

Section 1

Fossil Fuels

Key Concept Most of the energy used by humans comes from fossil fuels, which are made up of ancient plant and animal matter that stored energy from the sun.

What You Will Learn

- Fossil fuels are important energy resources.
- Fossil fuels form slowly over very long periods of time.
- Fossil fuels are found and obtained in different ways.
- Fossil fuels are nonrenewable and create pollution when burned.

Why It Matters

Fossil fuels, such as oil and coal, provide energy that you use every day.

How does a sunny day 200 million years ago relate to your life today? If you traveled to school today or used a product made of plastic, you likely used some of the energy from sunlight that warmed Earth several hundred million years ago.

The fuels that are used to run cars, planes, and factories and to generate electrical energy are energy resources. [Energy resources](#) are natural resources that humans use to generate energy. Most of the energy that we use comes from a group of natural resources called fossil fuels. A [fossil fuel](#) is a nonrenewable energy resource that forms from the remains of plants and animals that lived long ago. Petroleum, coal, and natural gas are examples of fossil fuels.

Fossil Fuels as Energy Resources

When fossil fuels are burned, they release energy. Most of the energy released is heat. Power plants and machines use that heat to produce electrical energy. Electrical energy is used to power lights, such as the lights shown in **Figure 1**, and is used in many other ways. But the use of a fossil fuel is limited by the way in which the fuel is obtained and by the availability of the fuel. It is also limited by the process in which the fuel is converted into energy and by the results of that process. Fossil fuels can be obtained and used relatively inexpensively. Thus, they are the most commonly used energy resource. However, fossil fuels are nonrenewable. Replacing fossil fuels that have been burned takes millions of years. Therefore, like other resources, fossil fuels must be conserved.



Figure 1 Light produced from electrical energy can be seen in this composite satellite image.



Types of Fossil Fuels

All living things contain the element carbon. Because fossil fuels form from the remains of plants and animals, all fossil fuels contain carbon, too. Most of the carbon in fossil fuels exists as hydrocarbons, which are hydrogen-carbon compounds. Fossil fuels may exist as liquids, gases, or solids.

Liquid Fossil Fuels: Petroleum

A liquid mixture of complex hydrocarbon compounds is called **petroleum**. Petroleum is commonly known as *crude oil*. Petroleum is separated into several kinds of products in refineries, such as the one shown in **Figure 2**. Examples of products separated from petroleum are gasoline, jet fuel, kerosene, diesel fuel, and fuel oil. Petroleum is also used to make plastics.



Figure 2 This refinery uses a process called distillation to separate petroleum into various types of petroleum products.

More than 40% of the world's energy comes from petroleum products. Petroleum products are the main fuel for airplanes, trains, boats, ships, and automobiles. Crude oil is so valuable that it is often called *black gold*.

Standards Check Which kind of resource is petroleum: renewable or nonrenewable?

Gaseous Fossil Fuels: Natural Gas

A gaseous mixture of hydrocarbons is called **natural gas**. Most natural gas is used for heating, but some is used for generating electrical energy. Your kitchen stove may be powered by natural gas. Some motor vehicles use natural gas as fuel. An advantage of using natural gas is that burning natural gas causes less air pollution than burning petroleum does. But natural gas is very flammable. Sometimes, gas leaks lead to fires or deadly explosions.

Methane, CH_4 , is the main component of natural gas. But other components, such as butane and propane, can be separated from natural gas, too. Butane and propane are used as fuel for camp stoves and outdoor grills.

Solid Fossil Fuels: Coal

The solid fossil fuel that humans use most is coal. **Coal** is a fossil fuel that forms underground from partially decomposed plant material. Coal was once the major source of energy in the United States. When fossil fuels, including coal, are burned, most of the energy released is heat. As a result, people burned coal in stoves to heat their homes. They also used coal in transportation. Many trains in the 1800s and early 1900s were powered by coal-burning steam locomotives.

As cleaner energy resources became available, people reduced their use of coal. They began to use coal less because burning coal produces large amounts of air pollution. Now, people use forms of transportation that use petroleum products instead of coal as fuel. In the United States, coal is now rarely used as fuel for heating. However, many power plants burn coal for heat to turn turbines that generate electrical energy. These power plants use pollution controls such as scrubbers and filters to prevent air pollution from the burning of coal. The power plant in **Figure 3** burned coal to produce electricity.

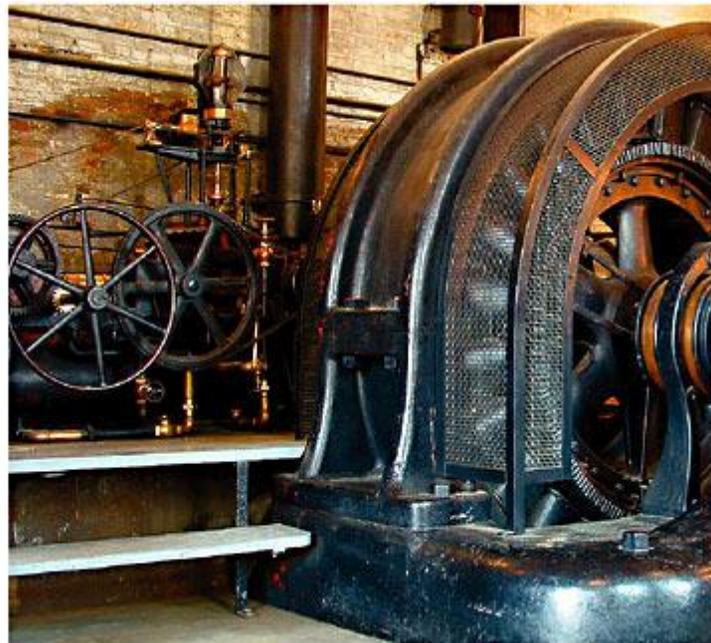


Figure 3 The photo at right shows a turbine at the old Folsom coal-fired power plant near Sacramento. The map above shows the locations of coal-fired power plants throughout California.

Standards Check Why is coal a useful fuel for heating?

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How Do Fossil Fuels Form?

All fossil fuels form from the buried remains of ancient organisms. But fossil fuels differ in the ways in which they form and in the kinds of organisms from which they form.

Formation of Petroleum and Natural Gas

Petroleum and natural gas form mainly from the remains of microscopic sea organisms. When these organisms die, their remains settle on the ocean floor. There, the remains are buried in sediment. Over time, the sediment is compacted and slowly becomes rock. Through physical and chemical changes over millions of years, the remains of the organisms become petroleum and natural gas. Gradually, more rocks form above the rocks that contain the fossil fuels. Under the pressure of overlying rocks and sediments, the fossil fuels can move through permeable rocks. *Permeable rocks* are rocks through which fluids, such as petroleum and gas, can move. As **Figure 4** shows, these permeable rocks become reservoirs that hold petroleum and natural gas.

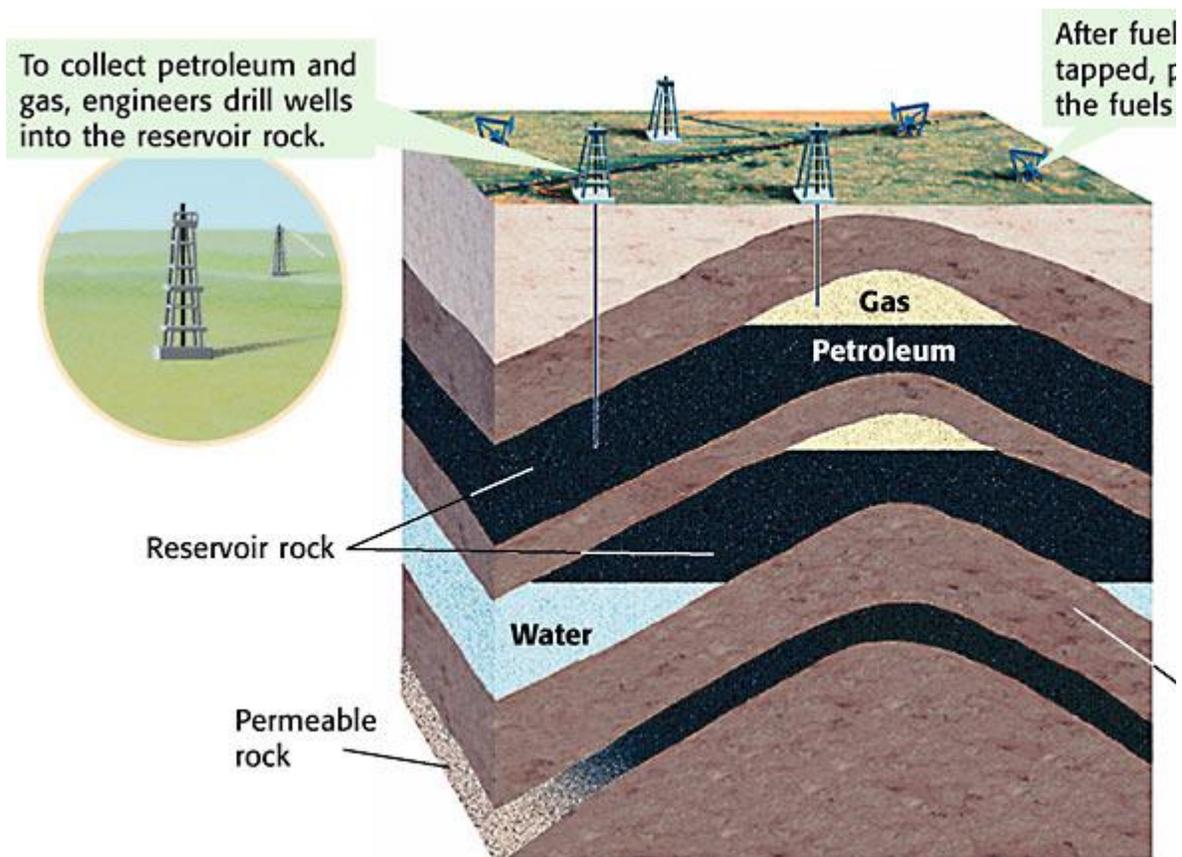


Figure 4 Petroleum and gas move through permeable rock. Eventually, these fuels collect in reservoirs. Rocks that are folded up ward are excellent fossil-fuel traps. The formation of petroleum and natural gas is an ongoing process. Part of the remains of today's sea life will become petroleum and natural gas millions of years from now.

Formation of Coal

Coal forms underground over millions of years when pressure and heat cause changes in the remains of swamp plants. When these plants die, they sink to the bottom of the swamp. If they do not decay completely, coal formation may begin. The stages of the formation of coal are shown in **Figure 5**.

Figure 5 Formation of Coal



Stage 1: Formation of Peat

Sunken swamp plants that have not decayed completely can change into peat. About 60% of an average sample of dried peat is carbon.



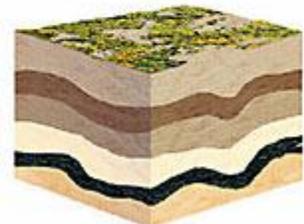
Stage 2: Formation of Lignite

If sediment buries the peat, pressure and temperature increase. The peat slowly changes into a type of coal called *lignite*. Lignite is harder than peat, and about 70% of an average sample of lignite is carbon.



Stage 3: Formation of Bituminous Coal

If more sediment is added, pressure and temperature force more water and gases out of the lignite. Lignite slowly changes into bituminous coal. About 80% of an average sample of bituminous coal is carbon.



Stage 4: Formation of Anthracite

If more sediment accumulates, temperature and pressure continue to increase. Bituminous coal slowly changes into anthracite. Anthracite is the hardest type of coal. About 90% of an average sample of anthracite is carbon.

The first step in the formation of coal is the change of plant remains into peat. Peat is brown, crumbly matter made mostly of plant material and water. Peat is not coal. In some parts of the world, peat is dried and burned for heat or as fuel. If the peat is buried by sediment, pressure and heat increase and the peat is converted into coal. The pressure and heat force water and gases out of the coal. As a result, the coal becomes harder, and its carbon content increases. The amount of heat and pressure determines the type of coal that forms. Lignite forms first, followed by bituminous coal and, finally, anthracite. The formation of coal can stop at any stage of the process.

Today, all three types of coal are mined throughout the world. The greater the carbon content of the coal, the more cleanly the coal burns. But when burned, all types of coal release heat and pollute the air.

Where Fossil Fuels Are Found

Fossil fuels are found in many parts of the world. Some fossil fuels are found on land. Other fossil fuels are found beneath the ocean in Earth's crust. As **Figure 6** shows, the United States has large reserves of petroleum, natural gas, and coal. Despite its large reserves of petroleum, the United States imports petroleum. More than one-half of the petroleum used by the United States is imported from the Middle East, South America, Africa, Canada, and Mexico.

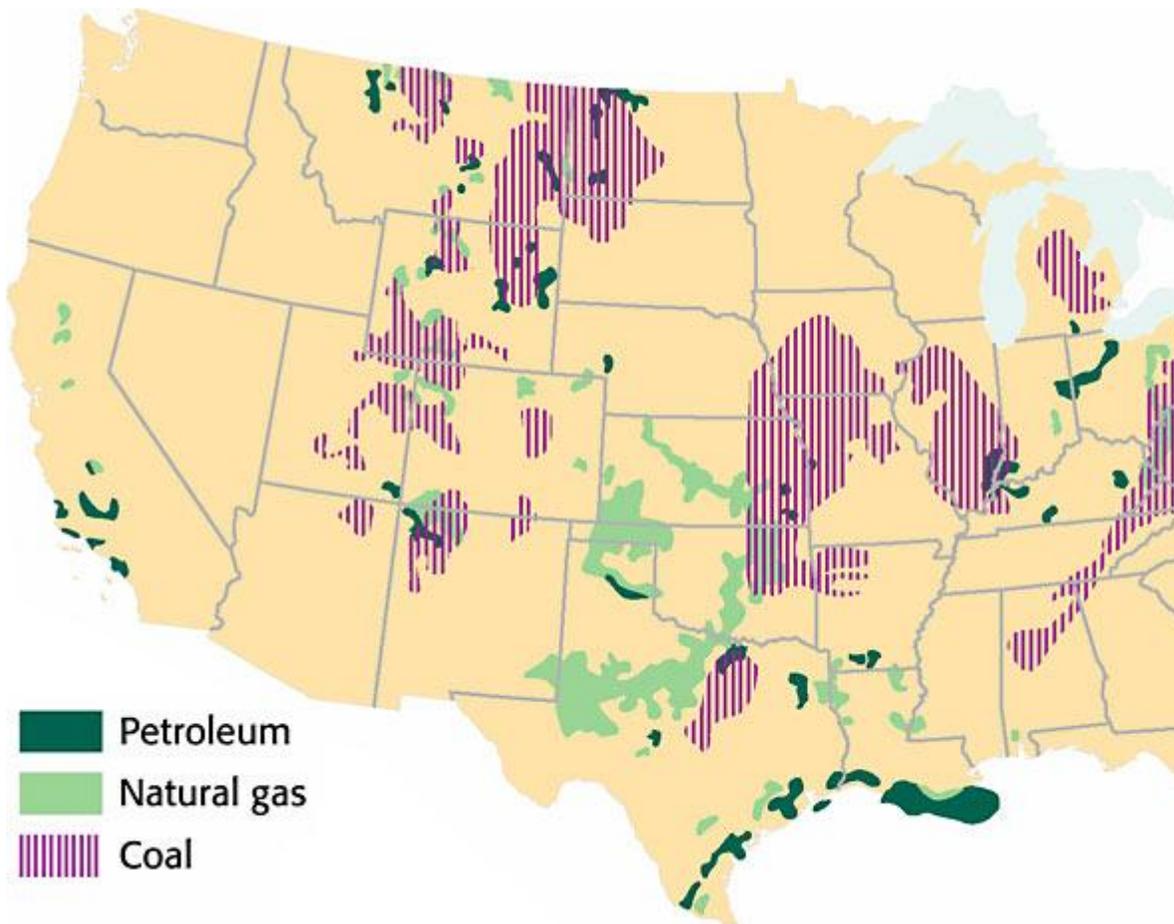


Figure 6 Most of the petroleum and natural gas mined in the continental United States comes from areas that were prehistoric oceans. Coal comes from areas that were swamps or bogs.

How Fossil Fuels Are Obtained

Humans use several methods to remove fossil fuels from Earth's crust. The method that is used to remove a fuel depends on the type of fuel and the location of the fuel. People remove petroleum and natural gas from the ground by drilling wells into rock that contains these resources. Oil wells exist on land and in the ocean. For offshore drilling, engineers mount drills on platforms that are secured to the ocean floor or that float at the ocean's surface. **Figure 7** shows an offshore oil rig.



Figure 7 Large oil rigs, some of which are more than 300 m tall, operate offshore in many places, such as the Gulf of Mexico and the North Sea.

People obtain coal either by mining deep beneath Earth's surface or by surface mining. Surface mining, or strip mining, is the removal of soil and surface rock to reveal underlying coal deposits.

Standards Check How are natural gas and petroleum removed from the ground?

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Problems with Fossil Fuels

Fossil fuels provide the energy that humans need. But the methods of obtaining and using these fuels can affect the environment negatively. For example, when coal is burned without pollution controls, sulfur dioxide is released. Sulfur dioxide combines with moisture in the air to produce sulfuric acid. Sulfuric acid is one of the acids in acid precipitation. **Acid precipitation** is rain, sleet, or snow that has a high concentration of acids, often because of air pollutants. Acid precipitation negatively affects wildlife, plants, buildings, and statues, as **Figure 8** shows.

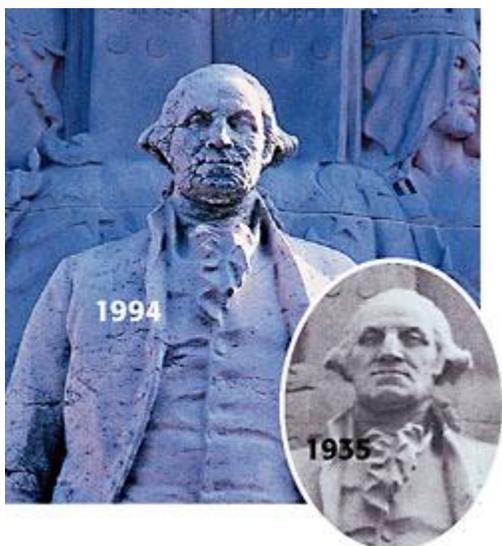


Figure 8 Notice how this statue looked before the effects of acid precipitation.

Standards Check How can burning fossil fuels affect rain?

Problems with Coal Mining

The mining of coal can also create environmental problems. Surface mining removes soil. Most plants need soil for growth, and some animals need soil for shelter. If land is not properly restored after surface mining, wildlife habitats can be destroyed. Coal mining can lower water tables and can pollute water supplies with heavy metals. The potential for underground mines to collapse endangers the lives of miners.

Petroleum Problems

Producing, transporting, and using petroleum can cause environmental problems and can endanger wildlife. In June 2000, the carrier *Treasure*

sank off the coast of South Africa and spilled more than 400 tons of oil. The toxic oil coated thousands of blackfooted penguins, as **Figure 9** shows. The oil hindered the penguins from swimming and catching fish for food.



Figure 9 The oil spilled from the carrier Treasure endangered the lives of many animals, including blackfooted penguins.

Smog

Burning petroleum products causes an environmental problem called smog. *Smog* is photochemical haze that forms when sunlight acts on industrial pollutants or gasoline engine exhaust. Smog is particularly serious in cities such as Los Angeles. In Los Angeles, millions of automobiles burn gasoline. The mountains that surround Los Angeles prevent the wind from blowing pollutants away. This combination of factors causes smog build up.



Section Summary

- Energy resources are natural resources that humans use to produce energy.
- Fossil fuels are nonrenewable resources that form slowly over long periods of time from the remains of dead organisms. Petroleum, natural gas, and coal are fossil fuels.
- When fossil fuels are burned, they release energy. Most of that energy is heat energy.
- How humans use fossil fuels depends on the availability of the fuel, the ways in which the fuels are converted into energy, and the effects of converting the fuels into energy.
- Fossil fuels are found all over the world. The United States imports more than half of the petroleum that it uses from the Middle East, South America, Africa, Mexico, and Canada.
- Fossil fuels are obtained by drilling oil wells, mining below Earth's surface, and strip mining.
- Acid precipitation, smog, water pollution, and the destruction of wildlife habitats are some of the environmental problems created by the use of fossil fuels.

