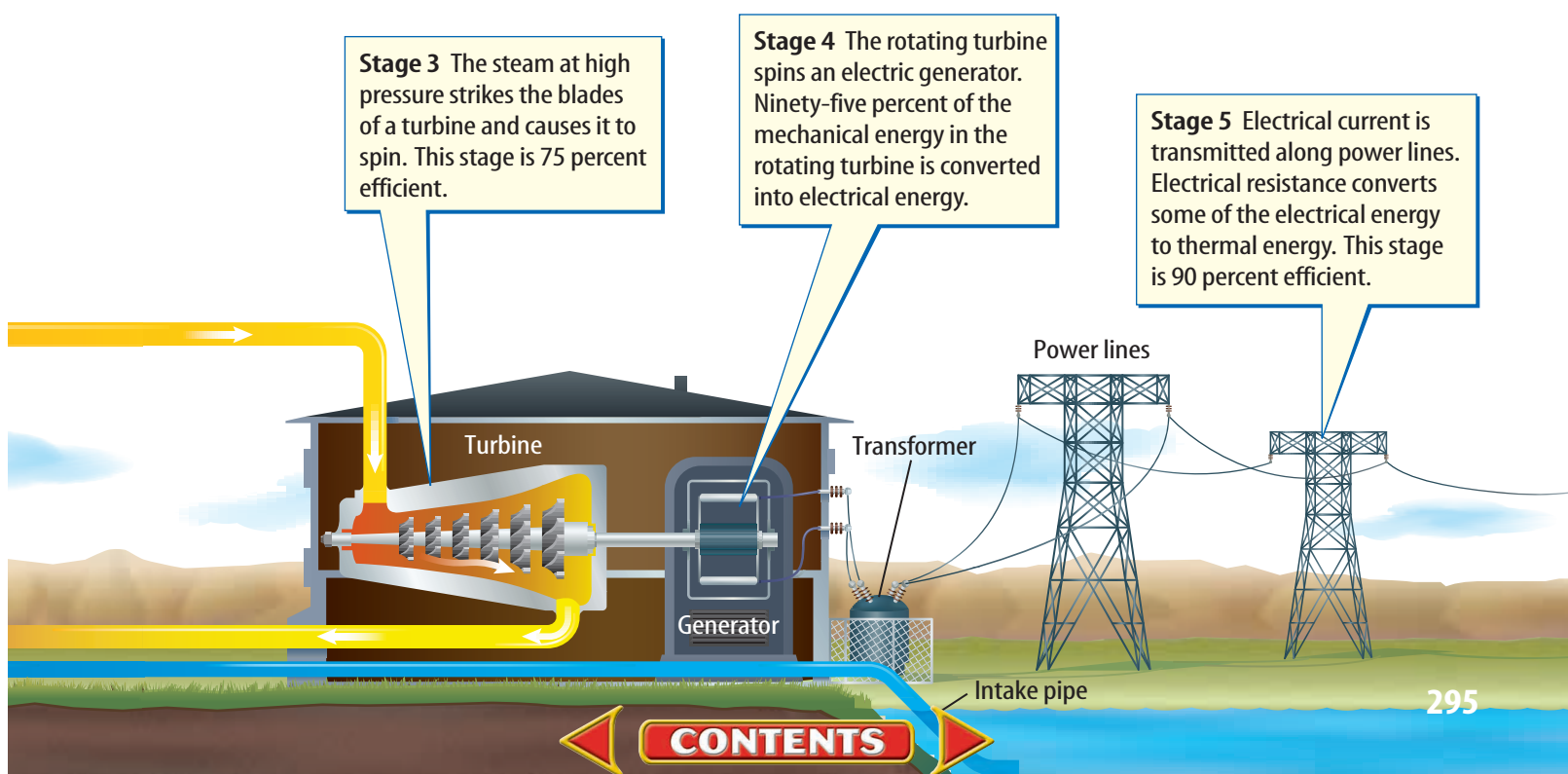


Table 1 Efficiency of Fossil Fuel Conversion

Process	Efficiency (%)
Chemical to thermal energy	60
Conversion of water to steam	90
Steam-turning turbine	75
Turbine spins electric generator	95
Transmission through power lines	90
Overall efficiency	35

Efficiency of Power Plants

When fossil fuels are burned to produce electricity, not all the chemical energy in the fuel is converted to electrical energy. Energy is lost in every stage of the process. No stage is 100 percent efficient.

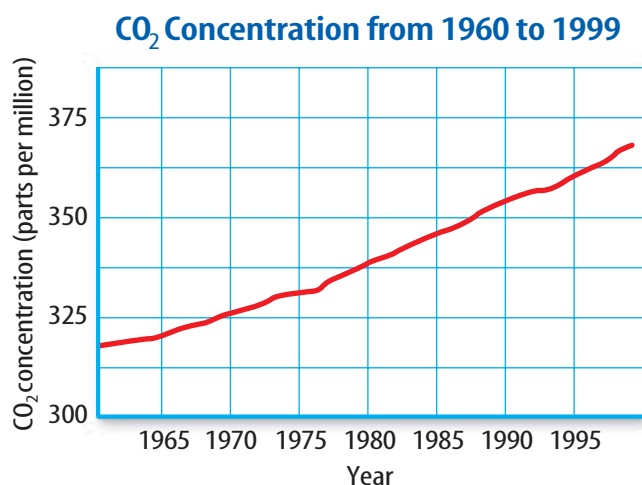
The overall efficiency of the entire process is given by multiplying the efficiencies of each stage of the process shown in **Table 1**. If you were to do this, you'd find that the resulting overall efficiency is only about 35

percent. This means that only about 35 percent of the energy contained in the fossil fuels is delivered to homes, schools, and businesses as electrical energy. The other 65 percent is lost as the chemical energy in the fuel is transformed into electrical energy and delivered to energy users.

The Costs of Using Fossil Fuels

Although fossil fuels are a useful source of energy for generating electricity and providing the power for transportation, their use has some undesirable side effects. When petroleum products and coal are burned, smoke is given off that contains small particles called particulates. These particulates cause breathing problems for some people. Burning fossil fuels also releases carbon dioxide. **Figure 9** shows how the carbon dioxide concentration in the atmosphere has increased from 1960 to 1999. The increased concentration of carbon dioxide in the atmosphere might cause Earth's surface temperature to increase.

Figure 9
The carbon dioxide concentration in Earth's atmosphere has been measured at Mauna Loa in Hawaii. From 1960 to 1999, the carbon dioxide concentration has increased by about 16 percent.



Using Coal The most abundant fossil fuel is coal, but coal contains even more impurities than oil or natural gas. Many electric power plants that burn coal remove some of these pollutants before they are released into the atmosphere. Removing sulfur dioxide, for example, helps to prevent the formation of compounds that might cause acid rain. Mining coal also can be dangerous. Miners risk being killed or injured, and some suffer from lung diseases caused by breathing coal dust over long periods of time.

Nonrenewable Resources

It's a safe bet that almost any time you use an electrical appliance or ride in a car, some type of fossil fuel is the energy source that is being used. All fossil fuels are **nonrenewable resources**, which means they are resources that cannot be replaced by natural processes as quickly as they are used. Therefore, fossil fuel reserves are decreasing as population and industrial demands are increasing. **Figure 10** shows how the production of oil might decline over the next 50 years as oil reserves are used up. As the production of energy from fossil fuels continues, the remaining reserves of fuel will decrease. Fossil fuels will become more difficult to obtain, causing them to become more costly in the future.

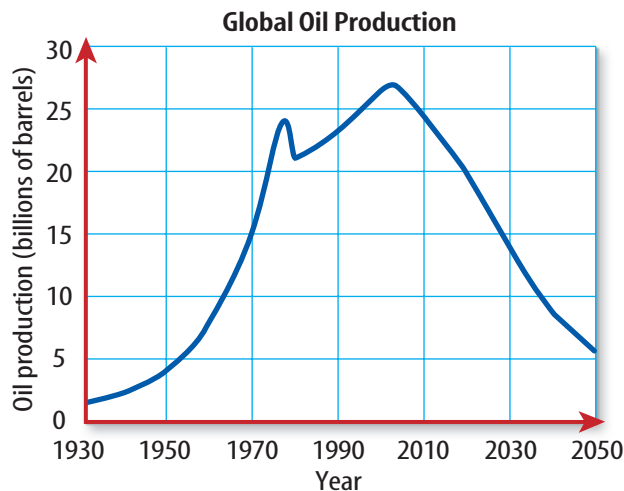


Figure 10
Some predictions show that worldwide oil production will peak by 2005 and then decline rapidly over the following 50 years.

Conserving Fossil Fuels

Even as reserves of fossil fuels decrease and they become more costly, the demand for energy continues to increase as the world's population increases. To meet these energy demands, the use of fossil fuels must be reduced and energy must be obtained from other sources. One way to reduce the use of fossil fuels is to make vehicles that are more fuel efficient. You can help reduce the demand for energy by not wasting energy in your daily activities.

✓ Reading Check

Why is it important to conserve nonrenewable resources?

Section 1 Assessment

1. Describe the three main forms of fossil fuels.
2. What are the advantages and disadvantages of using coal to generate electricity?
3. How are the different chemicals in crude oil separated?
4. Give three examples of different products derived from chemicals in crude oil.
5. **Think Critically** If fossil fuels are still forming, why are they considered to be nonrenewable resources?

Skill Builder Activities

6. **Comparing and Contrasting** Compare and contrast the different fossil fuels. Include the advantages and disadvantages of using each as a source of energy. **For more help, refer to the Science Skill Handbook.**
7. **Communicating** In your Science Journal, make a list of areas in your school where energy use could be reduced. **For more help, refer to the Science Skill Handbook.**

Nuclear Energy

As You Read

What You'll Learn

- **Outline** the steps in the operation of a nuclear reactor.
- **Compare** the advantages and disadvantages of using nuclear energy to produce electricity.
- **Discuss** nuclear fusion as a possible energy source.

Vocabulary

nuclear reactor
nuclear waste

Why It's Important

Nuclear energy can help reduce the use of fossil fuels, but its use may cause environmental problems.

Using Nuclear Energy

Over the past several decades, electric power plants have been developed that generate electricity without burning fossil fuels. Some of these power plants, such as the one shown in **Figure 11**, convert nuclear energy to electrical energy. Energy is released when the nucleus of an atom breaks apart. In this process, called nuclear fission, an extremely small amount of mass is converted into an enormous amount of energy. Today almost 20 percent of all the electricity produced in the United States comes from nuclear power plants. Overall, nuclear power plants produce about eight percent of all the energy consumed in the United States. Currently, there are more than 100 nuclear power plants in the United States, with 6 more under construction.

Nuclear Reactors

A **nuclear reactor** uses the energy from controlled nuclear reactions to generate electricity. Although nuclear reactors vary in design, all have some parts in common, as shown in **Figure 12**. They contain a fuel that can be made to undergo nuclear fission; they contain control rods that are used to control the nuclear reactions; and they have a cooling system that keeps the reactor from being damaged by the heat produced. The actual fission of the radioactive fuel occurs in a relatively small part of the reactor known as the core.

Figure 11

A nuclear power plant generates electricity using the energy released in nuclear fission. The dome in the center of the photo contains the reactor core. A cooling tower is on the left.



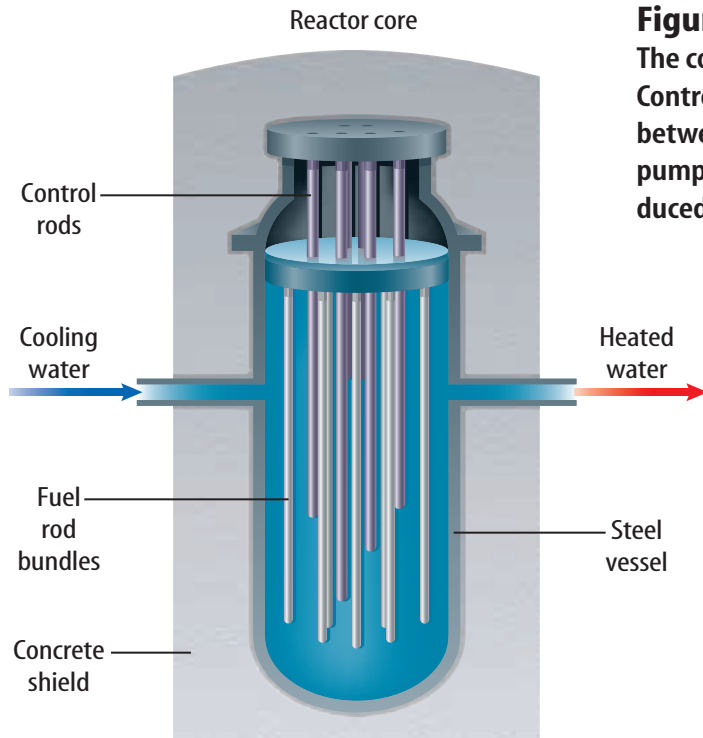


Figure 12

The core of a nuclear reactor contains the fuel rods. Control rods that absorb neutrons are inserted between the fuel rods. Water or another coolant is pumped through the core to remove the heat produced by the fission reaction.

Nuclear Fuel Only certain elements have nuclei that can undergo fission. Naturally occurring uranium contains an isotope, U-235, whose nucleus can split apart. As a result, the fuel that is used in a nuclear reactor is usually uranium dioxide. Naturally occurring uranium contains only about 0.7 percent of the U-235 isotope. In a reactor, the uranium usually is enriched so that it contains three percent to five percent U-235.

Figure 13

Nuclear fuel pellets are stacked together to form fuel rods. The fuel rods are bundled together, and the bundle is covered with a metal alloy.

The Reactor Core The reactor core contains uranium dioxide fuel in the form of tiny pellets like the ones in **Figure 13**. The pellets are about the size of a pencil eraser and are placed end to end in a tube. The tubes are then bundled and covered with a metal alloy, as shown in **Figure 13**. The core of a typical reactor contains about a hundred thousand kilograms of uranium in hundreds of fuel rods. For every kilogram of uranium that undergoes fission in the core, 1 g of matter is converted into energy. The energy released by this gram of matter is equivalent to the energy released by burning more than 3 million kg of coal.

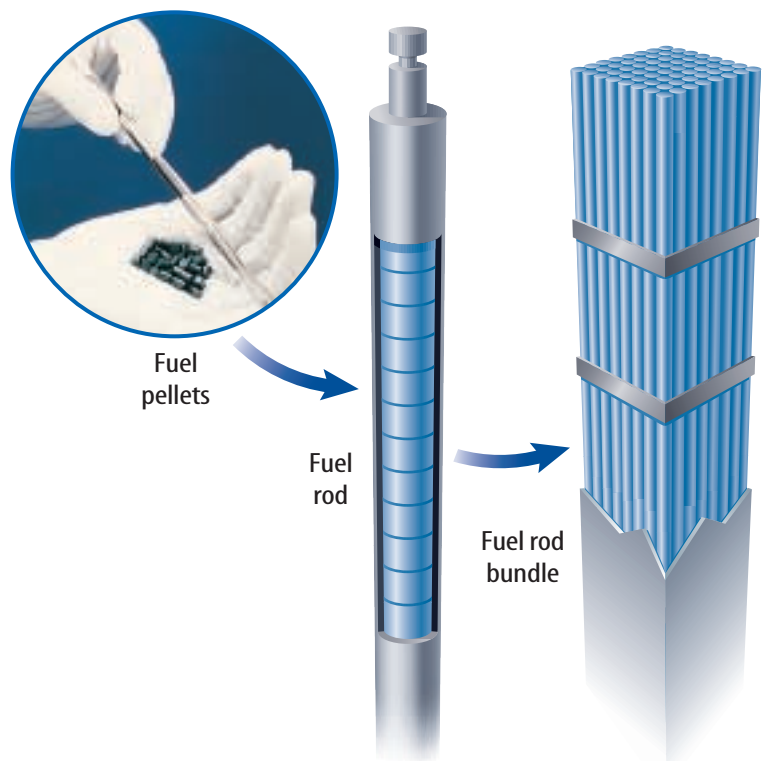
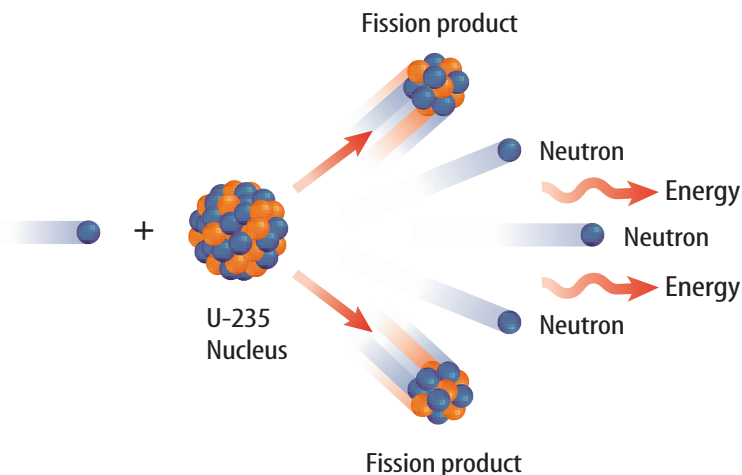


Figure 14

When a neutron strikes the nucleus of a U-235 atom, the nucleus splits apart into two smaller nuclei. In the process two or three neutrons also are emitted. The smaller nuclei are called fission products.



Nuclear Fission How does the nuclear reaction proceed in the reactor core? Neutrons that are produced by the decay of U-235 nuclei are absorbed by other U-235 nuclei. When a U-235 nucleus absorbs a neutron, it splits into two smaller nuclei and two or three additional neutrons, as shown in **Figure 14**. These neutrons strike other U-235 nuclei, causing them to release two or three more neutrons each when they split apart.

Because every uranium atom that splits apart releases neutrons that cause other uranium atoms to split apart, this process is called a nuclear chain reaction. In the chain reaction involving the fission of uranium nuclei, the number of nuclei that are split can more than double at each stage of the process. As a result, an enormous number of nuclei can be split after only a small number of stages. For example, if the number of nuclei involved doubles at each stage, after only 50 stages more than a quadrillion nuclei might be split.

Nuclear chain reactions take place in a matter of milliseconds. If the process isn't controlled, the chain reaction will release an ever-increasing amount of energy each millisecond, rather than releasing energy at a constant rate.

 **Reading Check** *What is a nuclear chain reaction?*

Controlling the Chain Reaction To control the chain reaction, some of the neutrons that are released when U-235 splits apart must be prevented from striking other U-235 nuclei. These neutrons are absorbed by rods containing boron or cadmium that are inserted into the reactor core. Moving these control rods deeper into the reactor allows them to absorb more neutrons and slow down the chain reaction. Eventually, only one neutron per fission reacts with a U-235 atom to produce another fission, and energy is released at a constant rate.



Life Science

INTEGRATION

Nuclear reactions can be harmful if they aren't carefully controlled. An accident at the Chernobyl nuclear power plant in the Ukraine in 1986 caused radiation sickness in many people and a worldwide concern about nuclear power. Research how the nuclear power industry has attempted to reduce concern about nuclear power. What type of promotional material exists for nuclear power?

Nuclear Power Plants

Nuclear fission reactors produce electricity in much the same way that conventional power plants do. **Figure 15** shows how a nuclear reactor produces electricity. The thermal energy released in nuclear fission is used to heat water and produce steam. This steam then is used to drive a turbine that rotates an electric generator. To transfer thermal energy from the reactor core to heat water and produce steam, the core is immersed in a fluid coolant. The coolant absorbs heat from the core and is pumped through a heat exchanger. There thermal energy is transferred from the coolant and boils water to produce steam. The overall efficiency of nuclear power plants is about 35 percent, similar to that of fossil fuel power plants.

The Risks of Nuclear Power

Producing energy from nuclear fission has some environmental advantages over burning fossil fuels. Nuclear power plants do not produce the air pollutants that are released by fossil-fuel burning power plants. Also, nuclear power plants don't produce carbon dioxide.

The nuclear generation of electricity, however, has its problems. The mining of the uranium can cause environmental damage. Water that is used as a coolant in the reactor core must cool before it is released into streams and rivers. Otherwise, the excess heat could harm fish and other animals and plants in the water.

Earth Science INTEGRATION

Uranium is used to determine the age of rocks in which it occurs. As uranium decays into lead at a constant rate, the age of a rock can be found by comparing the amount of uranium to the amount of lead produced. Uranium-lead dating is used by scientists to date rocks as old as 4.6 billion years. Research other methods used to determine the age of rocks.

Figure 15
A nuclear power plant uses the heat produced by nuclear fission in its core to produce steam. The steam turns an electric generator.

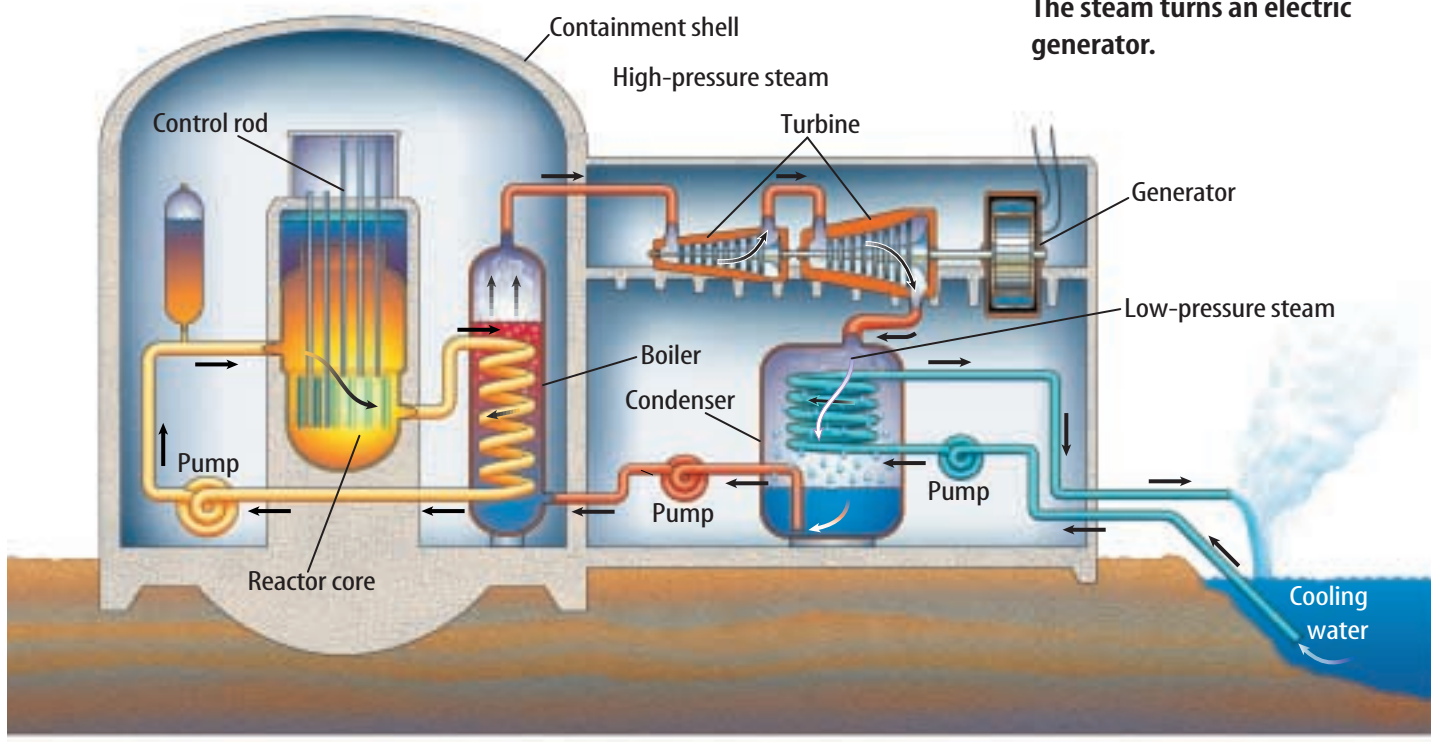




Figure 16
An explosion occurred at the Chernobyl reactor in the Ukraine after graphite control rods caught fire. The explosion shattered the reactor's roof.

The Release of Radioactivity

One of the most serious risks of nuclear power is the escape of harmful radiation from power plants. The fuel rods contain radioactive elements with various half-lives. Some of these elements could cause damage to living organisms if they were released from the reactor core. Nuclear reactors have elaborate systems of safeguards, strict safety precautions, and highly trained workers in order to prevent accidents. In spite of this, accidents have occurred.

For example, in 1986 in Chernobyl, Ukraine, an accident occurred when a reactor core overheated during a safety test. Materials in the core caught fire and

caused a chemical explosion that blew a hole in the reactor, as shown in **Figure 16**. This resulted in the release of radioactive materials that were carried by winds and deposited over a large area. As a result of the accident, 28 people died of acute radiation sickness. It is possible that 260,000 people might have been exposed to levels of radiation that could affect their health.

In the United States, power plants are designed to prevent accidents such as the one that occurred at Chernobyl. But many people still are concerned that similar accidents are possible.

The Disposal of Nuclear Waste

After about three years, not enough fissionable U-235 is left in the fuel pellets in the reactor core to sustain the chain reaction. The spent fuel contains radioactive fission products in addition to the remaining uranium. **Nuclear waste** is any radioactive by-product that results when radioactive materials are used.

Low-Level Waste Low-level nuclear wastes usually contain a small amount of radioactive material. They usually do not contain radioactive materials with long half-lives. Products of some medical and industrial processes are low-level wastes, including items of clothing used in handling radioactive materials. Low-level wastes also include used air filters from nuclear power plants and discarded smoke detectors. Low-level wastes usually are sealed in containers and buried in trenches 30 m deep at special locations. When dilute enough, low-level waste sometimes is released into the air or water.

SCIENCE Online



Research Visit the Glencoe Science Web site at science.glencoe.com for a link to more information about storing nuclear wastes. Communicate to your class what you learn.

CLICK HERE

High-Level Waste High-level nuclear waste is generated in nuclear power plants and by nuclear weapons programs. After spent fuel is removed from a reactor, it is stored in a deep pool of water, as shown in **Figure 17**. Many of the radioactive materials in high-level nuclear waste have short half-lives. However, the spent fuel also contains materials that will remain radioactive for tens of thousands of years. For this reason, the waste must be disposed of in extremely durable and stable containers.



Figure 17

Spent nuclear fuel rods are radioactive and are placed underwater after they are removed from the reactor core. The water absorbs the nuclear radiation and prevents it from escaping into the environment.

✓ Reading Check

What is the difference between low-level and high-level nuclear wastes?

One method proposed for the disposal of high-level waste is to seal the waste in ceramic glass, which is placed in protective metal-alloy containers. The containers then are buried hundreds of meters below ground in stable rock formations or salt deposits. It is hoped that this will keep the material from contaminating the environment for thousands of years.

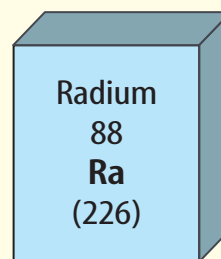
Problem-Solving Activity

Can a contaminated radioactive site be reclaimed?

In the early 1900s with the discovery of radium, extensive mining for the element began in the Denver, Colorado, area. Radium is a radioactive element that was used to make watch dials and instrument panels that glowed in the dark. After World War I, the radium industry collapsed. The area was left contaminated with 97,000 tons of radioactive soil and debris containing heavy metals and radium, which is now known to cause cancer. The soil was used as fill, foundation material, left in place, or mishandled.

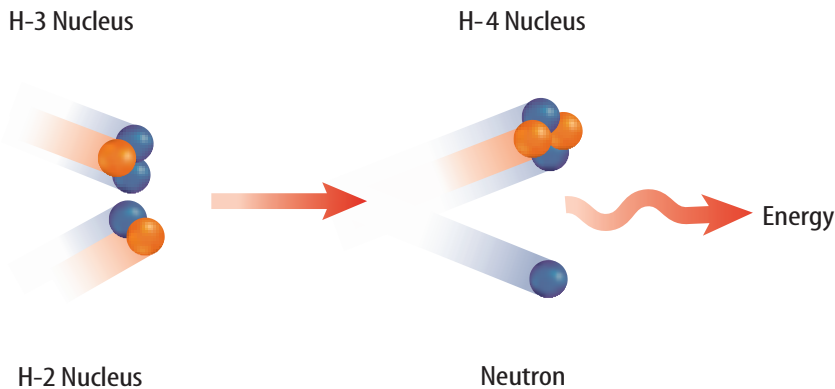
Identifying the Problem

In the 1980s one area became known as the Denver Radium Superfund Site and was cleaned up by the Environmental Protection Agency. The land then was reclaimed by a local commercial establishment.



Solving the Problem

1. The contaminated soil was placed in one area and a protective cap was placed over it. This area also was restricted from being used for residential homes. Explain why it is important for the protective cap to be maintained and why homes could not be built in this area.
2. The advantages of cleaning up this site are economical, environmental, and social. Give an example of each.



Nuclear Fusion

Imagine the amount of energy the Sun must give off to heat Earth from 150 million kilometers away. It gets this energy from thermonuclear fusion. Thermonuclear fusion is the joining together of small nuclei at high temperatures, as shown in **Figure 18**. In this

Figure 18

In nuclear fusion, two smaller nuclei join together to form a larger nucleus. Energy is released in the process. In the reaction shown here, two isotopes of hydrogen come together to form a helium nucleus.

process, a small amount of mass is converted into energy. Fusion is the most concentrated energy source known.

An advantage of producing energy from fusion is that the fuel it uses, hydrogen, is the most abundant element in the universe. Hydrogen can be obtained from water in the oceans in practically limitless amounts. Another advantage is that the fusion reaction produces helium gas, which is not radioactive and is chemically nonreactive.

However, fusion reactions occur only at temperatures of millions of degrees Celsius. The biggest challenge lies in creating and maintaining the high temperatures fusion requires. To do this requires enormous amounts of energy in order to start the fusion reaction. Because of these and other problems, the use of fusion as an energy source remains in the future.

Section 2 Assessment

1. How is the rate of fission controlled in a nuclear reactor?
2. Explain the major obstacles in controlling nuclear fusion.
3. What types of environmental hazards do nuclear reactors produce?
4. In what way are nuclear power plants similar to those that burn fossil fuels?
5. **Think Critically** In a research project, a scientist has generated a 10-g sample of nuclear waste. The materials have a short half-life and are not present in a significant amount. How would you classify this waste, and how will it likely be disposed of?

Skill Builder Activities

6. **Concept Mapping** Using a computer, design an events-chain concept map for the generation of electricity in a nuclear fission reactor. Begin with the bombarding neutron and end with electricity in overhead lines. **For more help, refer to the Science Skill Handbook.**
7. **Using a Word Processor** Use a word processor to create a table with two divisions for the advantages and disadvantages of nuclear power. Type as many entries under each as you can. Do you think nuclear power is or isn't a good idea? Explain. **For more help, refer to the Technology Skill Handbook.**

Renewable Energy Sources

Energy Options

The demand for energy increases continually, but supplies of fossil fuels are decreasing. Using more nuclear reactors to produce electricity will produce more high-level nuclear waste that has to be disposed of safely. As a result, sources of energy that can meet Earth's increasing demands and not damage the environment are being developed. A number of possible energy sources are renewable resources. A **renewable resource** is an energy source that is replaced nearly as quickly as it is used. Although no completely adequate energy source has been found, some promising options exist.

Energy from the Sun

The amount of solar energy that falls on the United States in one day, on average, is more than the total amount of energy used in the United States in one year. Because the Sun is expected to continue to supply energy for several billion years, solar energy cannot be used up like fossil fuels. Solar energy is a renewable resource that can provide a source of energy for the foreseeable future. Even if a small fraction of this solar energy could be used, it could significantly reduce the consumption of fossil fuels.

Solar Cells

The radiant energy from the Sun can be used to heat homes and provide hot water. This energy also can be converted directly into electricity. A device that is used to convert solar energy into electricity is the **photovoltaic cell**, which also is called a solar cell. Do you own a solar-powered calculator, like the one shown in **Figure 19**? It contains solar cells.



Reading Check

What does a photovoltaic cell do?

As You Read

What You'll Learn

- **Analyze** the need for alternate energy sources.
- **Describe** alternate methods of generating electricity.
- **Compare** the advantages and disadvantages of various alternate energy sources.

Vocabulary

renewable resource
photovoltaic cell
hydroelectricity
geothermal energy
biomass

Why It's Important

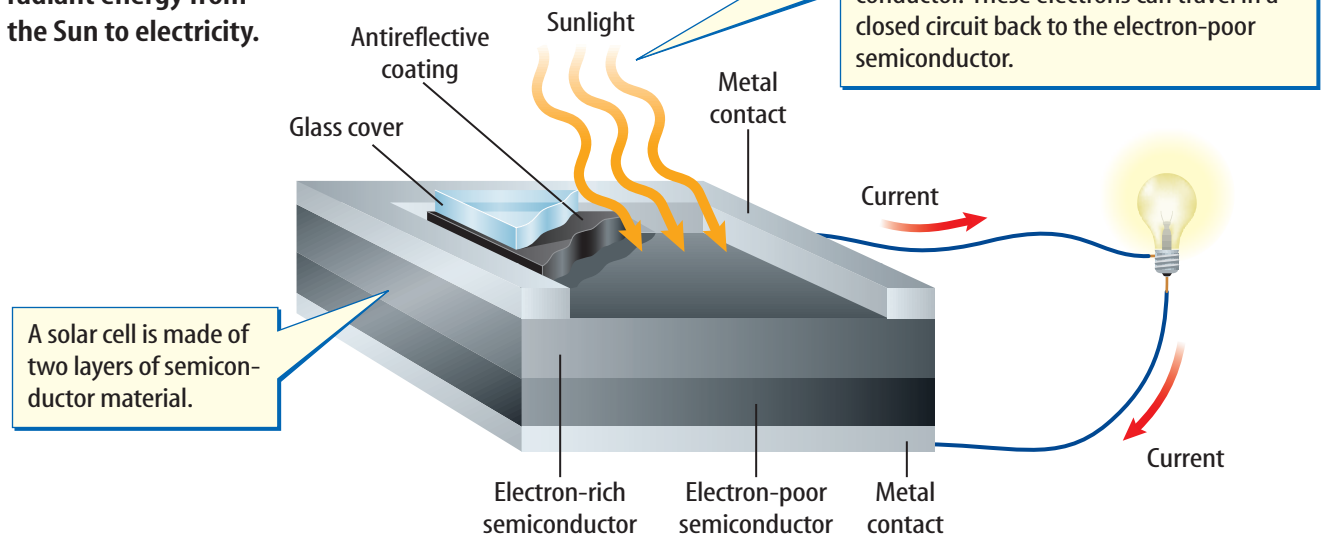
Our primary energy sources are non-renewable, so alternative energy sources need to be explored.

Figure 19

This calculator uses a solar cell to produce the electricity it needs to operate.



Figure 20
Solar cells convert radiant energy from the Sun to electricity.



TRY AT HOME
Mini LAB

Using Solar Power at Home

Procedure

1. Cut a piece of **cloth** into four equal sized pieces.
2. Wet the pieces and wring them out so they are the same dampness.
3. Spread the pieces out to dry—two pieces inside and two pieces outdoors. One piece of each set should be in direct sunlight and one piece should be in the shade.
4. In your **Science Journal**, record the time it takes for each cloth piece to dry.

Analysis

1. How long did it take for each cloth piece to dry?
2. What conditions determined how quickly the cloth dried?
3. Infer how you can use solar energy in your home to conserve electricity.

Making Electricity Solar cells are made of two layers of semiconductor materials sandwiched between two layers of conducting metal, as shown in **Figure 20**. One layer of semiconductor is rich in electrons, while the other layer is electron poor. When sunlight strikes the surface of the solar cell, electrons flow through an electrical circuit from the electron-rich semiconductor to the electron-poor material. This process of converting radiant energy from the Sun directly to electricity is only about 7 percent to 11 percent efficient.

Using Solar Energy Producing electricity using solar cells is, however, more expensive on a large scale than the use of non-renewable fuels is. The cost of electricity produced by a conventional fossil-fuel power plant is about 8 cents to 10 cents per kilowatt-hour. In 1998, the cost of electricity generated by solar cells was about 28 cents per kilowatt-hour. However, in remote areas the difference in cost drops if the cost of building transmission lines to those areas is considered.

One disadvantage of using solar cells to generate electricity is that the Sun's rays do not strike any place on Earth every hour of every day. Therefore, the electricity generated by solar cells when the Sun is shining must be stored in batteries to be used when the Sun isn't out. However, a large amount of energy is needed to manufacture batteries, and large batteries contain heavy metals such as lead that are environmental hazards. In spite of this disadvantage, solar energy is an energy resource that is becoming more economical as solar technology improves. One of the world's largest and most productive solar energy plants is located in California.

Energy from Water

Just as the expansion of steam can turn an electric generator, a river's rapidly moving water can as well. The energy carried by water can be increased if the water is retained by a high dam. This increases the gravitational potential energy of the water. This potential energy is released when the water flows through tunnels near the base of the dam. **Figure 21** shows how the rushing water spins a turbine, which rotates the shaft of an electric generator to produce electricity. Dams built for this purpose are called hydroelectric dams.

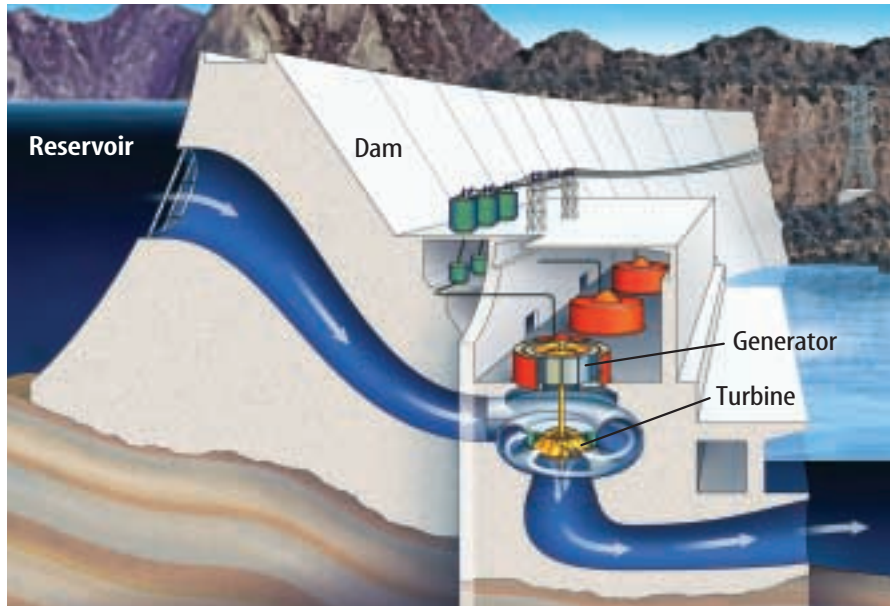


Figure 21

The potential energy contained in water stored behind the dam is converted to electrical energy in a hydroelectric power plant.

Using Hydroelectricity Electricity produced from the energy of moving water is called **hydroelectricity**. Currently about 8 percent of the electrical energy used in the United States is produced by hydroelectric power plants. Hydroelectric power plants are an efficient way to produce electricity with almost no pollution. Because no exchange of heat is involved in producing steam to spin a turbine, hydroelectric power plants are almost twice as efficient as fossil fuel or nuclear power plants.

Another advantage is that the bodies of water held back by dams can form lakes that can provide water for drinking and crop irrigation. These lakes also can be used for boating and swimming. Also, after the initial cost of building a dam and a power plant, the electricity is relatively cheap.

However, artificial dams can disturb the balance of natural ecosystems. Some species of fish that live in the ocean migrate back to the rivers in which they were hatched to breed. This migration can be blocked by dams, which causes a decline in the fish population. Fish ladders, such as those shown in **Figure 22**, have been designed to enable fish to migrate upstream past some dams. Also, some water sources suitable for a hydroelectric power plant are not near the people needing the power.

Figure 22

Fish ladders enable fish to migrate upstream past dams.



Reading Check

Could your area use a hydroelectric power plant? Explain.



Figure 23
This tidal energy plant at Annapolis Royal, Nova Scotia, generates 20 megawatts of electric power.

Energy from the Tides

The gravity of the Moon and Sun causes bulges in Earth's oceans. As Earth rotates, the two bulges of ocean water move westward. Each day, the level of the ocean on a coast rises and falls continually. Hydroelectric power can be generated by these ocean tides. As the tide comes in, the moving water spins a turbine that generates electricity. The water is then trapped behind a dam. At low tide the water behind the dam flows back out to the ocean, spinning the turbines and generating electric power.

Tidal energy is nearly pollution free. The efficiency of a tidal power plant is similar to that of a conventional hydroelectric power plant. However, only a few places on Earth have large enough differences between high and low tides for tidal energy to be a useful energy source. The only tidal power station in use in North America is at Annapolis Royal, Nova Scotia, shown in **Figure 23**. Tidal energy probably will be a limited, but useful, source of energy in the future.

Harnessing the Wind

Figure 24
Wind energy is converted to electricity as the spinning propeller turns a generator.

You might have seen a windmill on a farm or pictures of windmills in a book. These windmills use the energy of the wind to pump water. Windmills also can use the energy of the wind to generate electricity. Wind spins a propeller that is connected to an electric generator. Usually, areas that make use of wind power have several hundred windmills working together, as shown in **Figure 24**.

However, only a few places on Earth consistently have enough wind to rely on wind power to meet energy needs. Also, windmills are only about 20 percent efficient on average. Research is underway to improve the design of wind generators and increase their efficiency. Wind generators do not consume any resources. They do not pollute the atmosphere or water. However, they can be noisy and do change the appearance of a landscape. Also, they can disrupt the migration patterns of some birds. Still, wind energy can be a useful source of energy in some areas.



Energy from Inside Earth



Earth Science INTEGRATION

Earth is not completely solid. Heat is generated within Earth by the decay of radioactive elements. This heat is called geothermal heat. Geothermal heat causes the rock beneath Earth's crust to soften and melt. This hot molten rock is called magma. The thermal energy that is contained in hot magma is called **geothermal energy**.

In some places, Earth's crust has cracks or thin spots that allow magma to rise near the surface. Active volcanoes, for example, permit hot gases and magma from deep within Earth to escape. Perhaps you have seen a geyser, like Old Faithful in Yellowstone National Park, shooting steam and hot water. The water that shoots from the geyser is heated by magma close to Earth's surface. In some areas, this hot water can be pumped into houses to provide heat.



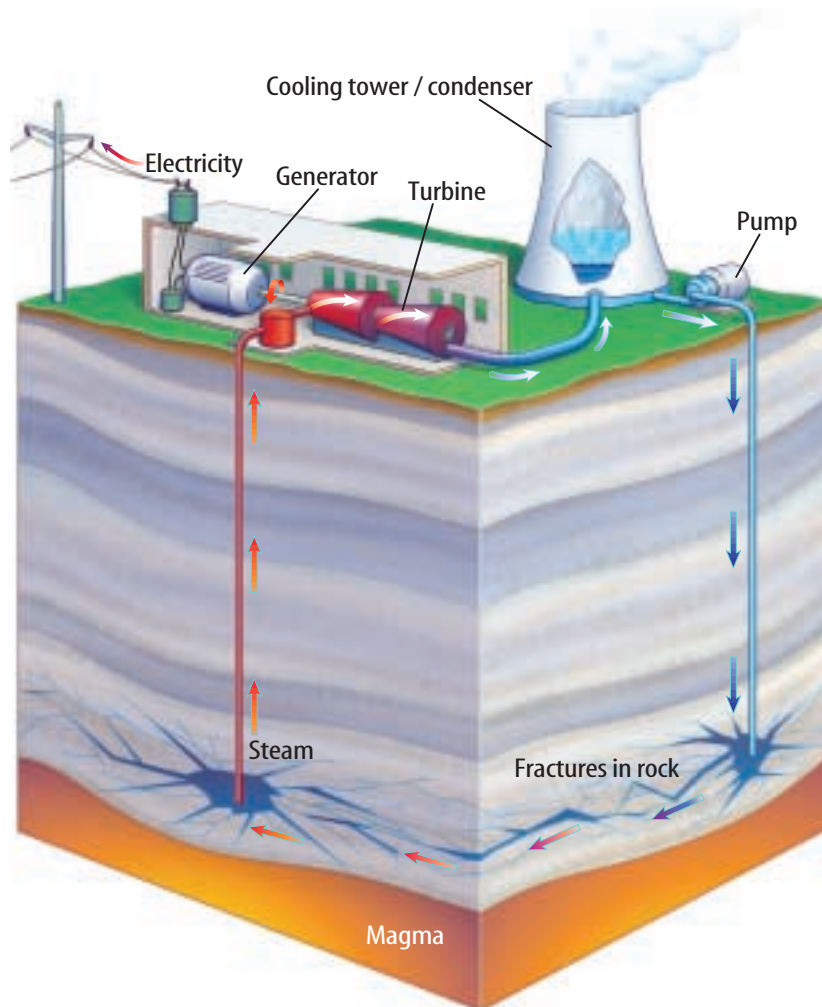
Reading Check

What two natural phenomena are caused by geothermal heat?

Geothermal Power Plants

Geothermal energy also can be used to generate electricity, as shown in **Figure 25**. Where magma is close to the surface, the surrounding rocks are also hot. A well is drilled and water is pumped into the ground, where it makes contact with the hot rock and changes into steam. The steam then returns to the surface, where it is used to rotate turbines that spin electric generators.

The efficiency of geothermal power plants is about 16 percent. Although geothermal power plants can release some gases containing sulfur compounds, pumping the water created by the condensed steam back into Earth can help reduce this pollution. However, the use of geothermal energy is limited to areas where magma is relatively close to the surface.



SCIENCE Online



Research Visit the Glencoe Science Web site at science.glencoe.com for a link to more information about geothermal energy. Communicate to your class what you learn.

Figure 25

A geothermal power plant converts geothermal energy to electrical energy. Water is changed to steam by the hot rock, and the steam is pumped to the surface where it turns a turbine attached to an electric generator.

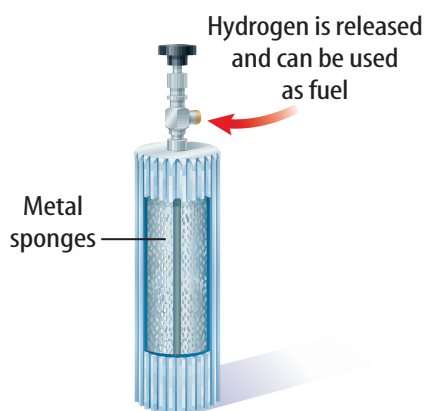


Figure 26
The hydrogen car might one day replace gasoline automobiles. One possible way of storing hydrogen is to use a metal sponge that will hold the hydrogen until it is ready to be used.

Alternative Fuels

More than two thirds of the petroleum used in the United States powers cars and other vehicles. The use of fossil fuels would be greatly reduced if cars could run on other fuels or sources of energy. For example, cars have been developed that use electrical energy supplied by batteries as a power source. Other designs use both electric motors and gasoline engines.

Hydrogen gas is another possible alternative fuel. It produces only water vapor when it burns and creates no pollution. The oceans contain an almost limitless supply of hydrogen that is combined with oxygen in water molecules. The hydrogen in water can be released by passing an electric current through the water. Producing the electric current, however, requires more energy than can be generated by burning the hydrogen gas that is produced. Other ways of producing hydrogen are being studied and might be useful in the future. **Figure 26** shows one possible way to store the fuel.

Biomass Fuels Fossil fuels and nuclear fission produce electricity by heating water. Could any other materials be used to heat water and produce electricity? **Biomass**, for example, is renewable organic matter, such as wood, sugarcane fibers, rice hulls, and animal manure. It, too, can be burned in the presence of oxygen to convert the stored chemical energy to thermal energy. In fact, burning biomass is probably the oldest use of natural resources for meeting human energy needs.

Section 3 Assessment

1. Why do humans need to develop and use alternative energy sources?
2. Describe three ways that solar energy can be used.
3. How is the generation of electricity by hydroelectric, tidal, and wind sources similar to each other? How is it similar to fossil fuel and nuclear power?
4. Why is geothermal energy unlikely to become a major energy resource?
5. **Think Critically** What single resource do most energy alternatives depend on, either directly or indirectly?

Skill Builder Activities

6. **Classifying** On a computer, draw a chart of the energy sources in this section. List the advantages and disadvantages of each. Which source do you feel is most promising? Why? **For more help, refer to the Science Skill Handbook.**
7. **Using Percentages** U.S. sources of energy follow: 39 percent petroleum, 23 percent natural gas, 23 percent coal, 8 percent nuclear, and 7 percent other. If the percent of nuclear energy was shown with a 1-m strip of paper, how long would the other strips be? **For more help, refer to the Math Skill Handbook.**

Activity

Solar Heating

Energy from the Sun is absorbed by Earth and makes its temperature warmer. In a similar way, solar energy also is absorbed by solar collectors to heat water and buildings. Does the rate at which an object absorbs solar energy depend on the color of the object?

What You'll Investigate

How does color affect the amount of heat absorbed from the Sun?

Materials

small cardboard boxes
black, white, and colored paper
tape or glue
thermometer
watch with a second hand

Goals

- **Demonstrate** solar heating.
- **Compare** the effectiveness of heating items of different colors.
- **Graph** your results.

Procedure

1. Cover at least three small boxes with colored paper. The colors should include black and white as well as at least one other color.
2. Copy the following data table into your Science Journal. Replace "Other color" with whatever color you are using.

Temperature Due to Different Colors					
Color	Minute 2	Minute 4	Minute 6	Minute 8	Minute 10
Black					
White					
Other color					

3. Place the three objects on a windowsill or other sunny spot and note the starting time.
4. **Measure and record** the temperature inside each box at 2-min intervals for at least 10 min.

Conclude and Apply

1. **Graph** your data using a line graph.
2. **Describe** the shapes of the lines on your graph. What color heated up the fastest? Which heated up the slowest?
3. **Explain** why the colored boxes heated at different rates.
4. Suppose you wanted to heat a tub of water using solar energy. Based on what you discovered in this activity, what color would you want the tub to be? Explain.
5. **Explain** why you might want to wear a white or light-colored shirt on a hot, sunny, summer day.

Communicating

Your Data

Compare your results with those of other students in your class. Discuss any differences found in your graphs, particularly if different colors were used by different groups.

Activity

Use the Internet



How much does energy really cost?

You know that it costs money to produce energy. Using energy also can have an impact on the environment. For example, coal costs less than some other fuels. However, combustion is a chemical reaction that can produce pollutants, and burning coal produces more pollution than burning other fossil fuels. How do energy providers convince consumers that their service is the most cost-efficient and the least polluting?

Recognize the Problem

What are the costs and environmental impacts of various energy-producing sources?

Form a Hypothesis

Form a hypothesis about which energy source you think will have the lowest cost and which will have the least impact on the environment.

Goals

- **Identify** three energy sources that people use.
- **Determine** the cost of each source.
- **Describe** the environmental impact of each source.
- **Describe** which energy source is most cost-efficient as well as the one which causes the least environmental impact.

Data Source

SCIENCE Online Go to the Glencoe Science Web site at science.glencoe.com to get more information about various energy sources and services and for data collected by other students.



Test Your Hypothesis

Plan

1. Think about the various sources of power used in different areas of the United States and make a list of possible energy sources to investigate.
2. Find the cost of 1 kWh of electric energy generated by three of these energy sources.
3. Determine whether your sources have a negative impact on the environment. Which sources are renewable?
4. Use your data to create a table of energy sources, costs, and impacts.
5. Write a summary describing which of your three energy sources is the best for producing 1 kWh of electric energy. Consider the cost of the

Energy Sources		
Energy Source	Cost per kWh	Environmental Impacts
Energy source 1		
Energy source 2		
Energy source 3		

energy and the environmental impact. Provide facts from your research to support your conclusions.

Do

1. Make sure your teacher approves your plan before you start.
2. Go to the Glencoe Science Web site at science.glencoe.com to post your data.



Analyze Your Data

1. Of the energy sources you investigated, which is the most expensive to use? The least expensive?
2. Which energy source do you think has the most impact on the environment? The least impact?

Draw Conclusions

1. Find this *Use the Internet* activity on the Glencoe Science Web site at science.glencoe.com. Post your data in the table provided. Compare your data to that of other students.
2. Of the energy sources you investigated, which is the least expensive energy source? Which is the best choice to use? Why or why not?
3. Of the energy sources you investigated, how did the environmental impact of that power influence your choice of the best energy solution?
4. Which data support your decision?

Communicating Your Data

Make a poster of magazine pictures to illustrate impact on the environment for each of the three energy sources.

Reacting to



Solar panels help power homes in this development.



The power of the wind is harnessed by these wind turbines in California.

Most people agree that thanks to energy sources, we have many things that make our quality of life better. Energy runs our cars, lights our homes, and powers our appliances. What many people don't agree on is where that energy should come from. Nuclear energy is a topic that stirs up strong opinions in people. As you read the summaries of the issues given here, think about your own opinions.

A Question of the Environment

Almost all of the world's electric energy is produced by thermal power plants. Most of these plants burn fossil fuels—such as coal, oil, and natural gas—to produce energy. Nuclear energy is produced by fission, which is the splitting of an atom's nucleus. People in favor of nuclear energy argue that, unlike fossil fuels, nuclear energy is nonpolluting.

When coal is burned, it releases large amounts of sulfur and other pollutants into the air. These pollutants contribute to serious environmental problems such as smog and acid rain. Uranium, the key fuel for nuclear reactors, releases no chemical or solid pollutants into the air during use.

Opponents counter, though, that the poisonous radioactive waste created in nuclear reactors qualifies as pollution—and will be lingering in the ground and water for hundreds of thousands of years.

Supporters of nuclear energy also cite the spectacular efficiency of nuclear energy—one metric ton of nuclear fuel produces the same amount of energy as up to 3 million tons of coal. Opponents point out that uranium is in very short supply and, like fossil fuels, is likely to run out in the next 100 years.

Nuclear Energy

A Question of Health & Safety

Opponents of nuclear energy point out the health dangers associated with mining and processing nuclear fuel. *Radiation sickness* is the term for a variety of symptoms that result when a person is exposed to damaging amounts of radiation. Exposure to high levels of radiation can cause lasting illness or even death. Opponents worry that as utilities come under less government regulation, safety standards will be ignored in the interest of profit. This could result in more accidents like the one that occurred at Chernobyl in the Ukraine. There, an explosion in the reactor core released radiation over a wide area.

Supporters counter that it will never be in the best interests of those running nuclear plants to relax safety standards since those safety standards are the best safeguard of workers' health. They cite the overall good safety record of nuclear power plants.

A Third Side of the Coin

Others argue that the solution to energy woes lies elsewhere. They say nuclear energy and fossil fuels are both non-renewable and produce dangerous by-products—and that investments should be made in sources of energy that are renewable and safe.



Radioactivity caused by an accident at this Ukraine nuclear power plant has given this baby physical problems.



They argue that if the same amount of money that has been spent to develop nuclear energy were spent to develop alternative energy sources, such as hydroelectric and solar power, many of the problems associated with these alternatives would have been solved by now.

This view is challenged by those who say that some alternative energy sources are not always available to people. For example, tidal energy isn't available everywhere, and solar power will not work well in areas that receive little sunlight.

CONNECTIONS Debate Form three teams and have each team defend one of the views presented here. If you need more information, go to the Glencoe Science Web site. “Debrief” after the debate. Did the arguments change your understanding of the issues?

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SCIENCE
Online

For more information, visit
science.glencoe.com

CONTENTS

Reviewing Main Ideas

Section 1 Fossil Fuels

1. Fossil fuels include oil, natural gas, and coal. They formed from the buried remains of plants and animals.
2. Fossil fuels can be burned to supply energy for generating electricity. Petroleum has other uses, as well. *What materials in this picture might have been made from petroleum?*
3. Fossil fuels are nonrenewable energy resources. They can be replaced but it takes millions of years.



Section 2 Nuclear Energy

1. A nuclear reactor uses the energy from a controlled nuclear chain reaction to generate electricity.
2. Nuclear wastes must be contained and disposed of carefully so radiation from nuclear decay will not leak into the environment. *What are the differences between low-level wastes, shown below, and high-level wastes?*



3. Nuclear fusion releases energy when two nuclei combine. Fusion only occurs at high temperatures that are difficult to produce in a laboratory.

Section 3 Renewable Energy Sources

1. Alternate energy resources can be used to supplement or replace nonrenewable energy resources.
2. Other sources of energy for generating electricity include hydroelectricity and solar, wind, tidal, and geothermal energy. Each source has its advantages and disadvantages. Also, some of these sources can damage the environment.
3. Although some alternate energy sources produce less pollution than fossil fuels do and are renewable, their use often is limited to the regions where the energy source is available.



What type of alternate energy might provide power for the area in this photo?

4. It's possible that humans might one day drive hydrogen-powered cars. Biomass is an alternate fuel that has been used for thousands of years.

After You Read

FOLDABLES Reading & Study Skills

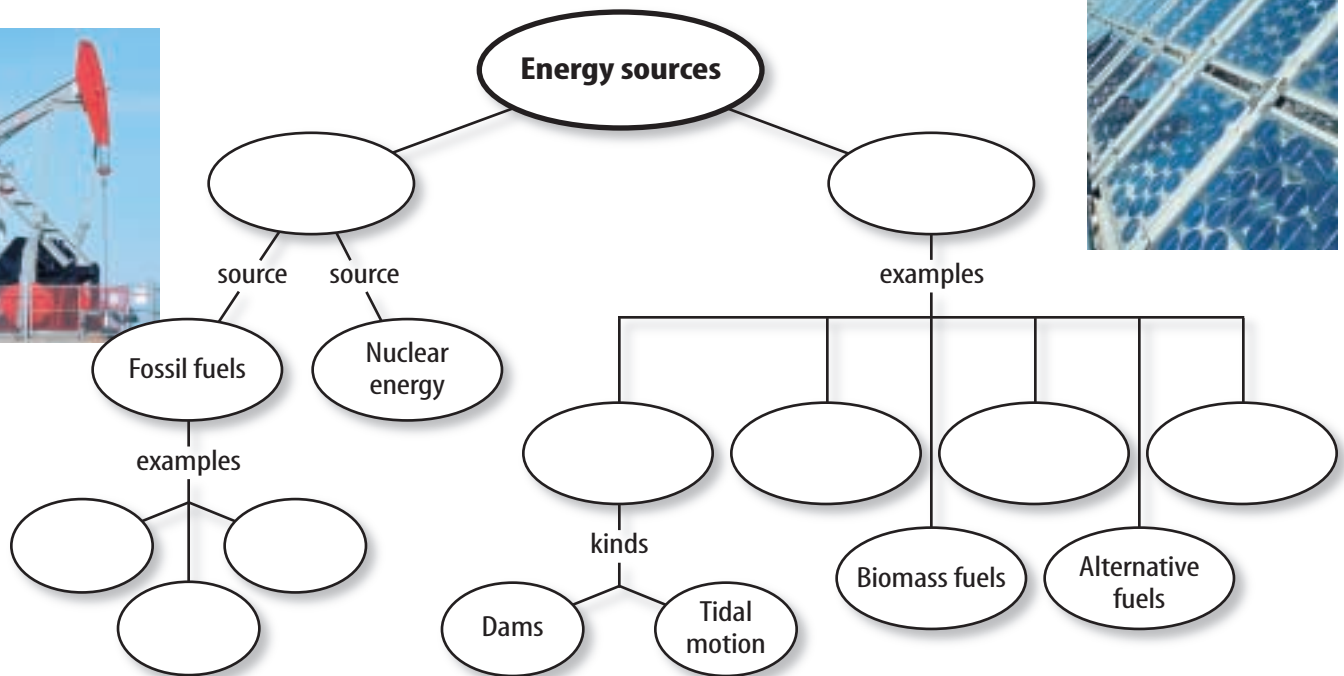
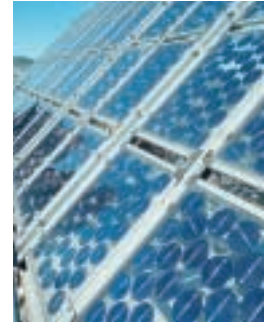


Using information from the chapter, list an example of each energy

source in the smaller ovals on the front of your Concept Map Study Fold.

Visualizing Main Ideas

Complete the following concept map on energy sources.



Vocabulary Review

Vocabulary Words

- | | |
|--------------------------|-----------------------|
| a. biomass | g. nuclear waste |
| b. fossil fuel | h. petroleum |
| c. geothermal energy | i. photovoltaic cell |
| d. hydroelectricity | j. renewable resource |
| e. nonrenewable resource | |
| f. nuclear reactor | |

Using Vocabulary

Change the incorrect terms so that the sentences read correctly. Underline your changes.

- A nuclear reactor uses the Sun to generate electricity.
- Hydroelectricity makes use of thermal energy inside Earth.
- Energy produced by the rise and fall of ocean levels is a nonrenewable resource.
- Petroleum includes the following: oil, natural gas, and coal.
- Fossil fuels are a renewable resource because they are being used up faster than they are being made.
- Special caution should be taken in disposing of a photovoltaic cell.



Study Tip

Listening is a learning tool, too. Record a reading of your notes on tape and listen to it several times each week.

Chapter 10 Assessment

Checking Concepts

Choose the word or phrase that best answers the question.

- How much energy in the United States comes from burning petroleum, natural gas, and coal?
A) 85% C) 65%
B) 35% D) 25%
- What do hydrocarbons react with when fossil fuels are burned?
A) carbon dioxide C) oxygen
B) carbon monoxide D) water
- Why are fossil fuels considered to be nonrenewable resources?
A) They are no longer being produced.
B) They are in short supply.
C) They are not being produced as fast as they're being used.
D) They contain hydrocarbons.
- To generate electricity, nuclear power plants produce which of the following?
A) steam C) plutonium
B) carbon dioxide D) water
- What is a major disadvantage of using nuclear fusion reactors?
A) use of hydrogen as fuel
B) less radioactivity produced
C) extremely high temperatures required
D) use of only small nuclei
- Which is NOT a source of nuclear waste?
A) products of fission reactors
B) materials with short half-lives
C) some medical and industrial products
D) products of coal-burning power plants
- To what can most of Earth's energy resources ultimately be traced?
A) plants C) magma
B) the Sun D) fossil fuels

- How are spent nuclear fuel rods usually disposed of?
A) releasing them into a river
B) storing them in a deep pool of water
C) burying them at the reactor site
D) releasing them into the air
- What characteristic would enable photovoltaic cells to be used more widely?
A) pollution free C) less expensive
B) nonrenewable D) larger
- What energy source uses water that is heated naturally by Earth's internal heat?
A) hydroelectricity C) tidal energy
B) nuclear fission D) geothermal energy

Thinking Critically

- Why aren't alternate energy resources more widely used?
- Match each of the energy resources described in the chapter with the proper type of energy conversion listed below.
a. kinetic energy to electricity
b. thermal energy to electricity
c. nuclear energy to electricity
d. chemical energy to electricity
e. light energy to electricity
- Why isn't fusion currently used as a source of energy?
- Classify the energy resources discussed in this chapter and in the photo as renewable or nonrenewable.
- Suppose new reserves of fossil fuels and a way to burn them cleanly were found. Why would it still be a good idea to decrease use of them as a source of energy?



Developing Skills

- 16. Communicating** Describe the steps that must occur before you can use the Sun's energy to power a car.
- 17. Drawing Conclusions** Discuss whether or not alternate energy sources could have negative effects on the environment.
- 18. Recognizing Cause and Effect** Complete the table describing possible effects of changes in the normal operation of a nuclear reactor.

Reactor Problems	
Cause	Effect
The cooling water is released hot.	
The control rods are removed.	
	The reactor core overheats and meltdown occurs.

- 19. Using Percentages** What is the overall efficiency of a power plant whose stages have efficiencies of 65 percent, 75 percent, 90 percent, and 70 percent?

Performance Assessment

- 20. Newspaper Article** Write a newspaper article to raise public awareness of current energy problems and solutions. In your article, discuss the economic and environmental costs of various energy sources.

TECHNOLOGY

Go to the Glencoe Science Web site at science.glencoe.com or use the Glencoe Science CD-ROM for additional chapter assessment.

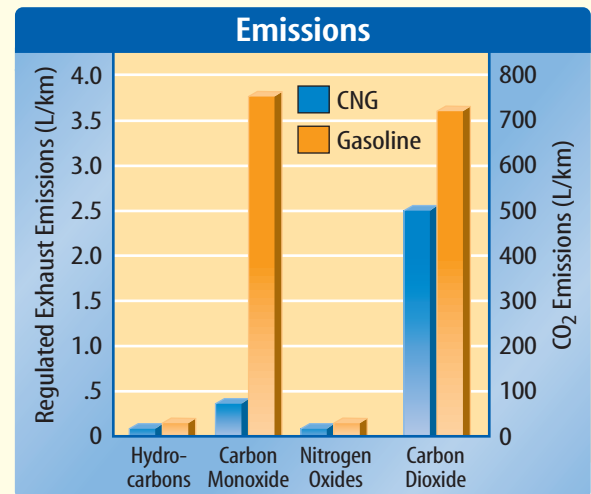
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CONTENTS



Test Practice

Concerned about air pollution, Andrew gathered information about compressed natural gas-powered cars. He made a graph comparing emissions from a compressed natural gas (CNG)-powered car to its gasoline-powered counterpart.



Study the graph and answer the following questions.

- According to the graph, which substance is emitted into the air in the greatest amount?
 - hydrocarbons
 - carbon monoxide
 - nitrogen oxides
 - carbon dioxide
- Based on the data in the graph, which is the greatest benefit of using cars that are powered by compressed natural gas?
 - better gas mileage when traveling on highways
 - fewer carbon monoxide emissions
 - increased carbon dioxide emissions
 - use of noncombustible fuel reclaimed

Reading Comprehension

Read the passage. Then read each question that follows the passage. Decide which is the best answer to each question.

Magnetic Levitation Train

One of the first things people learn about magnets is that like magnetic poles repel each other. This is the basic principle behind the Magnetic Levitation Train, or Maglev.

Maglev is a high-speed train. It uses high-strength magnets to lift and propel the train to incredible speeds as it hovers only a few centimeters above the track. A full-size Maglev in Japan achieved a speed of over 500 km/h! Its electromagnetic motor can be precisely controlled to provide smooth acceleration and braking between stops. The magnetic field prevents the vehicle from drifting away from the center of the guideway.

Because there is no friction between wheels and rails, Maglevs eliminate the principal limitation of conventional trains, which is the high cost of maintaining the tracks to avoid excessive vibration and wear that can cause dangerous derailments. Critics point out that Maglevs require enormous amounts of energy. However, studies have shown that Maglevs use 30 percent less energy than other high-speed trains traveling at the same speed. Others worry about the dangers from magnetic fields; however, measurements show that humans are exposed to magnetic fields no stronger than those from toasters or hair dryers.

In Japan, a series of Maglev vehicles are slated to begin tests later this year on a 43-km demonstration line. In Germany, a 290-km Maglev line between Berlin and Hamburg is scheduled to go into service in 2005. Perhaps, in the not-too-distant future, Maglev trains

also will transport commuters to and from work or school here in the United States.

Test-Taking Tip

After you read the passage, write a one-sentence summary of the main idea for each paragraph.



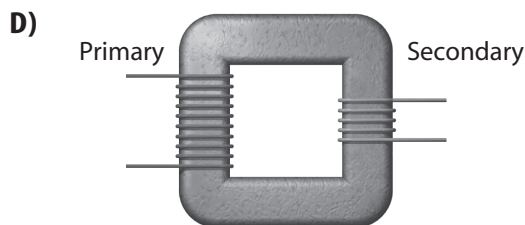
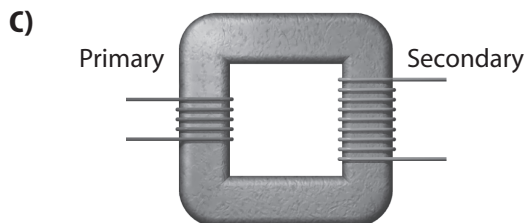
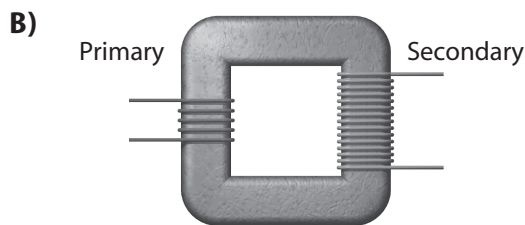
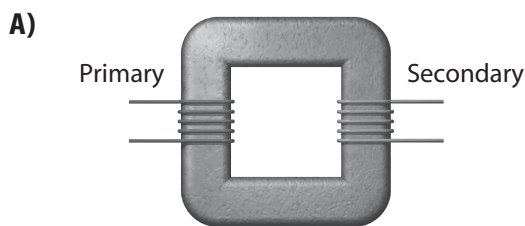
This is a Maglev train test in Japan.

- Which of these is the best summary of this passage?
 - Maglev transportation is currently in use in Germany and Japan.
 - Maglev might be a high-speed transport system of the future.
 - Maglevs use more energy than conventional high-speed trains.
 - Maglevs expose passengers to strong magnetic fields.
- In this passage, the word conventional means _____.
 - customary
 - innovative
 - political
 - unusual

Reasoning and Skills

Read each question and choose the best answer.

1. Voltage gets stepped up when the secondary coil in a transformer has more turns of wire than the primary coil. Which of the following steps up voltage the most?



Test-Taking Tip Use the information provided in the question to closely consider each answer choice.

2. Nuclear decay produces radiation, which can ionize nearby atoms. How could this radiation benefit human health?
- F) Absorbing excess hormones produced by the thyroid.
 - G) Increasing an organ's absorption of radioactive isotopes.
 - H) Destroying cells in cancerous tumors.
 - J) Boosting the immune system.

Test-Taking Tip Review information about cancer treatments that use radiation.

3. Shahid wanted to pick up pieces of metal with a magnet. Which observation would mean that the magnet would NOT allow Shahid to pick up the pieces of metal?
- A) The metal pieces were small and far away from the magnet.
 - B) The magnet was brand new.
 - C) The metal pieces were made out of aluminum foil.
 - D) The metal pieces and the magnet have the same magnetic poles.

Test-Taking Tip Review what you know about magnetic materials.

Consider this question carefully before writing your answer on a separate sheet of paper.

4. Recall what you know about the production of current. Explain the similarities and differences between direct current (DC) and alternating current (AC).

Test-Taking Tip Use the clues *direct* and *alternating* to guide your answer.