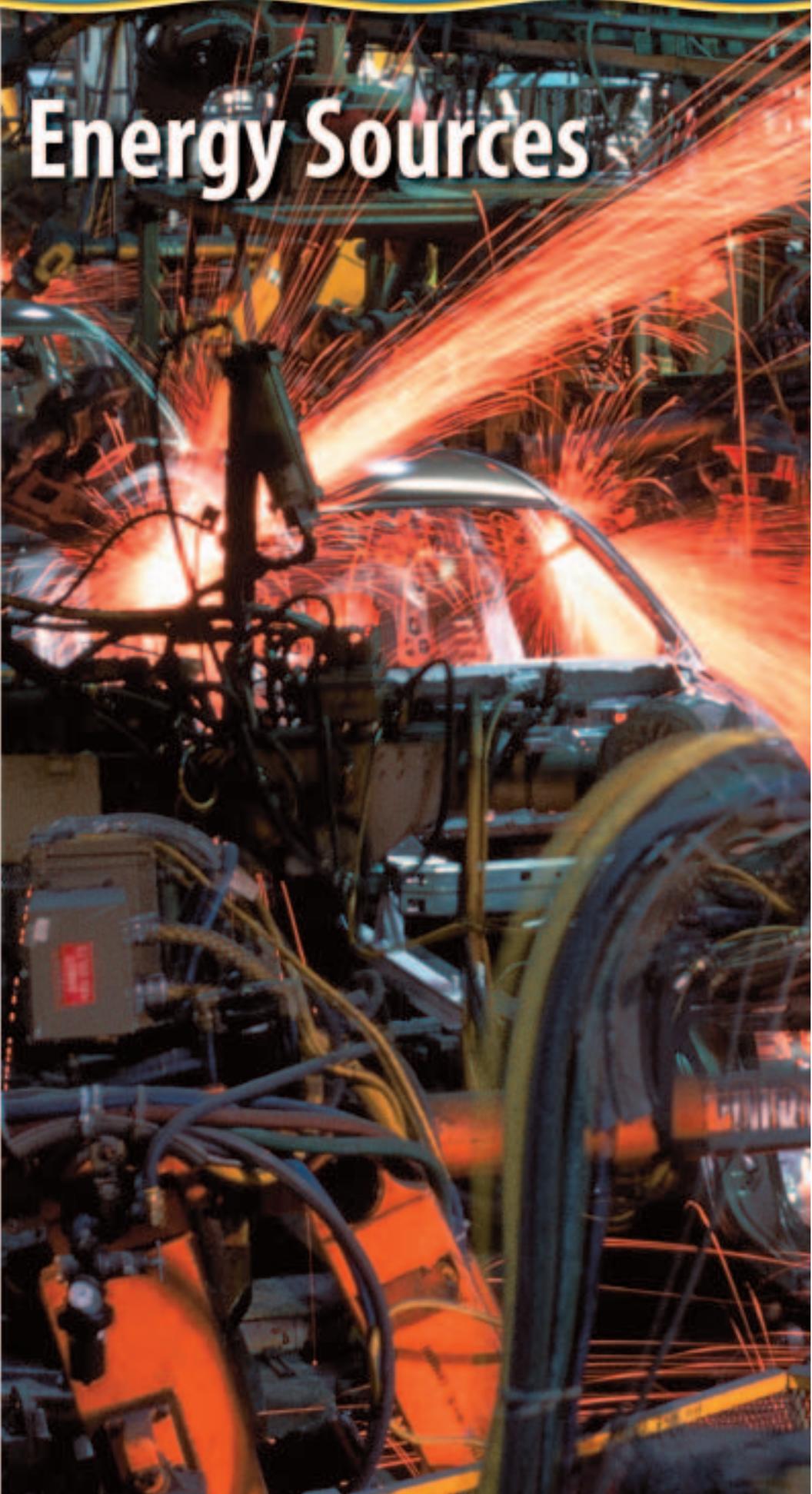




Energy Sources



BIG Idea

The energy in an energy source is transformed into other forms of energy that are used by humans.

9.1 Fossil Fuels

MAIN Idea Burning fossil fuels produces thermal energy that is converted into other useful forms of energy

9.2 Nuclear Energy

MAIN Idea Nuclear power plants convert thermal energy produced by the fission of uranium atoms into electrical energy.

9.3 Renewable Energy Sources

MAIN Idea Renewable energy sources are not used up because they are replaced as they are used.

Doing the Robot

A car uses the chemical energy in gasoline to make it run. But energy is also needed to make a car. For example, these welding robots use energy to join pieces of a car together. Even the materials that a car is made from, such as aluminum and plastic, are produced using energy.

Science Journal

Describe how your day would be different if the electric power were off all day.

Start-Up Activities



Heating with Solar Energy

The Sun constantly bathes our planet with enormous amounts of energy. This energy can be captured and used to make electricity, heat homes, and provide hot water. How can the Sun's energy be used to heat water?



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.
5. **Think Critically** Write a paragraph explaining why the temperature change differed between the two cans.

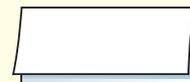


Preview this chapter's content and activities at gpscience.com

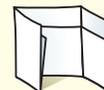
FOLDABLES™ Study Organizer

Energy Sources There are many sources of energy. Make the following Foldable to help you organize information about various types of energy sources.

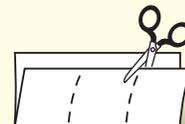
- STEP 1** **Fold** a sheet of paper in half lengthwise. Make the back edge about 5 cm longer than the front edge.



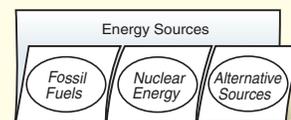
- STEP 2** **Turn** the paper so the fold is on the bottom. Then **fold** it into thirds.



- STEP 3** **Unfold and cut** only the top layer along both folds to make three tabs.



- STEP 4** **Label** the Foldable as shown.



Summarize As you read this chapter, summarize important information about each type of energy source under the appropriate tab.

Fossil Fuels

Reading Guide

What You'll Learn

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

Why It's Important

Fossil fuels are used to generate most of the energy you use every day.

Review Vocabulary

chemical potential energy: the energy stored in the chemical bonds between atoms in molecules

New Vocabulary

- fossil fuel
- petroleum
- nonrenewable resource

Figure 1 Energy is used in many ways.



Automobiles burn gasoline to provide energy.

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.



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 2** shows energy usage 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, powering 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 2** also 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.

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 potential 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 1 kg 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.

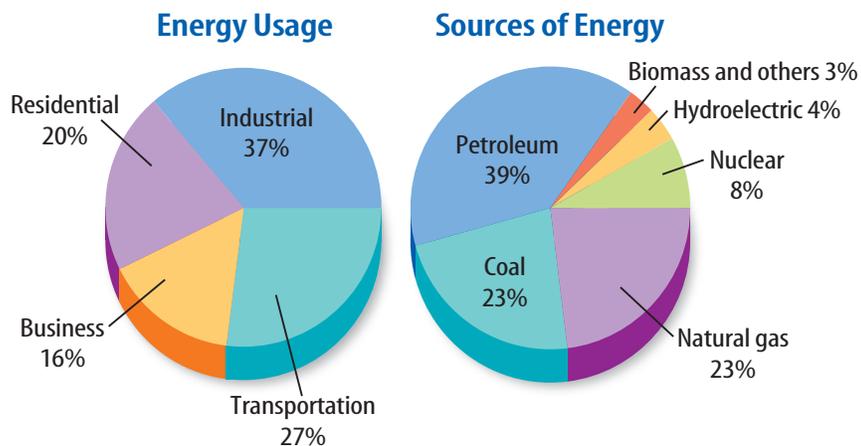


Figure 2 These circle graphs show where energy is used in the United States and sources of this energy.

Figure 3 The bar graph shows the amount of energy released by burning one gram of four different fuels. **Determine** the ratio of the energy content of natural gas to the energy content of wood.

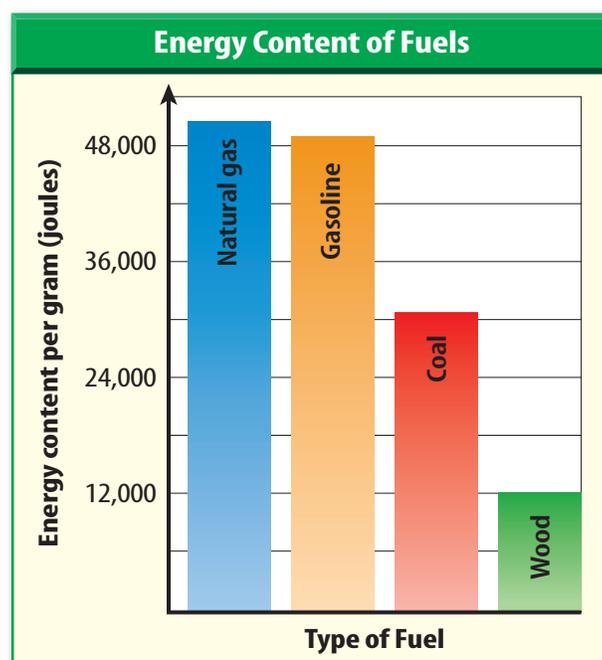
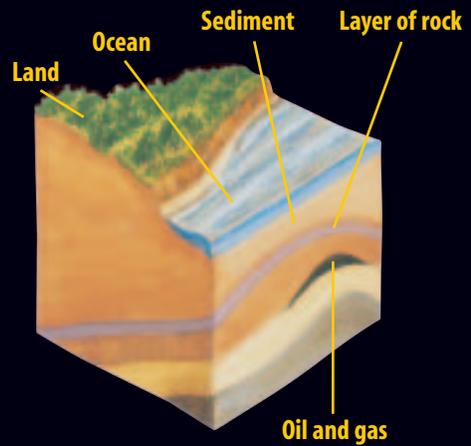
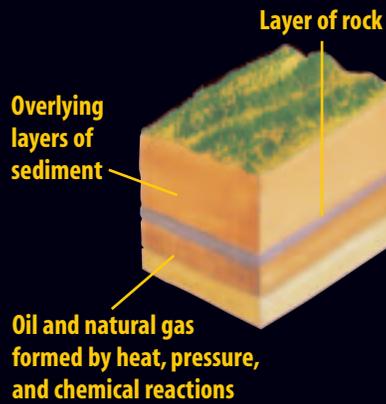
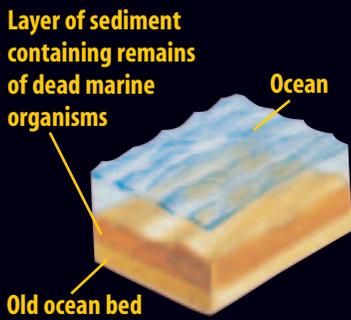




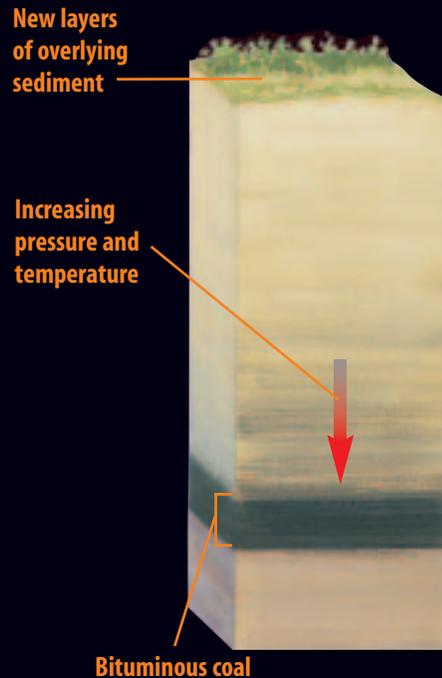
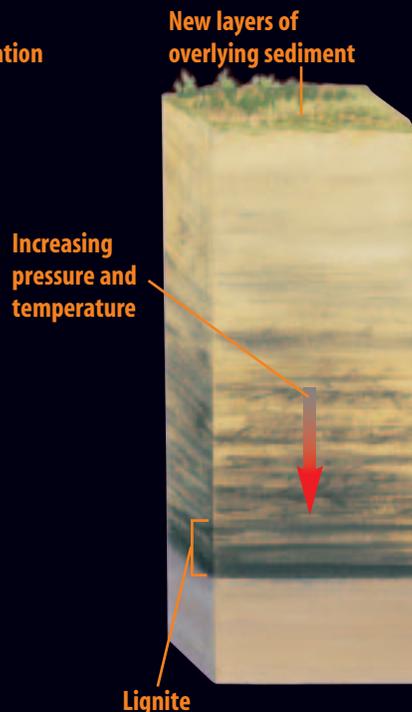
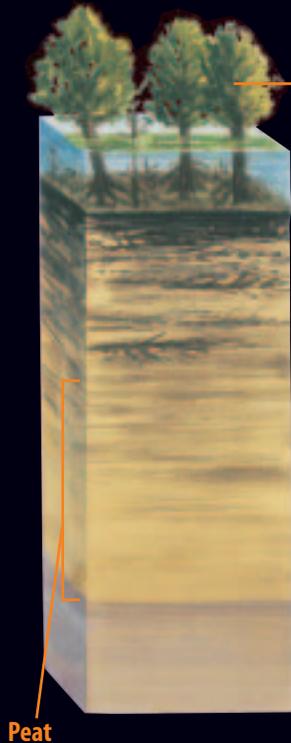
Figure 4

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 their molecules contain only carbon atoms and hydrogen atoms.

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.

Identify *four objects in your classroom that are made from 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.

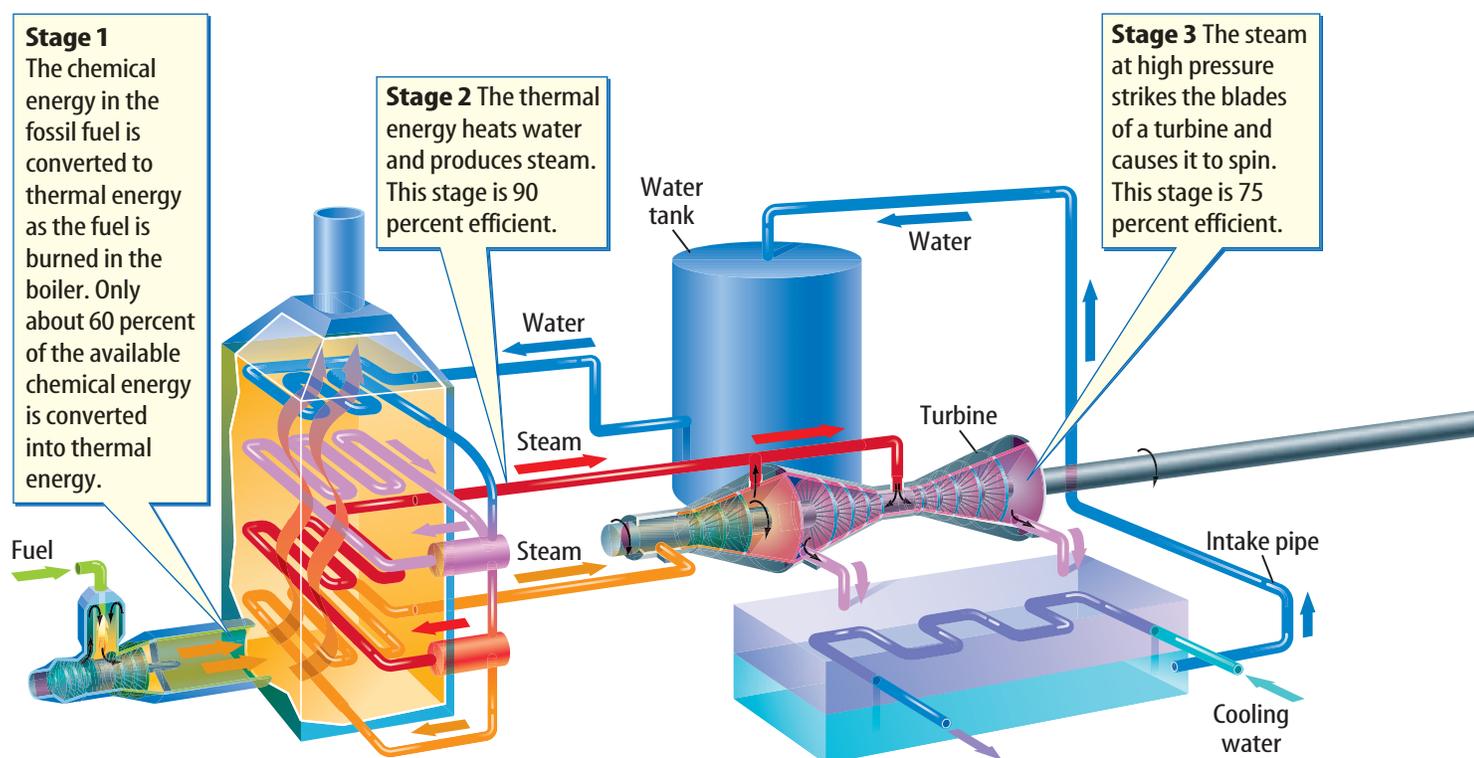
Natural Gas

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 was 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 sites of ancient swamps. Coal formed from the organic material that was deposited as the plants that lived in these swamps died. 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 and nitrogen compounds. As a result, more pollutants, such as sulfur dioxide and nitrogen oxides, 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

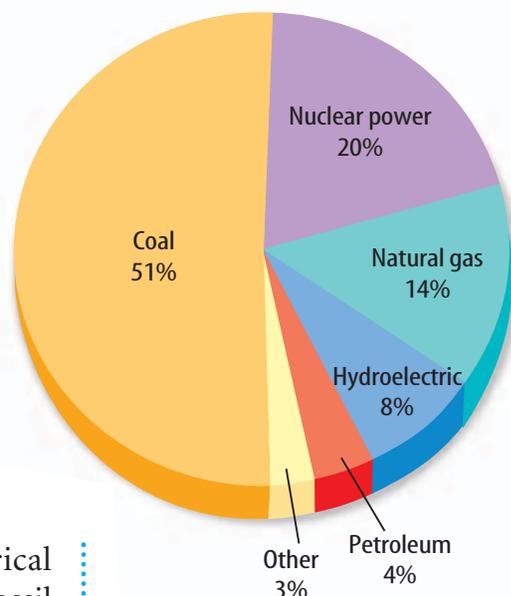
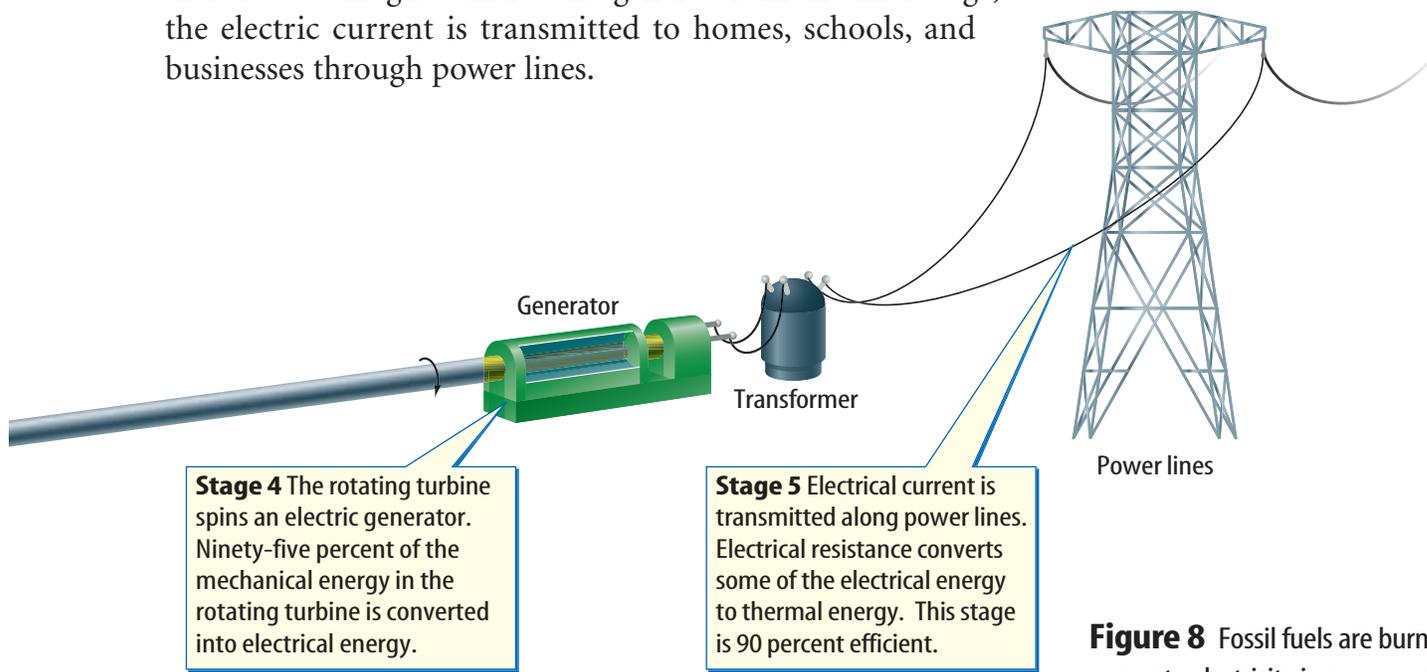


Figure 7 This circle graph shows the percentage of electricity generated in the United States that comes from various energy sources.



Stage 4 The rotating turbine spins an electric generator. Ninety-five percent of the mechanical energy in the rotating turbine is converted into electrical energy.

Stage 5 Electrical current is transmitted along power lines. Electrical resistance converts some of the electrical energy to thermal energy. This stage is 90 percent efficient.

Figure 8 Fossil fuels are burned to generate electricity in a power plant. **Determine** which stage in this process is the most inefficient.



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. In every stage of the process, some energy is converted into forms of energy that can't be used.

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 converted mainly into thermal energy when the chemical energy in fuel is transformed into electrical energy that is delivered to energy users.

The Costs of Using Fossil Fuels

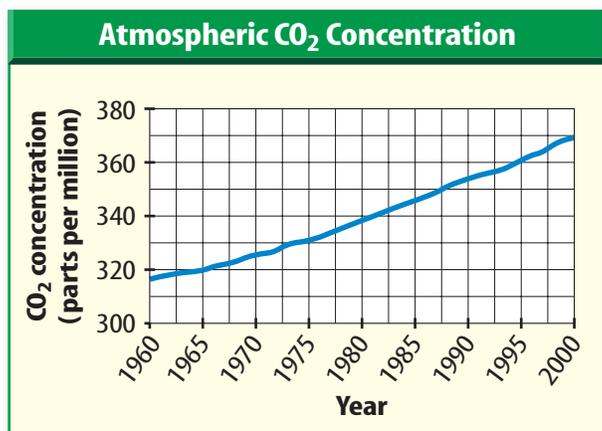
Although fossil fuels are a useful source of energy for generating electricity and providing the power for transportation, their use has some undesirable side effects. When petroleum products and coal are burned, smoke is given off that contains small particles called particulates. These particulates 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 2000. One consequence of increasing the atmospheric carbon dioxide concentration could be to cause Earth's surface temperature to increase.

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.

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

Figure 9 The carbon dioxide concentration in Earth's atmosphere has been measured at Mauna Loa in Hawaii. From 1960 to 2000, the carbon dioxide concentration has increased by about 16 percent.



Nonrenewable Resources

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 at the same time that 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 fossil fuels will decrease. Fossil fuels will become more difficult to obtain, causing them to become more costly in the future.

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. One way to meet these energy demands would be to reduce the use of fossil fuels and obtain energy from other sources.

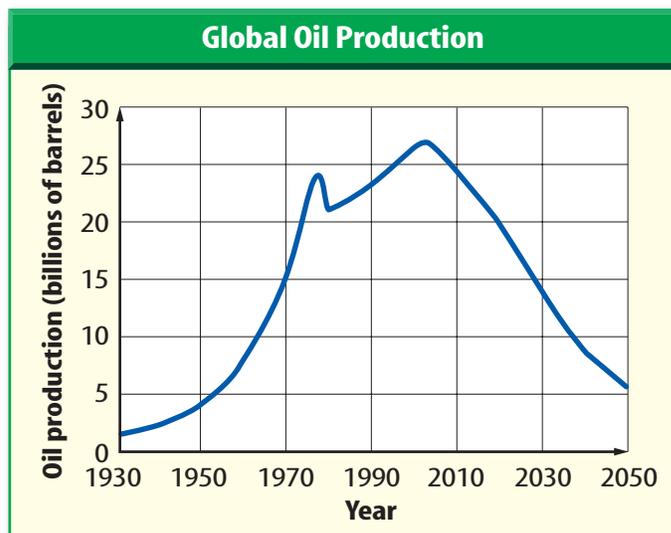


Figure 10 Some predictions show that worldwide oil production will peak by 2005 and then decline rapidly over the following 50 years.

section 1 review

Summary

Using Energy

- Energy cannot be created or destroyed, but can only be transformed from one form to another.

Fossil Fuels

- Petroleum, natural gas, and coal are fossil fuels formed by the decay of ancient plants and animals.
- Petroleum is a mixture of thousands of chemical compounds, most of which are hydrocarbons.
- About 90 percent of all coal used in the United States is burned by power plants to produce electricity.

Generating Electricity

- Power plants burn fossil fuels to produce steam that spins turbines attached to electric generators.

Self Check

1. **Describe** the advantages and disadvantages of using fossil fuels to generate electricity.
2. **Explain** how the different chemical compounds in crude oil are separated.
3. **Describe** how fossil fuels are formed.
4. **Name** three materials that are derived from the chemical compounds in petroleum.
5. **Think Critically** If fossil fuels are still forming, why are they considered to be a nonrenewable resource?

Applying Math

6. **Interpret a Graph** According to the graph in **Figure 9**, by how many parts per million did the concentration of atmospheric carbon dioxide increase from 1960 to 2000?
7. **Use a Table** In **Table 1**, if the efficiency of converting chemical to thermal energy was 90 percent, what would be the overall efficiency be?

Nuclear Energy

Reading Guide

What You'll Learn

- **Explain** how a nuclear reactor converts nuclear energy to thermal energy.
- **Describe** advantages and disadvantages of using nuclear energy to produce electricity.
- **Discuss** nuclear fusion as a possible energy source.

Why It's Important

Using nuclear energy to produce electricity can help reduce the use of fossil fuels. However, like all energy sources, the use of nuclear energy has advantages and disadvantages.

Review Vocabulary

nuclear fission: the process of splitting an atomic nucleus into two or more nuclei with smaller masses

New Vocabulary

- nuclear reactor
- nuclear waste

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. In 2003, there were 104 nuclear reactors producing electricity at 65 nuclear power plants in the United States.

Figure 11 A nuclear power plant generates electricity using the energy released in nuclear fission. Each of the domes contain a nuclear reactor. A cooling tower is on the left.



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.

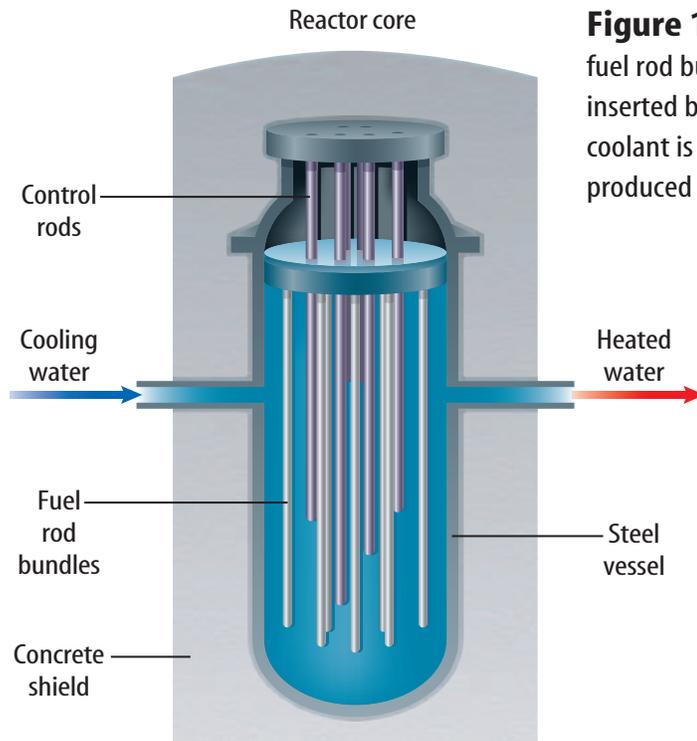


Figure 12 The core of a nuclear reactor contains the fuel rod bundles. Control rods that absorb neutrons are inserted between the fuel rod bundles. Water or another coolant is pumped through the core to remove the heat produced by the fission reaction.

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.

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 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.

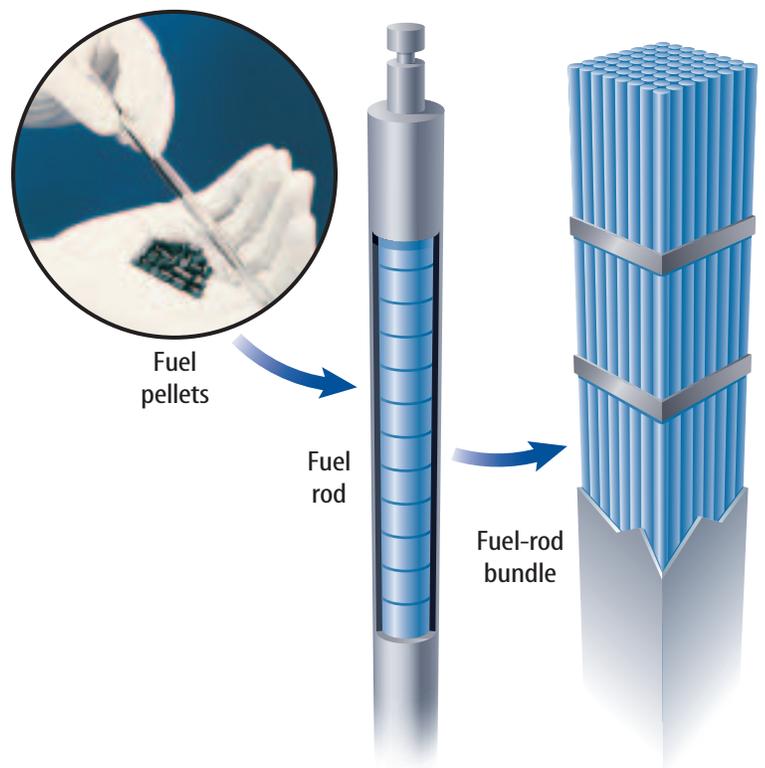
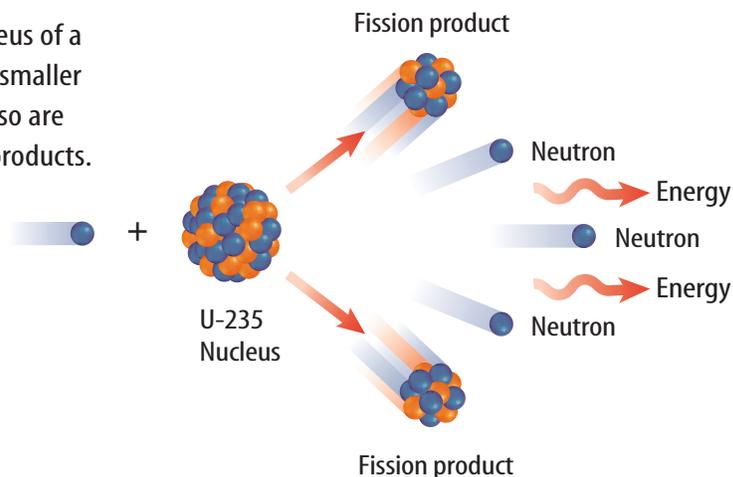




Figure 14 When a neutron strikes the nucleus of a U-235 atom, the nucleus splits apart into two smaller nuclei. In the process two or three neutrons also are emitted. The smaller nuclei are called fission products.

Explain *what happens to the neutrons that are released in this reaction.*



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 energy explosively 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 causes them to absorb more neutrons and slow down the chain reaction. Eventually, only one of the neutrons released in the fission of each of the U-235 nuclei strikes another U-235 nucleus, and energy is released at a constant rate.



Uranium-Lead Dating

Uranium is used to determine the age of rocks. 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.



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 several advantages. 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.

However, there are also disadvantages to using nuclear power. For example, if an accident occurs, a nuclear plant could release radioactive materials that could harm the environment. Nuclear power plants also produce radioactive waste materials that must be safely disposed of.



Ukraine The worst nuclear accident in history occurred at the Chernobyl nuclear power plant in the Ukraine in 1986. Many people in the area suffered from radiation sickness. Use a map or atlas to find the location of the Ukraine. Write a description of the location in your Science Journal.

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.

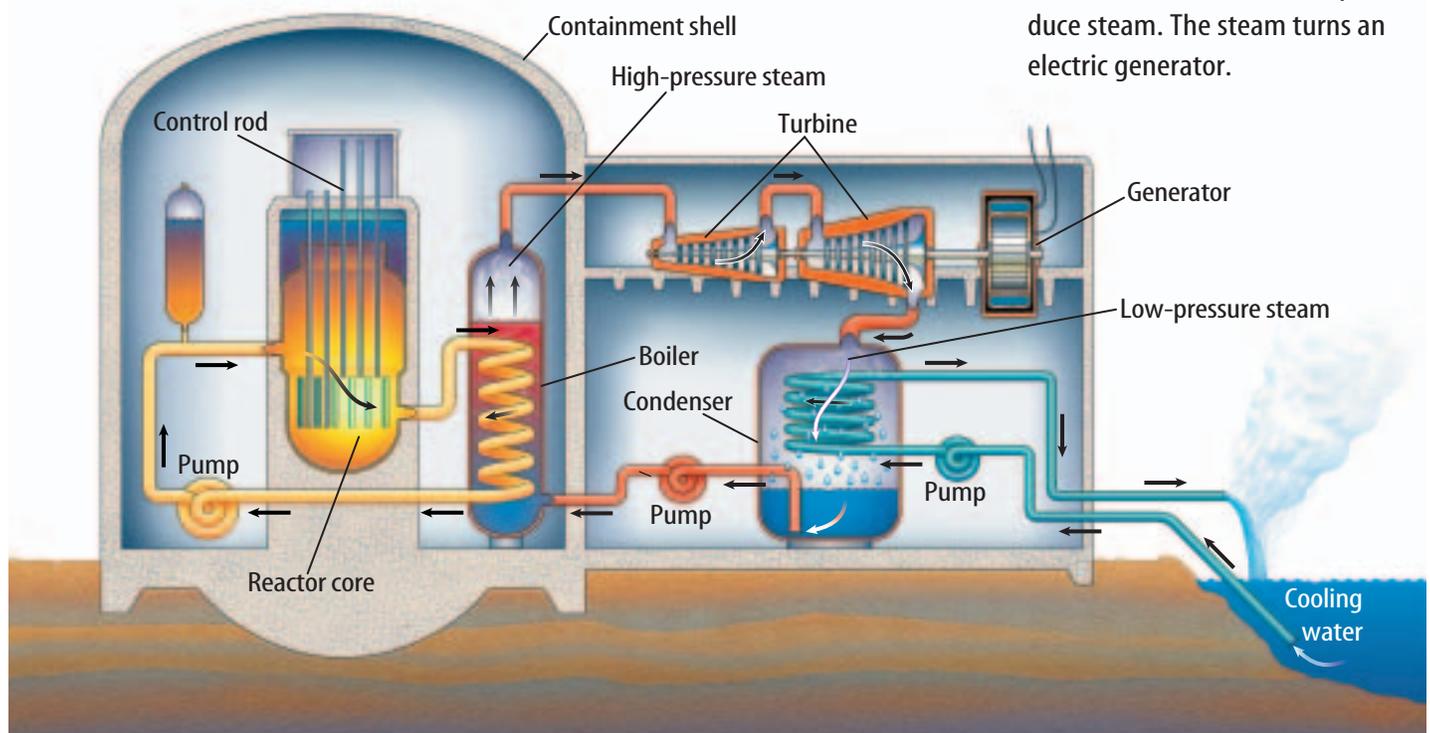




Figure 16 An explosion occurred at the Chernobyl reactor in the Ukraine after graphite control rods caught fire. The explosion shattered the reactor's roof.

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.



Topic: Storing Nuclear Wastes

Visit gpscience.com for Web links to information about storing nuclear wastes.

Activity Obtain a map or sketch an outline of the United States. Mark the locations of the nuclear waste sites that you found. What do these locations have in common? Why do you think these locations were chosen over other sites that were closer to the nuclear waste generating sites?



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.



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

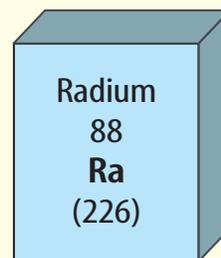
One method proposed for the disposal of high-level waste is to seal the waste in ceramic glass, which is placed in protective metal-alloy containers. The containers then are buried hundreds of meters below ground in stable rock formations or salt deposits. It is hoped that this will keep the material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

Figure 17 Spent nuclear fuel rods 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.

Applying Science

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.

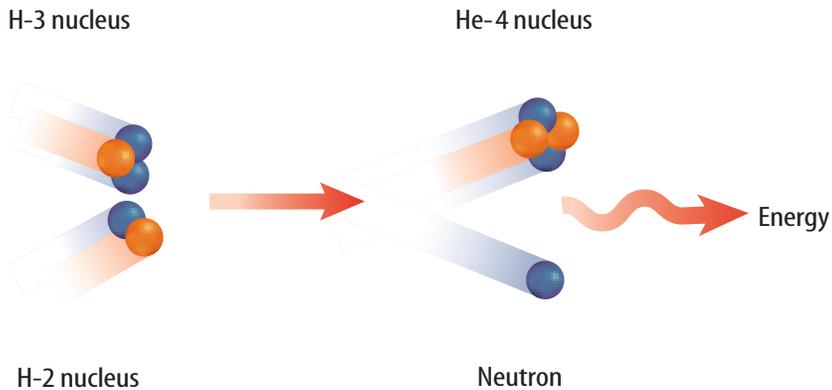


Identifying the Problem

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

The Sun gives off a tremendous amount of energy through a process called thermonuclear fusion. Thermonuclear fusion is the joining together of small nuclei at high temperatures, as shown in **Figure 18**. In this process, a small amount of mass is converted into energy. Fusion

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.

Identify the source of the energy released in a fusion reaction.

is the most concentrated energy source known.

An advantage of producing energy using nuclear fusion is that the process uses hydrogen as fuel. Hydrogen is abundant on Earth. Another advantage is that the product of the reaction is helium. Helium is not radioactive and is chemically nonreactive.

One disadvantage of fusion is that it occurs only at temperatures of millions of degrees Celsius. Research reactors often consume more energy to reach and maintain these temperatures than they produce. Another problem is how to contain a reaction that occurs at such extreme conditions. Until solutions to these and other problems are found, the use of nuclear fusion as an energy source is not practical.

section 2 review

Summary

Using Nuclear Energy

- Nuclear power plants produce about eight percent of the energy used each year in the United States.

Nuclear Power Plants

- Nuclear reactors use the energy released in the fission of U-235 to produce electricity.
- The energy released in the fission reaction is used to make steam. The steam drives a turbine that rotates an electric generator.

The Risks of Nuclear Energy

- Nuclear power generation produces high-level nuclear wastes.
- Organisms could be damaged if radiation is released from the reactor.
- Nuclear waste is the radioactive by-product produced by using radioactive materials.

Self Check

1. **Explain** why a chain reaction occurs when uranium-235 undergoes fission.
2. **Describe** how the chain reaction in a nuclear reactor is controlled.
3. **Compare** the advantages and disadvantages of nuclear power plants and those that burn fossil fuels.
4. **Describe** the advantages and disadvantages of using nuclear fusion reactions as a source of energy.
5. **Think Critically** A research project produced 10 g of nuclear waste with a short half-life. How would you classify this waste and how would it be disposed of?

Applying Math

6. **Use Percentages** Naturally occurring uranium contains 0.72 percent of the isotope uranium-235. What is the mass of uranium-235 in 2,000 kg of naturally-occurring uranium?

Renewable Energy Sources

Reading Guide

What You'll Learn

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

Why It's Important

The primary sources of energy in the United States are nonrenewable, so alternative energy sources need to be explored.

Review Vocabulary

radiant energy: the energy carried by an electromagnetic wave

New Vocabulary

- renewable resource
- photovoltaic cell
- hydroelectricity
- geothermal energy
- biomass

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, other sources of energy that can meet Earth's increasing energy demands are being developed. Some alternative energy sources are renewable resources. A **renewable resource** is an energy source that is replaced nearly as quickly as it is used.

Energy from the Sun

The average amount of solar energy that falls on the United States in one day is more than the total amount of energy used in the United States in one year. Because only about one billionth of the Sun's energy falls on Earth, and because the Sun is expected to continue producing energy for several billion years, solar energy cannot be used up. Solar energy is a renewable resource.

Many devices use solar energy for power including solar-powered calculators similar to the one in **Figure 19**. These devices use a **photovoltaic cell** that converts radiant energy from the Sun directly into electrical energy. Photovoltaic cells also are called solar cells.

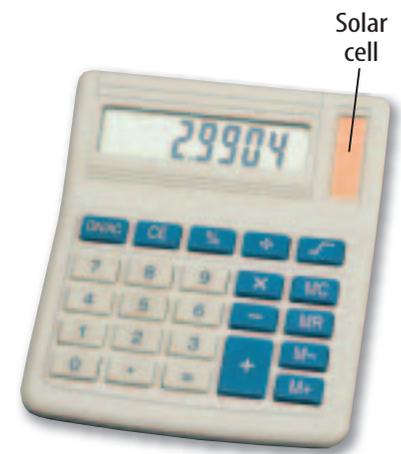
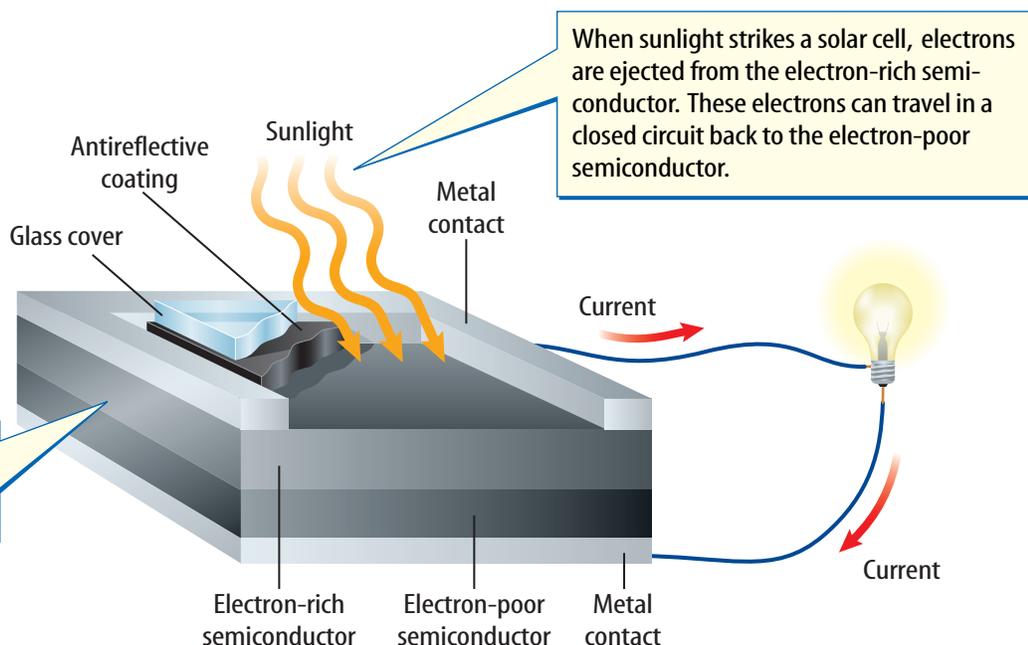


Figure 19 This calculator uses a solar cell to produce the electricity it needs to operate.

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

Identify two devices that use solar cells for power.

A solar cell is made of two layers of semiconductor material.



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.



How Solar Cells Work 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 electrical energy is only about 7 percent to 11 percent efficient.

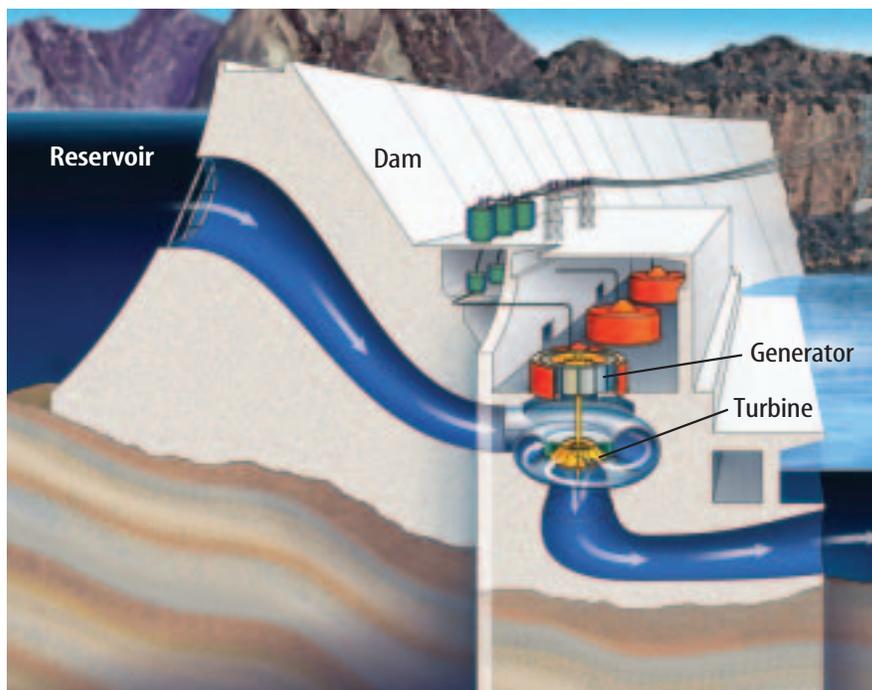
Using Solar Energy Producing large amounts of electrical energy using solar cells is more expensive than producing electrical energy using fossil fuels. However, in remote areas where electric distribution lines are not available, the use of solar cells is a practical way of providing electrical power.

Currently, the most promising solar technologies are those that concentrate the solar power into a receiver. One such system is called the parabolic trough. The trough focuses the sunlight on a tube that contains a heat-absorbing fluid such as synthetic oil or liquid salt. The heated fluid is circulated through a boiler where it generates steam to turn a turbine, generating electricity.

The world's largest concentrating solar power plant is located in the Mojave Desert in California. This facility consists of nine units that generate over 350 megawatts of power. These nine units can generate enough electrical power to meet the needs of approximately 500,000 people. These units use natural gas as a backup power source for generating electricity at night and on cloudy days when solar energy is unavailable.

Energy from Water

Just as the expansion of steam can turn an electric generator, rapidly moving water can as well. The gravitational potential energy of the water can be increased if the water is retained by a high dam. 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.



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.

Reading Check *Why are hydroelectric power plants more efficient than fossil fuel 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 located far from the regions needing power.

Figure 21 The potential energy in water stored behind the dam is converted to electrical energy in a hydroelectric power plant.

Diagram the energy conversions that occur as a hydroelectric dam produces electrical energy.

Figure 22 Fish ladders enable fish to migrate upstream past dams.

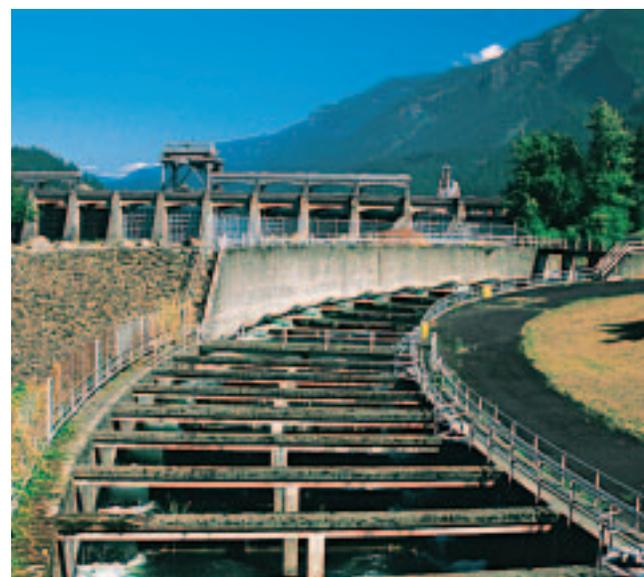




Figure 23 This tidal energy plant at Annapolis Royal, Nova Scotia, generates 20 megawatts of electric power.

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 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. Windmill farms, like the one shown in **Figure 24**, may contain several hundred windmills.

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. Other disadvantages of wind energy are that windmills can be noisy and change the appearance of a landscape. Also, they can disrupt the migration patterns of some birds. However, wind generators do not consume any nonrenewable natural resources, and they do not pollute the atmosphere or water.



Energy from Inside Earth



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**.

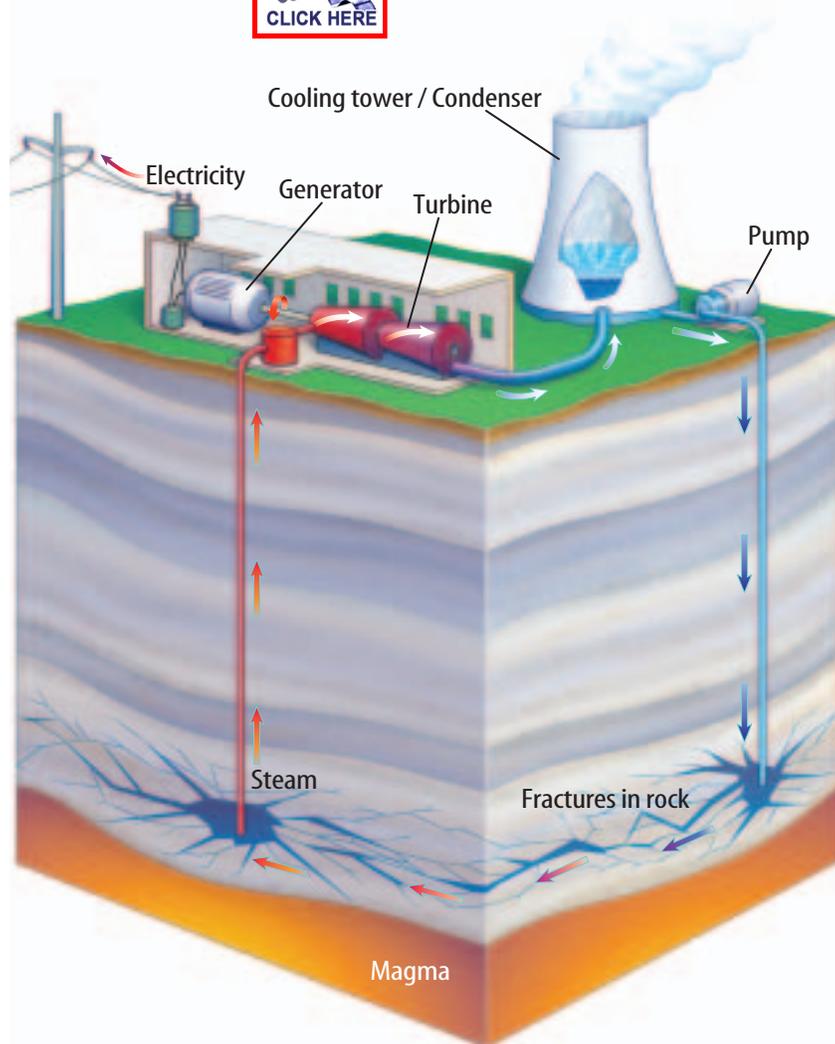
In some places, Earth's crust has cracks or thin spots that allow magma to rise near the surface. Active volcanoes, for example, permit hot gases and magma from deep within Earth to escape. Perhaps you have seen a geyser, like Old Faithful in Yellowstone National Park, shooting steam and hot water. The 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.



Topic: Geothermal Energy

Visit gpscience.com for Web links to information about geothermal energy.

Activity Using the information that you find write a paragraph describing why current facilities are located where they are.

Figure 25 A geothermal power plant converts geothermal energy to electrical energy. Water is changed to steam by the hot rock. The steam is pumped to the surface where it turns a turbine attached to an electric generator.



Alternative Fuels

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. Hybrid cars 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. **Figure 26** shows a car that is equipped to use hydrogen as fuel.

Biomass Fuels Could any other materials be used to heat water and produce electricity like fossil fuels and nuclear fission?

Figure 26 Hydrogen may one day replace gasoline as a fuel for automobiles. Burning hydrogen produces water vapor, instead of carbon dioxide.

Biomass can be burned in the presence of oxygen to convert the stored chemical energy to thermal energy. **Biomass** is renewable organic matter, such as wood, sugarcane fibers, rice hulls, and animal manure. Converting biomass is probably the oldest use of natural resources for meeting human energy needs.

section 3 review

Summary

Energy Options

- The development of alternative energy sources can help reduce the use of fossil fuels.

Solar Energy

- Photovoltaic cells, or solar cells, convert radiant energy from the Sun into electrical energy.
- Producing large amounts of energy from solar cells is more expensive than using fossil fuels.

Other Renewable Energy Sources

- Hydroelectric power plants convert the potential energy in water to electrical energy.
- Tidal energy, wind energy, and geothermal energy can be converted into electrical energy, but are useable only in certain locations.
- Alternative fuels such as hydrogen could be used to power cars, and biomass can be burned to provide heat.

Self Check

1. **Explain** the need to develop and use alternative energy sources.
2. **Describe** three ways that solar energy can be used.
3. **Explain** how the generation of electricity by hydroelectric, tidal, and wind sources are similar to each other.
4. **Explain** why geothermal energy is unlikely to become a major energy source.
5. **Think Critically** What single energy source do most energy alternatives depend on, either directly or indirectly?

Applying Math

6. **Use Percentages** A house uses solar cells that generate 6.0 kW of electrical power to supply some of its energy needs. If the solar panels supply the house with 40 percent of the power it needs, how much power does the house use?

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.

Real-World Question

Does the rate at which an object absorbs solar energy depend on the color of the object?

Goals

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

Materials

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

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 data table into your Science Journal. Replace *Other color* with whatever color you are using.
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.

Temperature Due to Different Colors

Color	2 min	4 min	6 min	8 min	10 min
Black					
White	Do not write in this book.				
Other color					

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. **Infer** Suppose you wanted to heat a tub of water using solar energy. Based on the results of 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.

How much does energy really co\$?

Goals

- **Identify** three energy sources that people use.
- **Determine** the cost of the energy produced by each source.
- **Describe** the environmental impact of each source.

Data Source



Visit gpscience.com/internet_lab for more information about energy sources and for data collected by other students.

Real-World Question

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, such as natural gas. Even energy sources, such as hydroelectric power, that don't produce pollution can have an impact on the environment. What are some of the environmental impacts of the energy sources used in the United States? How can these environmental impacts be compared to the cost of the energy produced?

Make a Plan

1. **Research** the various sources of energy used in different areas of the United States and choose three energy sources to investigate.
2. **Research** the cost of the consumer of 1 kWh of electrical energy generated by energy sources you have chosen.
3. **Determine** the effects each of the three energy sources has on the environment.
4. **Use** your data to create a table showing the energy sources, and the energy cost and environmental impact of each energy source.
5. **Decide** how you will evaluate the environmental impact of each of your energy sources.
6. **Write** a summary describing which of your three energy sources is the most cost-effective for producing energy. Consider the cost of the energy and your evaluation of the environmental impact in making your decision. Use information from your research to support your conclusions.



Using Scientific Methods



▶ Follow Your Plan

1. Make sure your teacher approves your plan before you start.
2. **Record** your data in your Science Journal.

▶ 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?

Energy Sources		
Energy Source	Cost per kWh	Environmental Impacts
Energy source 1		
Energy source 2	Do not write in this book.	
Energy source 3		

▶ Conclude and Apply

1. **Explain** Of the energy sources you investigated, which is the least expensive energy source? Which is the best choice to use? Why or why not?
2. **Explain** Of the energy sources you investigated, how did the environmental impact of using that energy source influence your choice of the best energy solution?
3. **Evaluate** Which data support your decision?

Communicating Your Data

Find this lab using the link below.
Post your data in the table provided.
Compare your data to those of other students.


gpscience.com/internet_lab

Reacting to Nuclear Energy

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.

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.

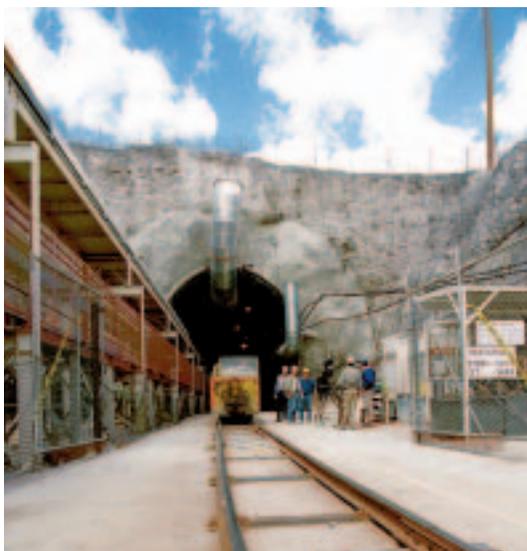
Opponents counter, though, that the poisonous radioactive waste created in nuclear reactors qualifies as pollution—and will be lingering in the ground and water for hundreds of thousands of years.

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.

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.



This site at Yucca Mountain, Nevada, is the location of a proposed high-level nuclear waste storage facility. Here radioactive materials would be buried for tens of thousands of years.

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?

Science  nline

For more information, visit
gpscience.com/time

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 also is used to make plastics and synthetic fabrics.
3. Fossil fuels are nonrenewable energy resources. They can be replaced, but it takes millions of years.



Section 2 Nuclear Energy

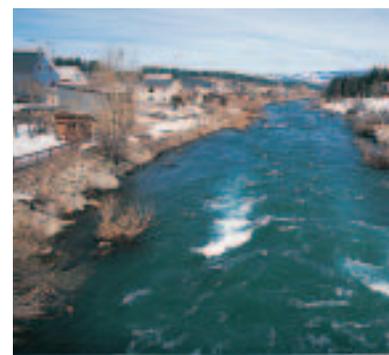
1. A nuclear reactor transforms the energy from a controlled nuclear chain reaction to electrical energy.
2. Nuclear wastes must be contained and disposed of carefully so radiation from nuclear decay will not leak into the environment. These low-level nuclear wastes are buried to protect living organisms.



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. Alternative 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 alternative 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. For example, tides can be used to generate electricity in coastal regions only.
4. It may be possible to use hydrogen as a fuel for automobiles and other vehicles. Biomass, such as wood and other renewable organic matter, has been used as fuel for thousands of years.



FOLDABLES™

Use the Foldable that you made at the beginning of the chapter to help you review energy sources.

Using Vocabulary

biomass p. 276	nuclear reactor p. 264
fossil fuel p. 257	nuclear waste p. 268
geothermal energy p. 275	petroleum p. 259
hydroelectricity p. 273	photovoltaic cell p. 271
nonrenewable resource p. 263	renewable resource p. 271

Complete each statement using a term from the vocabulary list above.

- A(n) _____ uses the Sun to generate electricity.
 - _____ makes use of thermal energy inside the Earth.
 - Energy produced by the rise and fall of ocean levels is a(n) _____.
 - _____ includes the following: oil, natural gas, and coal.
 - Fossil fuels are a(n) _____ because they are being used up faster than they are being made.
 - A special caution should be taken in disposing of _____.
- What is a major disadvantage of using nuclear fusion reactors?
 - use of hydrogen as fuel
 - less radioactivity produced
 - extremely high temperatures required
 - use of only small nuclei
 - How are spent nuclear fuel rods usually disposed of?
 - burying them in a community landfill
 - storing them in a deep pool of water
 - burying them at the reactor site
 - releasing them into the air
 - How much energy in the United States comes from burning petroleum, natural gas, and coal?

A) 85%	C) 65%
B) 35%	D) 25%
 - Solar cells would be more practical to use if they were which of the following?

A) pollution free	C) less expensive
B) nonrenewable	D) larger
 - Which energy source uses water that is heated naturally by Earth's internal heat?

A) hydroelectricity	C) tidal energy
B) nuclear fission	D) geothermal energy
 - What do hydrocarbons react with when fossil fuels are burned?

A) carbon dioxide	C) oxygen
B) carbon monoxide	D) water
 - Which of the following is NOT a source of nuclear waste?
 - products of fission reactors
 - materials with short half-lives
 - some medical and industrial products
 - products of coal-burning power plants
 - Which of the following is the source of almost all of Earth's energy resources?

A) plants	C) magma
B) the Sun	D) fossil fuels

Checking Concepts

Choose the word or phrase that best answers the question.

- Why are fossil fuels considered to be nonrenewable resources?
 - They are no longer being produced.
 - They are in short supply.
 - They are not being produced as fast as they're being used.
 - They contain hydrocarbons.
- To generate electricity, nuclear power plants produce which of the following?

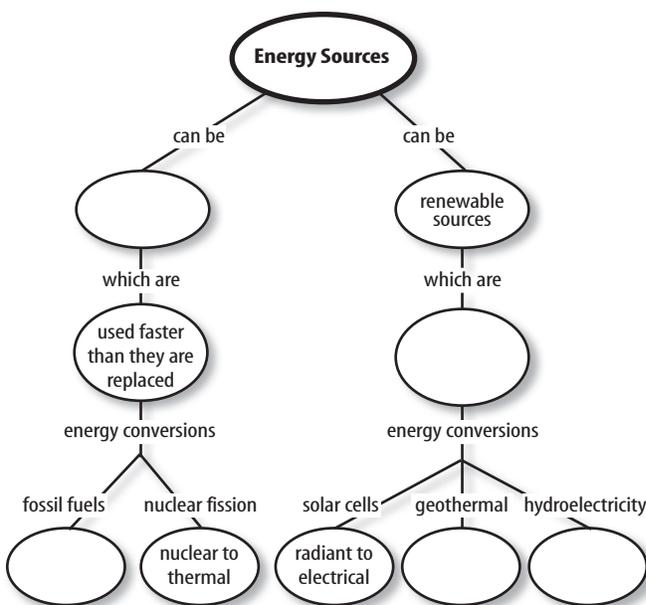
A) steam	C) plutonium
B) carbon dioxide	D) water

Interpreting Graphics

17. Copy and complete the table below describing possible effects of changes in the normal operation of a nuclear reactor.

Reactor Problems	
Cause	Effect
The cooling water is released hot.	Do not write in this book.
The control rods are removed.	
	The reactor core overheats and meltdown occurs.

18. Copy and complete this concept map.



Thinking Critically

19. **Infer** why alternative energy resources aren't more widely used.
20. **Infer** whether fossil fuels should be conserved if renewable energy sources are being developed.

21. **Infer** Suppose new reserves of fossil fuels were found and a way to burn these fuels was developed that did not release pollutants and carbon dioxide into the atmosphere. Should fossil fuels still be conserved? Explain
22. **Explain** why coal is considered a nonrenewable energy source, but biomass, such as wood, is considered a renewable energy source.
23. **Make a table** listing two advantages and two disadvantages for each of the following energy sources: fossil fuels, hydroelectricity, wind turbines, nuclear fission, solar cells, and geothermal energy.

Applying Math

24. **Convert Units** Crude oil is sold on the world market in units called barrels. A barrel of crude oil contains 42 gallons. If 1 gallon is 3.8 liters, how many liters are there in a barrel of crude oil?

Use the table below to answer question 25.

High-Production Coal Mines	
Coal Mine	Metric tons/year
North Antelope Rochelle	6.78×10^7
Black Thunder	6.13×10^7

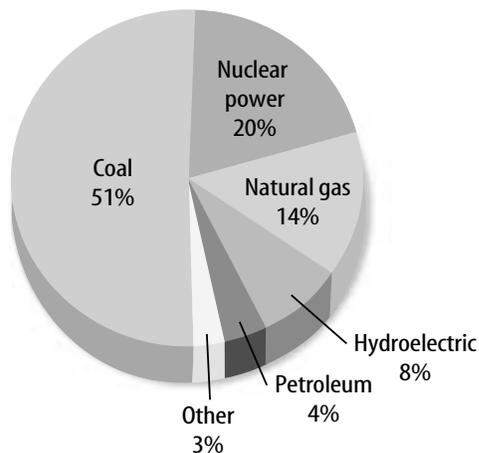
25. **Use Percentages** Nine of the top coal producing mines are located in Wyoming. Production information on two of the mines is in the table above. A total of about 1.02×10^9 metric tons is produced per year in the United States. What percentage do these two coal mines contribute to the total yearly coal production in the U.S.?

Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Use the graph below to answer questions 1 and 2.

Sources of Electricity



- The graph above shows the percentage of electricity generated in the United States that comes from various energy sources. According to the graph, about what percentage comes from fossil fuels?
 - 51%
 - 55%
 - 65%
 - 69%
- The graph shows that approximately what percentage of electricity comes from nonrenewable energy sources?
 - 97%
 - 89%
 - 69%
 - 55%
- Which of the following is a typical efficiency for a solar cell?
 - 10%
 - 50%
 - 75%
 - 95%
- Which of the following best describes wind mills used for the production of electricity?
 - They are quiet.
 - They can be used anywhere.
 - They are 90 percent efficient.
 - They are nonpolluting.
- Which of the following forms only from ancient plant material, not from ancient animal remains?
 - coal
 - crude oil
 - natural gas
 - petroleum

Use the table below to answer questions 6 and 7.

Efficiency of Fossil Fuel Conversion	
Process	Efficiency (%)
Chemical to thermal energy	60
Conversion of water to steam	90
Steam spins turbine	75
Turbine spins electric generator	95
Transmission through power lines	90

- The table above shows the efficiency of different steps in the conversion of fossil fuels to electricity at a power plant. According to the table, what is the efficiency for converting chemical energy in the fossil fuels to heat, and then converting water to steam?
 - 30%
 - 54%
 - 75%
 - 90%
- What is the overall efficiency shown in the table for converting chemical energy in fossil fuels to electricity?
 - 35%
 - 82%
 - 90%
 - 95%

Test-Taking Tip

Determine the Information Needed Concentrate on what the question is asking about a table, instead of all the information in the table.

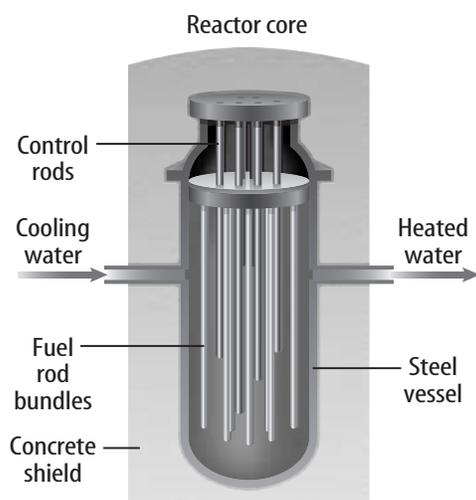
Question 7 Read the question carefully to determine which rows in the table contain the information needed to answer the question.

Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

8. Explain why hydroelectric power plants are almost twice as efficient as fossil fuel or nuclear power plants.
9. About 90 percent of the coal that is used in the United States is used for what purpose?
10. What is the most inefficient stage in the production of electrical energy at a fossil-fuel burning power plant?
11. Describe the typical disposal method for low-level nuclear wastes.

Use the illustration below to answer questions 12 and 13.



12. The core of a nuclear reactor might contain hundreds of fuel rods. Describe the composition of a fuel rod.
13. Describe the purpose of the control rods and explain how their placement in the reactor affects the nuclear chain reaction.
14. Fusion is the most concentrated energy source known. Why, then, is it not used at nuclear plants to make electricity?

Part 3 Open Ended

Record your answers on a sheet of paper.

Use the photograph below to answer questions 15 and 16.



15. The photograph above shows a nuclear power plant that generates electricity using the energy released in nuclear fission of uranium-235. Draw a sketch showing this fission process. Describe your sketch and explain how the process results in a chain reaction.
16. Explain how a nuclear reactor at a nuclear power plant produces electricity. What is the purpose of the large tower shown in the photograph?
17. Explain how the steam that is used to run turbines is produced at a geothermal power plant.
18. Describe two advantages and three disadvantages of using solar energy to generate electricity.
19. Explain why biomass is considered a renewable energy source.
20. Describe the processes that form oil, natural gas, and coal.
21. What is the difference between low-level and high-level nuclear waste? Describe an example of each type.