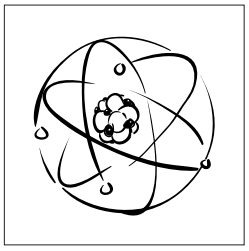
Nonrenewable Energy Sources



Nonrenewable Energy Source: FOSSIL FUELS

TERMS IN GLOSSARY

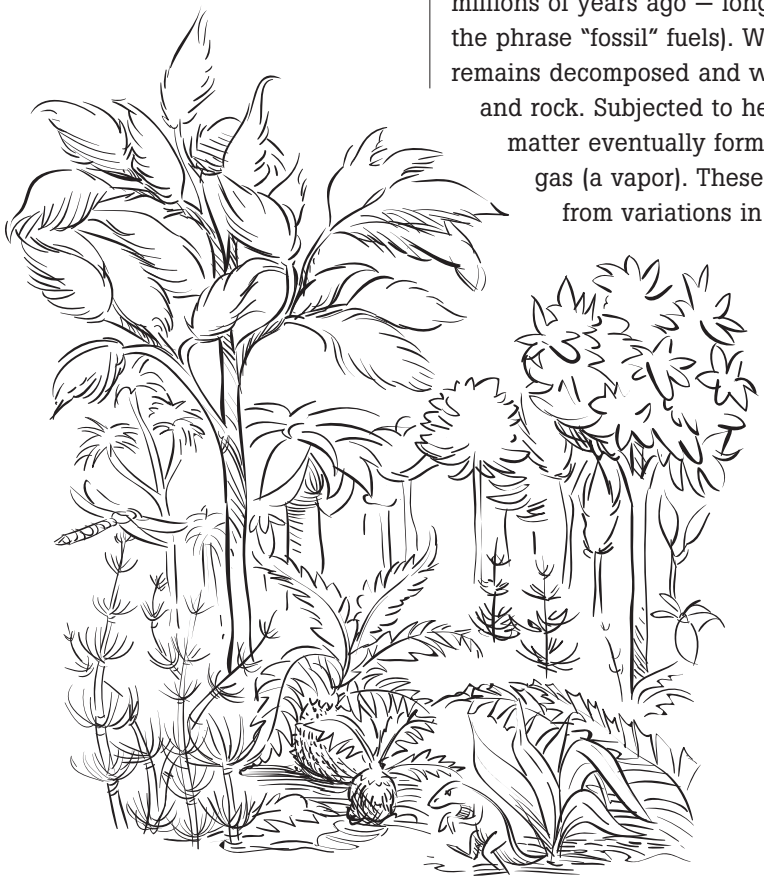
acid rain
carbon-based compound
combined cycle power plant
crude oil
gas turbine
global climate change
greenhouse gas
hydrocarbon
liquefied natural gas (LNG)
oil rig
oil refinery
scrubber
synthetic

FOSSIL FUELS — COAL, OIL, AND NATURAL GAS — have been highly prized energy sources for centuries. Mining for coal may have first occurred in China as far back as 200 B.C. By 200 A.D. the Romans made wide use of the coal resources they found in the British Isles. In the 1100s, oil wells were being drilled in Europe and along the west coast of the Caspian Sea. It was the Industrial Revolution, however, that launched the widespread use of fossil fuels to power factories and transportation systems. Electricity was first produced using coal in the 1880s. Since that time, fossil fuels have been the dominant source of energy for electrical production, transportation, and industry in the United States and around the world.

THE FOSSIL FUEL RESOURCE

All fossil fuels were formed from plants and animals that lived millions of years ago — long before the days of the dinosaurs (hence, the phrase "fossil" fuels). When these plants and animals died, their remains decomposed and were eventually buried under tons of soil and rock. Subjected to heat and pressure over time, this organic matter eventually formed coal (a solid), oil (a liquid), and natural gas (a vapor). These three different fossil fuel types resulted from variations in geologic conditions over time.

Fossil fuels are nonrenewable resources. They formed very long ago, when much of the earth was covered with swamps and the climate was extremely warm. These conditions were perfect for many living things, including huge ferns, trees, and other plants. The swamps and seas were teeming with algae and other small organisms. These lush conditions are not nearly as widespread today. Small amounts of fossil fuels may still be forming, but not in significant quantities. And, they will not form in a useful amount of time.



Plants and animals of long ago formed the fossil fuels we use today.

Living things are carbon-based, so all fossil fuels are made of molecules that contain carbon. They also contain hydrogen, giving rise to the name "hydrocarbons." Hydrocarbons burn easily. They are a reliable source of heat energy and are convenient to transport.

When fossil fuels are burned, carbon combines with oxygen, resulting in emissions of carbon dioxide gas. Fossil fuels contain other substances in addition to hydrocarbons. Sulfur, nitrogen, mercury and other impurities are found in varying amounts in each fossil fuel. When burned, these recombine with other materials and form air pollutants.

Coal

Coal is a solid hydrocarbon that we excavate from underground, just as we mine for minerals. One age-old method is to mine coal from tunnels dug deep underground. The other, and more recent, method is called surface- or strip-mining. Here, deposits within about 200 feet of the surface are exposed by removing the overlaying rock and soil. Once topside, coal is easy to transport, usually in large containers aboard ships or on trains.

There are abundant supplies of coal in the United States, with coal deposits in states across the continent. The top coal-producing states are Wyoming, West Virginia, Illinois, Montana, and Pennsylvania. Outside the U.S., China, Australia, India, and South Africa produce the most coal.

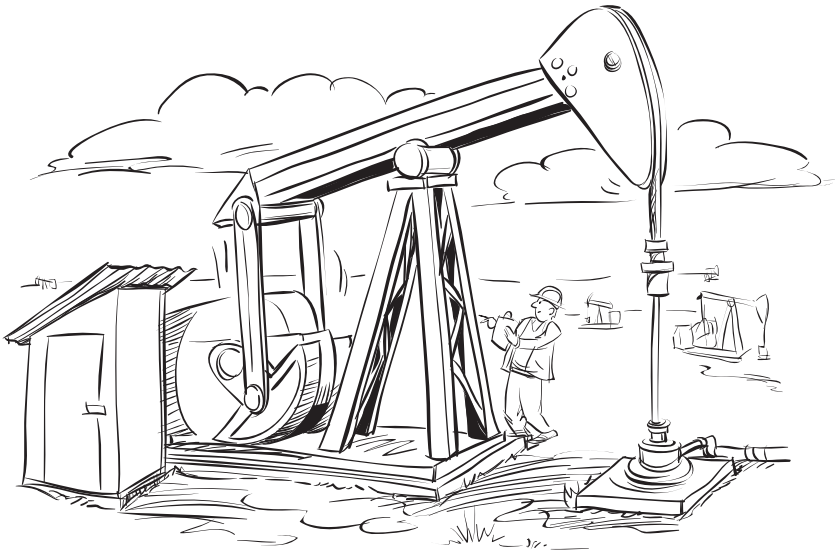
Oil

Oil, also known as petroleum or crude oil, is a thick black liquid hydrocarbon found in reservoirs hundreds to thousands of feet below the surface. We extract it by drilling wells deep into the underground rock and then inserting pipes. Natural pressure can bring the oil shooting to the surface when wells are new; but, in most cases, pumps are needed to bring the oil to the surface. These oil field pumping units are common sights on land and at sea (on offshore platforms) in oil-producing areas.

Once captured, crude oil is taken to refineries and processed into various products. These include gasoline, diesel, aviation fuel, home heating oil, asphalt, and oil burned for electrical power. Oil products are sent from refineries through pipelines directly to consumers, or are delivered in large tanks aboard trains, trucks, or tanker ships.

MAKING AMERICA GO

Though less commonly used for producing electricity than coal, oil is still the most widely used fossil fuel. Why? Because for decades it has been refined into gasoline, diesel, and aviation fuel to power our cars, trains, trucks, and planes. It is also used extensively for heating homes and businesses, for industrial process heat, and to make fertilizers, machinery lubricants, medicines, and many types of plastics.



A pumping rig is used to bring up crude oil.

Of the world's top producers of crude oil, Saudi Arabia is first, the United States is second, and Russia is third. In the U.S., oil is produced in Texas, Alaska, California, and 28 other states. Production in the United States has already begun its decline. Over half of the oil used in the U.S. today is imported, and experts expect Africa to supply much of the world's oil in the future.

Natural Gas

Natural gas (mostly methane) is a hydrocarbon vapor that occurs naturally underground. (It is not the same thing as the liquid gasoline that we use in our vehicles, though we do call this "gas" for short.) Natural gas is piped to the surface through wells drilled into the underground rock.

Natural gas can be processed into propane and other types of fuels. All natural gas fuels are highly flammable. Natural gas is odorless, so for safety it is mixed with a chemical to give it a noticeable smell before it is sent to consumers. Huge networks of pipelines deliver most natural gas directly to homes, factories, and power plants. Natural gas can be stored and shipped in pressurized containers. It can also be condensed to a liquid. This liquefied natural gas (also known as LNG) can be transported and re-vaporized for later use. Natural gas can also be used to produce nonrenewable hydrogen.

Russia, the United States, and Canada are currently the world's top producers of natural gas. As natural gas production in the U.S. and Canada continues to decline, more and more natural gas is likely to be imported as liquefied natural gas.

GENERATING ELECTRICITY WITH FOSSIL FUEL RESOURCES

Most electricity in the United States is produced in "conventional" fossil fuel power plants. A fuel is burned to boil water to make steam. The force of steam is what drives the turbine generator. (See "How a Steam-Driven Power Plant Works," page 29.) While some plants burn petroleum or, more frequently, natural gas, the fuel most used for electricity generation in the U.S. has been, and still is, coal.

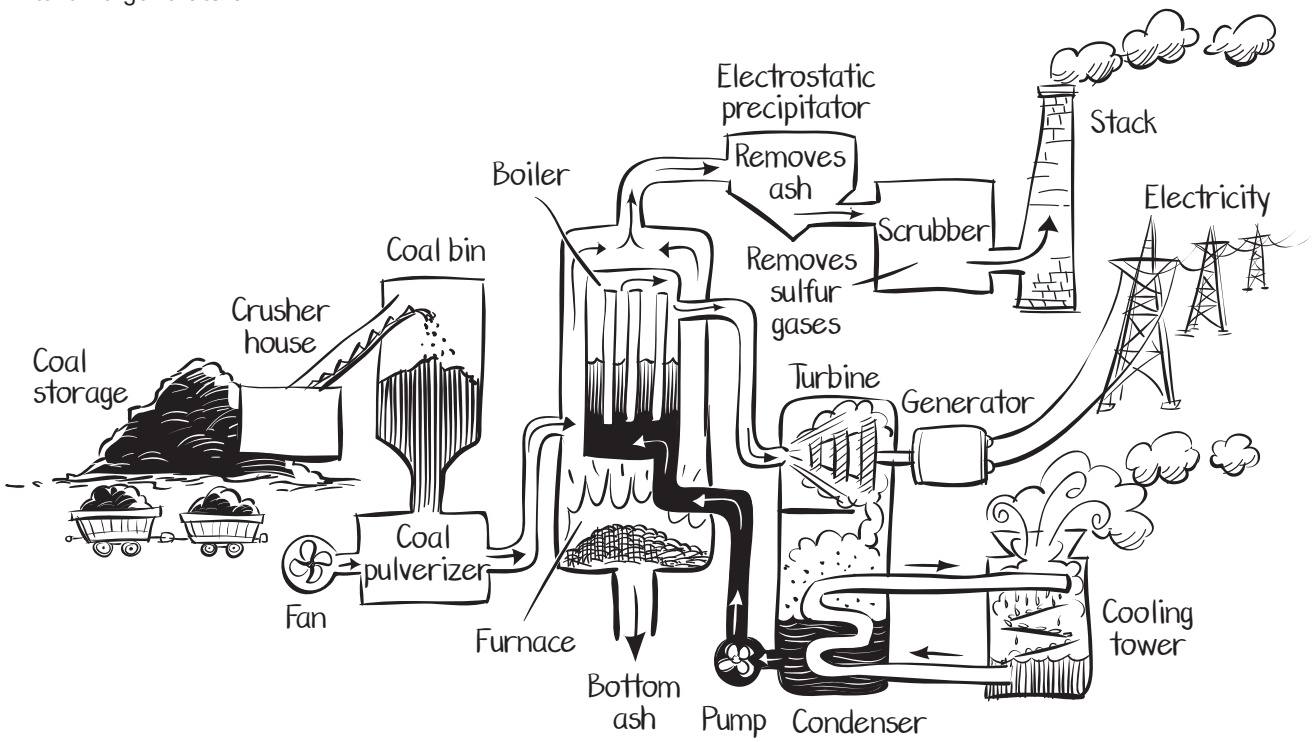
REMINDER

W = watt
kW = kilowatt = 1,000 watts
MW = megawatt = 1,000 kilowatts

1 megawatt can serve about 1,000 homes in the United States.

Coal-fired Power Plants

A 1,000 MW coal-fired power plant burns about 10,000 tons of coal a day, providing electricity to about one million people. Sometimes a coal-powered plant is located right at a coal mine. Other times the coal arrives in trains that go back and forth non-stop between the mine and the power plant. The coal is usually processed into pulverized fine particles that are burned to create the steam needed to power the turbine generators.



A conventional coal power plant

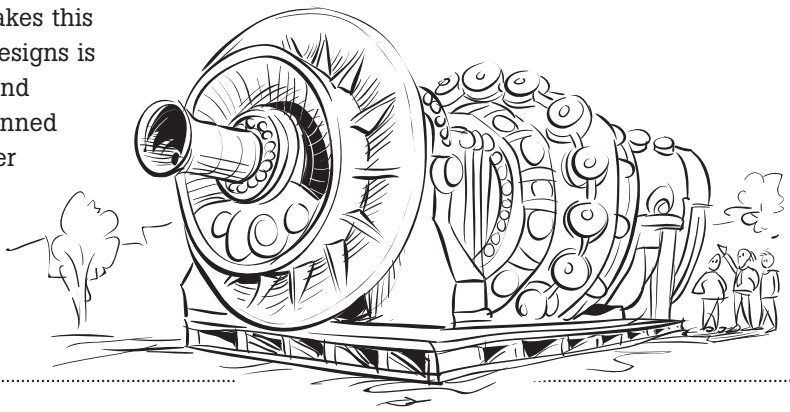
Currently we are developing methods to "clean" coal. These methods reduce the amounts of some impurities, such as sulfur and nitrogen, before the coal is burned. This process lessens the need to remove by-products after it is burned. We have also developed a technology to "cook" coal using gasification. This produces a cleaner-burning, synthetic (artificially made) gas. Coal gasification can also produce hydrogen.

Gas Turbines

Natural gas was originally used mostly for heating and in industrial processes. But now it is also used for generating electricity and was, in fact, the preferred fuel for new power plants in the 1990s. The first natural gas power plants were conventional steam-driven combustion turbines. Today's gas-powered plants use a turbine based on jet aircraft engine design. A mixture of compressed natural gas and high-pressure air is burned in a continuous fiery explosion. The hot exhaust from this combustion reaction is what drives the turbines. This method is more efficient and cleaner burning than the steam-driven turbines.

POWER SKETCH: Clean Spin on an Old Design

Recent advances in the design of gas turbines mean much greater efficiency and far less pollution. One of these high-tech turbines is larger than the biggest locomotive. It uses the same system as today's gas turbine models: the exhaust resulting from the explosive combustion of compressed natural gas is used to spin the turbine. What makes this turbine even better than earlier designs is its exceptional energy efficiency and greatly reduced air emissions. Planned to work in "combined cycle" power plants (see next page), these sophisticated turbines are being applauded as a cleaner way to produce electricity when using fossil fuels.



"Combined Cycle" Power Plants

Since about 1985, most new natural gas power plants have been "combined cycle" plants, in which two turbine types work together to produce electricity. First the gas turbine produces electricity using the hot exhaust from the combustion reaction as described on page 121. Then that same exhaust — still extremely hot — is used to boil water to produce steam in a conventional boiler. The steam spins a second turbine that generates even more electricity. Since combined cycle systems produce extra electricity by using what would otherwise be wasted heat, they are exceptionally energy efficient.

Size of Fossil Fuel Power Plants

Coal plants and natural gas power plants are typically large, generating 300 to 1000 MW of electricity or more. But natural gas plants come in all sizes. A university in Florida uses a 42 MW plant to produce electricity, hot water, and heat for its buildings. Often hospitals, or other places that must continue to operate at all times, have back-up diesel or natural gas turbines in case the power goes out. Natural gas "microturbines" of 25 to 500 kW can also be used in small businesses and as standby or peaking power.

CONSIDERATIONS

- Coal, oil and natural gas are high-energy fuels that are easy to transport. They can also be converted to other forms like propane.
- Fossil fuels have the advantage of a long history. Technology using fossil fuels has been refined over time, so their use is convenient and familiar.
- Forecasts differ for how long world oil and natural gas supplies will last at projected rates of consumption. There seems to be agreement that it will be only decades, not centuries. Many experts suggest oil supplies have already peaked.
- As oil and natural gas production decline worldwide (as it already has in the U.S.), prices will rise due to shortages or fear of shortages.

- Fossil fuels create air pollution when burned. In the United States, regulations require that most fossil-fuel power plants equip their smokestacks with "scrubbers" that trap some of these pollutants. Enforcement of regulations tends to vary with the political climate. (See also Chapter 4, "Energy, Health, and the Environment," pages 133–142, and Chapter 5, "Energy Management Strategies and Energy Policy," pages 143–155.)
- Natural gas has fewer impurities than coal or petroleum and burns cleaner than other fossil fuels.
- Most of the power plants built in the U.S. in the last 20 years have been natural gas plants. As U.S., Canadian, and Mexican natural gas supplies decline, the U.S. will need to import more and more liquefied natural gas in LNG vessels from distant ports.
- It takes energy to liquify and transport natural gas, which must be cooled to -260°F (-162°C) and be kept at that temperature. Then, at its destination port, it takes still more energy to return it to a vapor and pressurize it for delivery through pipelines to customers.
- Although grateful for worldwide fuel sources, many Americans have concerns about importing them: supply and cost impact the economy, and foreign dependence impacts national security.
- Every industry has accidents, and, while they are not common, some have greater consequences than others. For example, the 1982 Valdez oil tanker accident in Alaska created an oil spill that covered over 1,000 miles of shoreline. The oil killed many birds, fish, and other animals. It greatly disrupted the natural habitat and the local fishing economy.

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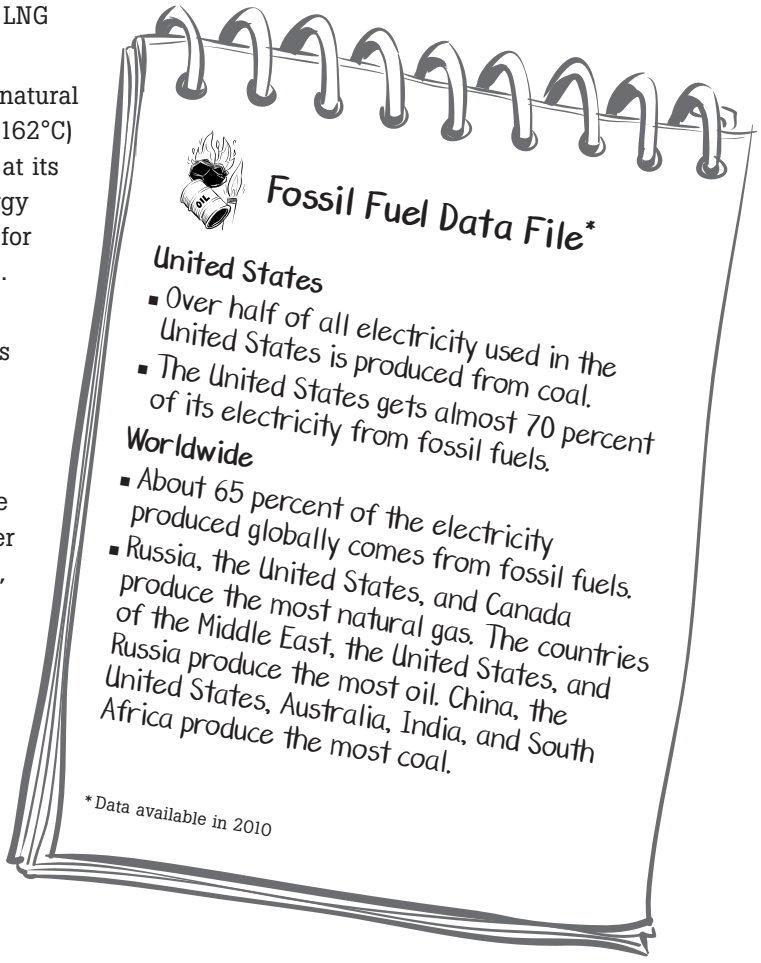

CONSIDERATIONS (continued)

- Mining coal often causes serious disturbances to the surface habitat of an area. For example, to uncover the coal deposits at some surface coal mines, hilltops are scraped off, and the plants, soil, and rocks are pushed into the valleys and streams below. And with tunnelling, holes usually remain after a mine is abandoned. If soils are set aside and replaced, an agricultural area can usually be "reclaimed" and returned to farmland once the coal has been removed. However, any natural area disrupted by mining activity will in all likelihood never be the same.
- Coal and oil power plants are usually baseload facilities. Natural gas power plants can be operated as baseload or peaking plants, and small gas turbines are often used as emergency backup. Diesel plants are used for peaking or emergency standby power.