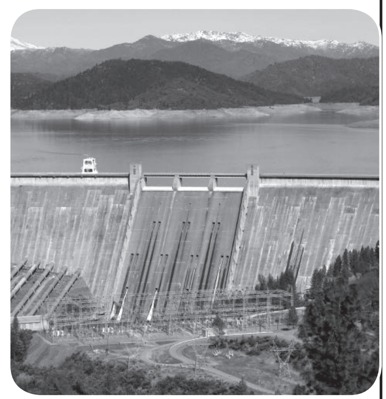
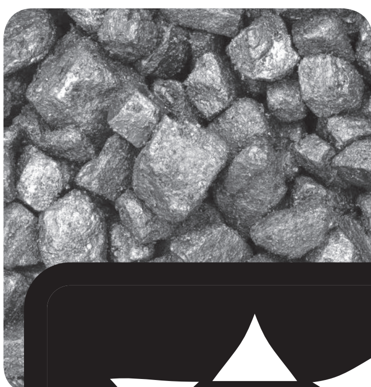
2014-2015

Intermediate Energy Infobook

A comprehensive classroom resource containing fact sheets that introduce students to energy, and describe energy sources, electricity, consumption, efficiency, conservation, transportation, climate change, and emerging technologies. The Infobooks can be used as a resource for many energy activities.




Grade Level:

Int Intermediate

Subject Areas:

- Science
- Social Studies
- Math
- Language Arts
- Technology

NEED
National Energy Education Development Project

Introduction to Energy

What Is Energy?

Energy makes change; it does things for us. It moves cars along the road and boats over the water. It bakes a cake in the oven and keeps ice frozen in the freezer. It plays our favorite songs and lights our homes. Energy makes our bodies grow and allows our minds to think. Scientists define energy as the ability to do work.

Forms of Energy

Energy is found in different forms, such as light, heat, sound, and motion. There are many forms of energy, but they can all be put into two categories: potential and kinetic.

POTENTIAL ENERGY

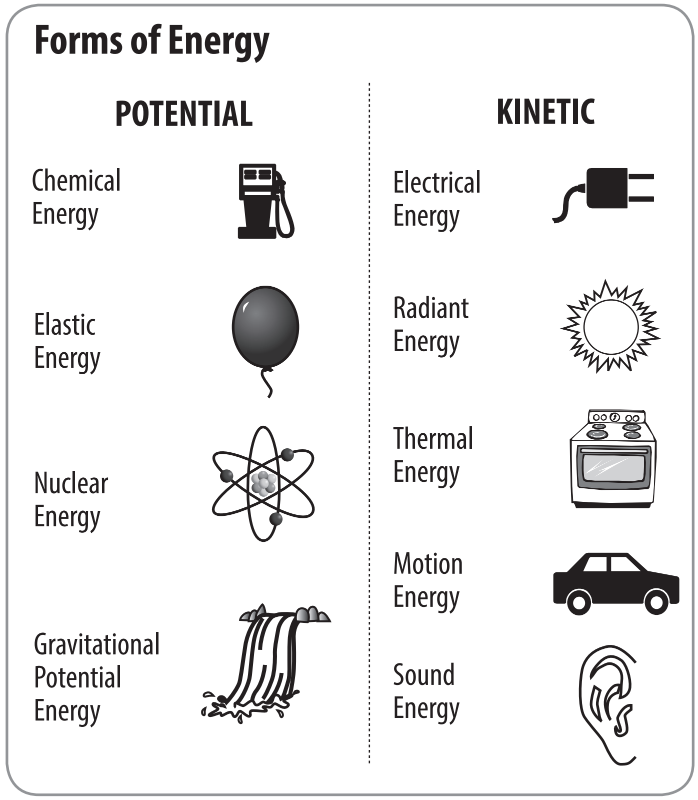
Potential energy is stored energy and the energy of position, or gravitational potential energy. There are several forms of potential energy.

- **Chemical energy** is energy stored in the bonds of **atoms** and **molecules**. It is the energy that holds these particles together. Biomass, petroleum, natural gas, propane, and the foods we eat are examples of stored chemical energy.
- **Elastic energy** is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of elastic energy.
- **Nuclear energy** is energy stored in the nucleus of an atom; it is the energy that holds the nucleus together. The energy can be released when the nuclei are combined or split apart. Nuclear power plants split the nuclei of uranium atoms in a process called **fission**. The sun combines the nuclei of hydrogen atoms in a process called **fusion**.
- **Gravitational potential energy** is the energy of position or place. A rock resting at the top of a hill contains gravitational potential energy because of its position. Hydropower, such as water in a reservoir behind a dam, is an example of gravitational potential energy.

KINETIC ENERGY

Kinetic energy is motion; it is the motion of waves, **electrons**, atoms, molecules, substances, and objects.

- **Electrical energy** is the movement of electrons. Everything is made of tiny particles called atoms. Atoms are made of even smaller particles called electrons, protons, and neutrons. Applying a force can make some of the electrons move. Electrons moving through a wire are called **electricity**. Lightning is another example of electrical energy.
- **Radiant energy** is **electromagnetic** energy that travels in vertical (transverse) waves. Radiant energy includes visible light, x-rays, gamma rays, and radio waves. Solar energy is an example of radiant energy.



- **Thermal energy**, or heat, is the internal energy in substances; it is the vibration and movement of the atoms and molecules within a substance. The more thermal energy in a substance, the faster the atoms and molecules vibrate and move. Geothermal energy is an example of thermal energy.
- **Motion energy** is the movement of objects and substances from one place to another. Objects and substances move when an unbalanced force is applied according to **Newton's Laws of Motion**. Wind is an example of motion energy.
- **Sound energy** is the movement of energy through substances in longitudinal (compression/rarefaction) waves. Sound is produced when a force causes an object or substance to vibrate; the energy is transferred through the substance in a longitudinal wave.

Biomass

What Is Biomass?

Biomass is any **organic** matter that can be used as an energy source. Wood, crops, and yard and animal waste are examples of biomass. People have used biomass longer than any other energy source. For thousands of years, people have burned wood to heat their homes and cook their food.

Biomass gets its energy from the sun. Plants absorb sunlight in a process called **photosynthesis**. With sunlight, air, water, and nutrients from the soil, plants make sugars called **carbohydrates**. Foods that are rich in carbohydrates (like spaghetti) are good sources of energy for the human body. Biomass is called a **renewable** energy source because we can grow more in a short period of time.

Use of Biomass

Until the mid-1800s, wood gave Americans 90 percent of the energy they used. Today, biomass provides us almost five percent of the energy we use. It has been replaced by coal, natural gas, petroleum, and other energy sources.

There are many sources of biomass used in the U.S. today. Two sources, wood and **biofuels**, make up the majority of consumption. Other biomass sources include crops, garbage, landfill gas, and by-products from agriculture.

Industry is the biggest biomass consumer today; it uses 51.2 percent of biomass to make products. The transportation sector uses 26.4 percent of biomass by consuming **ethanol** and other biofuels. Power companies use biomass to produce electricity. Over 10 percent of biomass is used to generate electricity today.

Homes and businesses are the third biggest users; about one in ten homes burn wood in fireplaces and stoves for additional heat. Less than three percent use wood as their main heating fuel.

In the future, plants may be grown to fuel power plants. Farmers may also have huge farms of energy crops to produce ethanol and other biofuels for transportation.

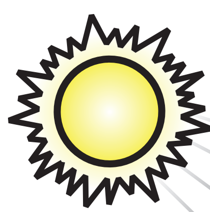
Biomass and the Environment

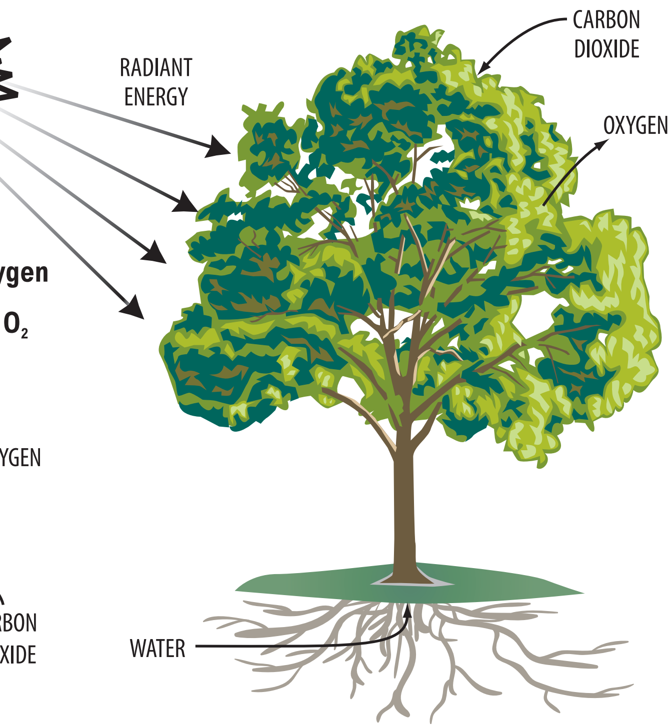
Biomass can pollute the air when it is burned, though not as much as fossil fuels. Burning biomass fuels does not produce pollutants like sulfur, which can cause acid rain.

Growing plants for biomass fuel may help to reduce greenhouse gases, since plants use **carbon dioxide** and produce oxygen as they grow. Carbon dioxide is considered an important **greenhouse gas**.

Photosynthesis

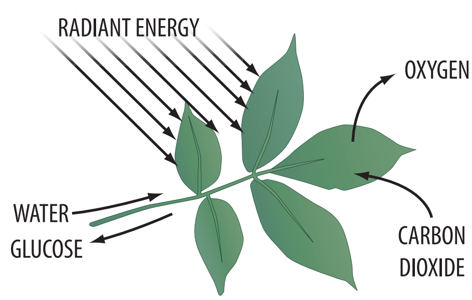
In the process of photosynthesis, plants convert radiant energy from the sun into chemical energy in the form of glucose (or sugar).





water + carbon dioxide + sunlight → glucose + oxygen

$$6\,H_2O + 6\,CO_2 + \text{radiant energy} \rightarrow C_6H_{12}O_6 + 6\,O_2$$



Data: Energy Information Administration

Using Biomass Energy

A log does not give off energy unless you do something to it. Usually, wood is burned to make heat. Burning is not the only way to use biomass energy, though. There are four ways to release the energy stored in biomass: burning, bacterial decay, **fermentation**, and conversion to gas/liquid fuel.

▪ Burning

Wood was the biggest energy provider in the United States and the rest of the world until the mid-1800s. Wood heated homes and fueled factories. Today, wood supplies only a little of our country's energy needs. Wood is not the only biomass that can be burned. Wood shavings, fruit pits, manure, and corn cobs can all be burned for energy.

Garbage is another source of biomass. Garbage can be burned to generate steam and electricity. Power plants that burn garbage and other waste for energy are called **waste-to-energy plants**. These plants are a lot like coal-fired plants. The difference is the fuel. Garbage doesn't contain as much heat energy as coal. It takes about 900 kilograms (2,000 pounds) of garbage to equal the heat energy in 225 kilograms (500 pounds) of coal.

Sometimes, fast-growing crops like sugar cane are grown especially for their energy value. Scientists are also researching ways to grow aquatic plants like seaweed and algae for their energy value.

▪ Bacterial Decay

Bacteria feed on dead plants and animals. As the plants and animals decay, they produce a colorless, odorless gas called **methane**. Methane gas is rich in energy. Methane is the main ingredient in natural gas, the gas we use in our furnaces and stoves. Methane is a good energy source. We can burn it to produce heat or to generate electricity.

In some landfills, wells are drilled into the piles of garbage to capture methane produced from the decaying waste. The methane can be purified and used as an energy source, just like natural gas.

▪ Fermentation

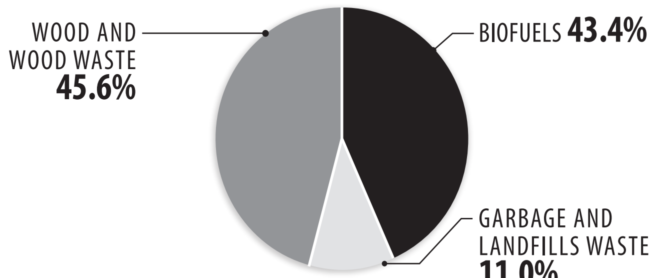
We can add yeast (a fungus) to biomass to produce an alcohol called ethanol. For centuries, people have fermented crops to make alcoholic drinks like beer and wine. Wine is fermented from grapes. Wheat, corn, grasses, and many other crops can be used to make ethanol.

Ethanol is sometimes made from corn to produce a motor fuel. Automobile pioneer Henry Ford wanted to use ethanol to power his cars instead of gasoline. Ethanol is more expensive to use than gasoline. Usually, it is mixed with gasoline to produce a fuel called E-10, which is 90 percent gasoline and 10 percent ethanol. For cars to run on a higher percentage of ethanol, their engines would have to be changed. But cars can run on E-10 without changes. Adding ethanol to gasoline lowers carbon dioxide emissions.

▪ Conversion

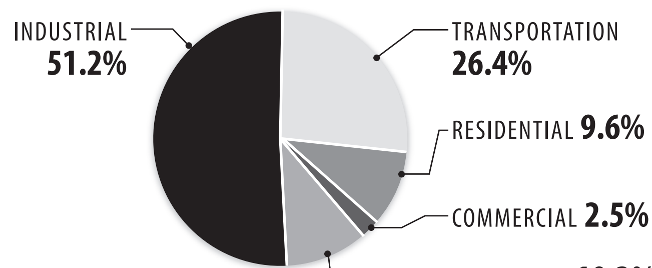
Conversion means changing a material into something else. Today, we can convert biomass into gas and liquid fuels. We do this by adding heat or chemicals to the biomass. The gas and liquid fuels can then be burned to produce heat or electricity, or it can be used as a fuel for automobiles. In India, cow manure is converted to methane gas to provide heat and light.

U.S. Sources of Biomass, 2012



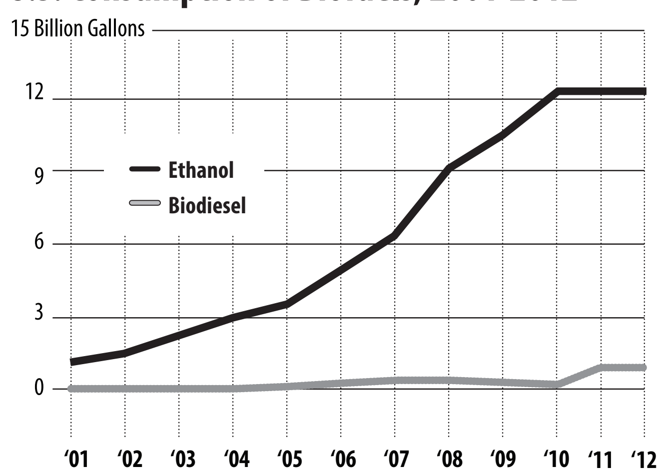
Data: Energy Information Administration

U.S. Biomass Consumption by Sector, 2012



Data: Energy Information Administration

U.S. Consumption of Biofuels, 2001-2012



Data: Energy Information Administration

Coal

What Is Coal?

Coal is a **fossil fuel** formed from the remains of plants that lived and died hundreds of millions of years ago, when parts of the Earth were covered with huge swampy forests. Coal is called a **nonrenewable** energy source because it takes millions of years to form.

The energy we get from coal today came from the energy that plants absorbed from the sun hundreds of millions of years ago. All living plants store energy from the sun. After the plants die, this energy is usually released as the plants decay. Under certain conditions, however, the decay is interrupted, preventing the release of the stored solar energy.

100—400 million years ago, plants that fell to the bottom of the swamp began to decay as layers of dirt and water were piled on top. Heat and pressure from these layers caused a chemical change to occur, eventually creating coal over time, a **sedimentary** rock..

History of Coal in America

Native Americans used coal long before the first settlers arrived in the New World. Hopi Indians used coal to bake the pottery they made from clay.

European settlers discovered coal in North America during the first half of the 1600s. They used very little coal at first. Instead, they relied on water wheels and burning wood to power colonial industries.

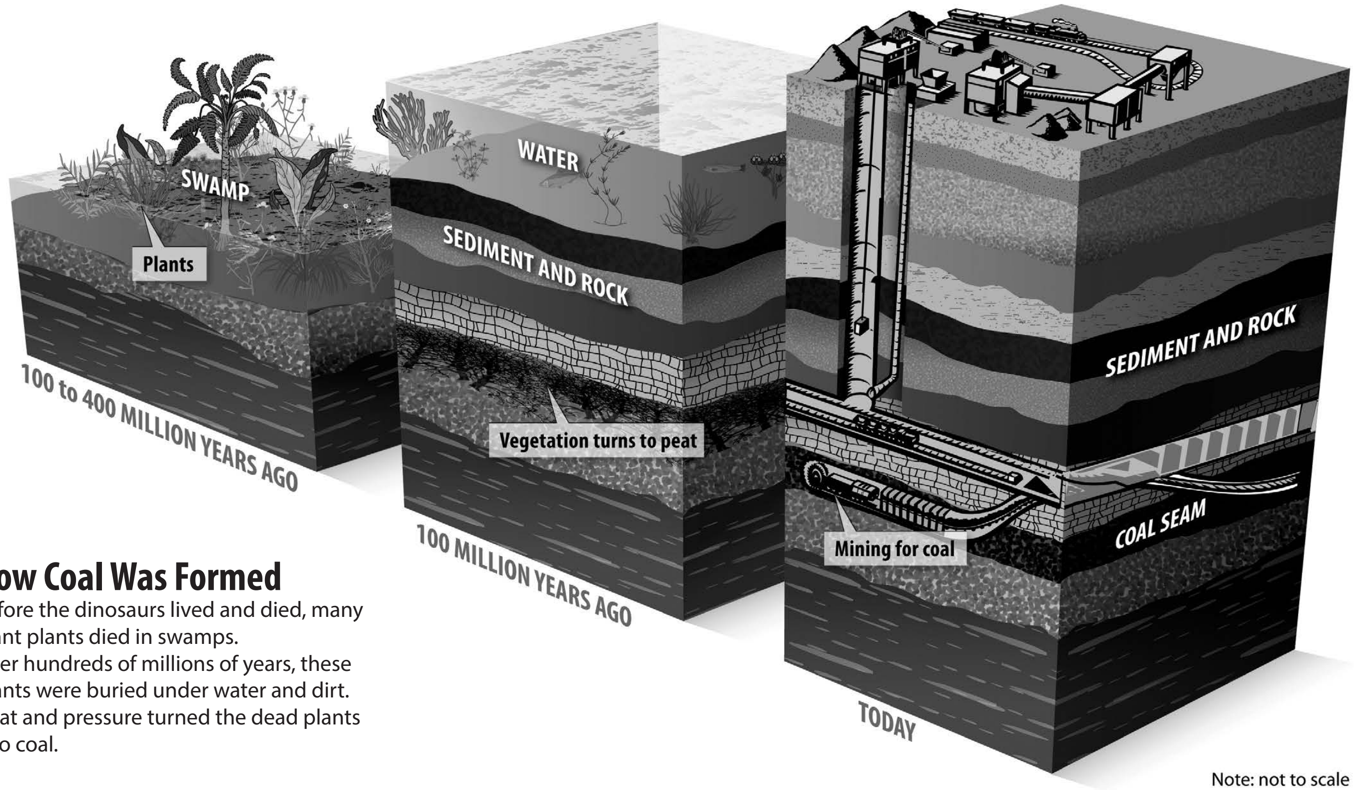
Coal became a powerhouse by the 1800s. People used coal to manufacture goods and to power steamships and railroad engines. By the time of the American Civil War, people also used coal to make iron and steel. And by the end of the 1800s, people began using coal to make electricity.

Today, coal provides 18.2 percent of America's energy needs. Over 37 percent of our electricity comes from coal-fired **power plants**.

Coal Mining

Coal companies use two methods to mine coal: surface mining and underground mining.

Surface mining is used to extract about two-thirds of the coal in the United States. Surface mining can be used when the coal is buried less than 200 feet underground. In surface mining, the topsoil and layers of rock are removed to expose large deposits of coal. The coal is then removed by huge machines. Once the mining is finished, the



How Coal Was Formed

Before the dinosaurs lived and died, many giant plants died in swamps.
Over hundreds of millions of years, these plants were buried under water and dirt.
Heat and pressure turned the dead plants into coal.

mined area is **reclaimed**. The dirt and rock are returned to the pit, the topsoil is replaced, and the area is seeded. The land can then be used for croplands, wildlife habitats, recreation, or offices and stores.

Underground (or deep) mining is used when the coal is buried deep within the Earth. Some underground mines are 1,000 feet deep! To remove coal from underground mines, miners are transported down mine shafts to run machines that dig out the coal.

Processing and Transporting Coal

After coal comes out of the ground, it goes to a preparation plant for cleaning. The plant removes rock, ash, sulfur, and other impurities from the coal. Cleaning improves the heating value of coal.

After cleaning, the coal is ready to be shipped to market. Trains are used to transport most coal. Sometimes, river barges and trucks are used to ship coal. For short distances, coal can also be moved using conveyors. Deciding how to ship coal is very important because it can cost more to ship it than to mine it.

Coal Reserves and Production

Coal **reserves** are beds of coal still in the ground that can be mined. The United States has the world's largest known coal reserves. Depending on consumption rates, the U.S. has enough coal to last for 170 to 240 years.

Coal production is the amount of coal that is mined and sent to market. Coal is mined in 25 states. Wyoming mines the most, followed by West Virginia, Kentucky, Pennsylvania, and Illinois.

How Coal Is Used

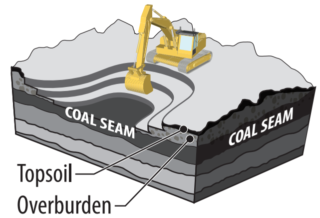
Roughly 93 percent of the coal mined in the U.S. today is used to make electricity. The steel and iron industries use coal for **smelting** metals. Other industries use coal, too. Paper, brick, limestone, and cement industries all use coal to make products. Very little coal is used for heating homes and buildings.

Coal and the Environment

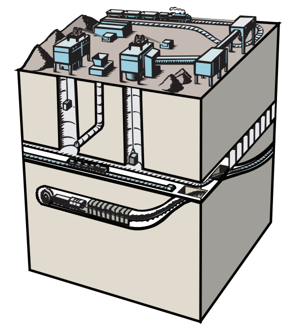
Burning coal produces emissions that can pollute the air. It also produces **carbon dioxide**, a **greenhouse gas**. When coal is burned, a chemical called sulfur may also be released. Sulfur mixes with oxygen to form sulfur dioxide, a chemical that can affect trees and water when it combines with moisture to produce **acid rain.**

Coal companies look for low-sulfur coal to mine. They work hard to remove sulfur and other impurities from the coal. Power plants install machines called **scrubbers** to remove most of the sulfur from coal smoke so it doesn't get into the air. Other by-products, like the ash that is left after coal is burned, once were sent to landfills. Now they are being used to build roads, make cement, and make ocean reefs for animal habitats.

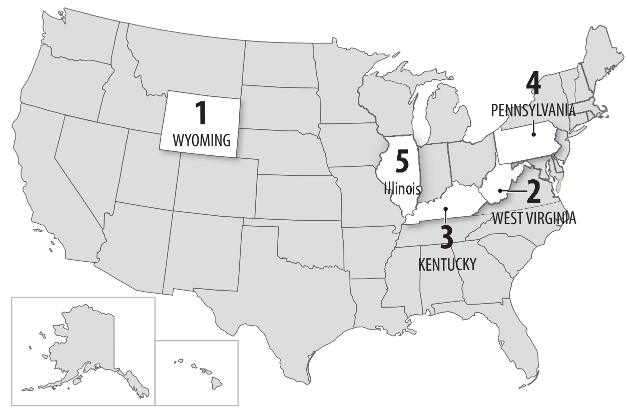
Surface Mining



Deep Mining

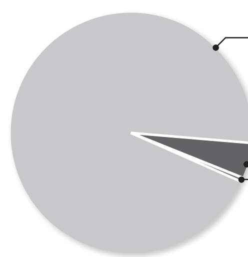


Top Coal Producing States, 2012



Data: Energy Information Administration

U.S. Coal Consumption by Sector, 2012



Data: Energy Information Administration

COAL MINERS

Photo courtesy of gettyimages

Geothermal

What Is Geothermal Energy?

The word **geothermal** comes from the Greek words *geo* (Earth) and *therme* (heat). Geothermal energy is heat from within the Earth.

Geothermal energy is generated in the Earth's **core**, almost 4,000 miles (6,400 km) beneath the Earth's surface. The double-layered core is made up of very hot **magma** surrounding a solid iron center. Very high temperatures are continuously produced inside the Earth because of the immense pressure on the core and mantle. Rocks in the crust are warmed by the continuous, slow **radioactive decay** of rock particles, which is natural in all rocks.

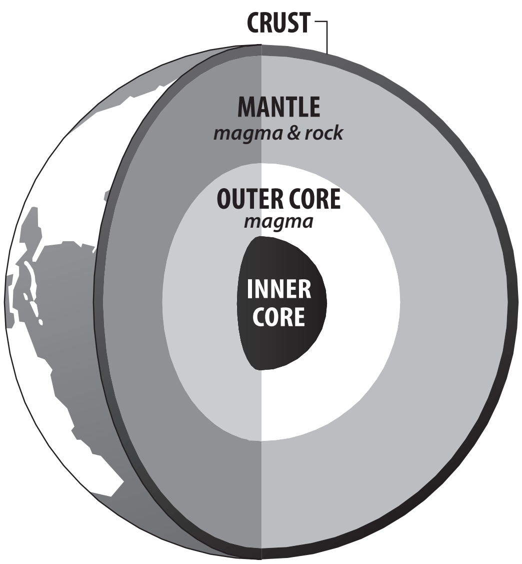
Surrounding the outer core is the **mantle**, which is about 1,800 miles (2,900 km) thick and made of magma and rock. The outermost layer of the Earth, the land that forms the continents and ocean floors, is called the **crust**. The crust is three to five miles (5-8 km) thick under the oceans and 15 to 35 miles (24-56 km) thick on the continents.

The crust is not a solid piece, like the shell of an egg, but is broken into pieces called **plates**. Magma comes close to the Earth's surface near the edges of these plates. This is where volcanoes occur. The lava that erupts from volcanoes is magma that has reached the Earth's surface. Deep underground, the rocks and water in the crust absorb the heat from this magma.

We can dig wells and pump the heated, underground water to the surface. People around the world use geothermal energy to heat their homes and to produce electricity.

Geothermal energy is called a **renewable** energy source because the water is replenished by rainfall and the heat is continuously produced deep within the Earth. We won't run out of geothermal energy.

The Earth's Interior



History of Geothermal Energy

Geothermal energy was used by ancient people for heating and bathing. Even today, hot springs are used worldwide for bathing, and many people believe hot mineral waters have natural healing powers.

Using geothermal energy to produce electricity is a new industry. A group of Italians first used it in 1904. The Italians used the natural steam erupting from the Earth to power a turbine generator.

The first successful American geothermal plant began operating in 1960 at The Geysers in northern California. There are now geothermal power plants in eight states, with many more in development. Most of these geothermal power plants are in California with the remainder in Nevada, Hawaii, Idaho, Utah, Oregon, and Montana.

Finding Geothermal Energy

What are the characteristics of geothermal resources? Some visible features of geothermal energy are volcanoes, hot springs, geysers, and fumaroles. But you cannot see most geothermal resources. They are deep underground. There may be no clues above ground that a geothermal reservoir is present below.

Geologists use different methods to find geothermal reservoirs. The only way to be sure there is a reservoir is to drill a well and test the temperature deep underground.

The most active geothermal resources are usually found along major plate boundaries where earthquakes and volcanoes are concentrated. Most of the geothermal activity in the world occurs in an area called the **Ring of Fire**. This area borders the Pacific Ocean.

Hydrothermal Resources

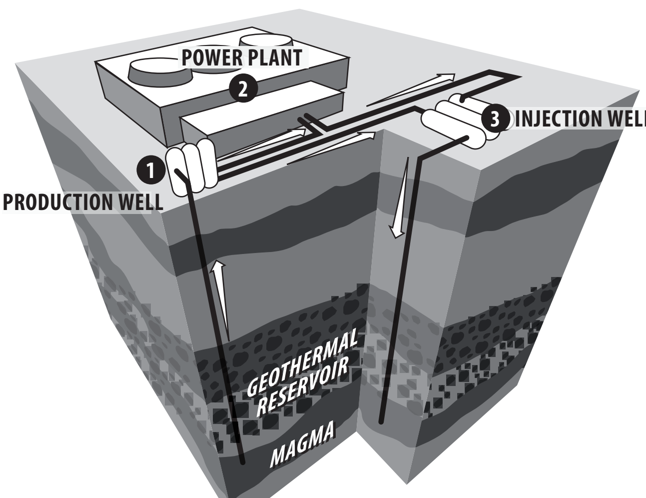
There is more than one type of geothermal energy, but only one kind is widely used to make electricity. It is called **hydrothermal** energy. Hydrothermal resources have two common ingredients: water *(hydro)* and heat *(thermal)*. Depending on the temperature of the hydrothermal resource, the heat energy can either be used for making electricity or for heating.

▪ Low Temperature Resources: Heating

Hydrothermal resources at low temperatures (50-300°F, 10-150°C) are located everywhere in the United States, just a few feet below the ground. This low temperature geothermal energy is used for heating homes and buildings, growing crops, and drying lumber, fruits, and vegetables.

In the U.S., geothermal heat pumps are used to heat and cool homes and public buildings. In fact, each year about 50,000 **geoexchange systems** are installed in the U.S. Almost 90 percent of the homes and businesses in Iceland use geothermal energy for space heating.

Geothermal Power Plant



1. **Production Well:** Geothermal fluids, such as hot water and steam, are brought to the surface and piped into the power plant.
2. **Power Plant:** Inside the power plant, the geothermal fluid turns the turbine blades, which spins a shaft, which spins magnets inside a large coil of wire to generate electricity.
3. **Injection Well:** Used geothermal fluids are returned to the reservoir.

▪ High Temperature Resources: Electricity

Hydrothermal resources at high temperatures (250-700°F, 150-370°C) can be used to make electricity.

These high-temperature resources may come from either dry steam **wells** or hot water wells. We can use these resources by drilling wells into the Earth and piping the steam or hot water to the surface. Geothermal wells are one to two miles deep.

In a **dry steam plant**, the steam from the geothermal reservoir is piped directly from a well to a turbine generator to make electricity. In a hot water plant, some of the hot water is turned into steam. The steam powers a turbine generator just like a dry steam plant. When the steam cools, it condenses to water and is injected back into the ground to be used over and over again.

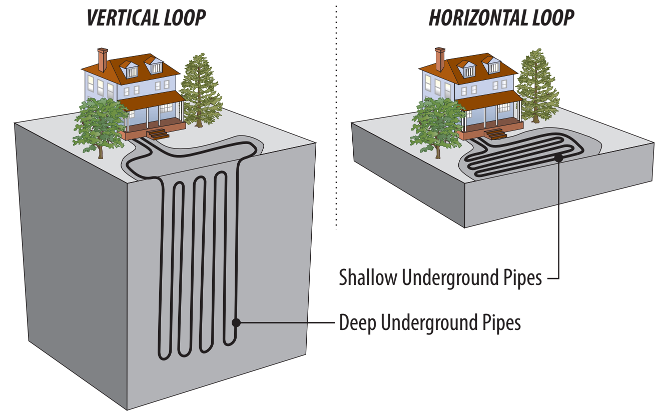
Geothermal energy produces only a small percentage of U.S. electricity. Today, it produces over 15 billion kilowatt-hours, or less than one percent of the electricity produced in this country.

Geothermal Energy and the Environment

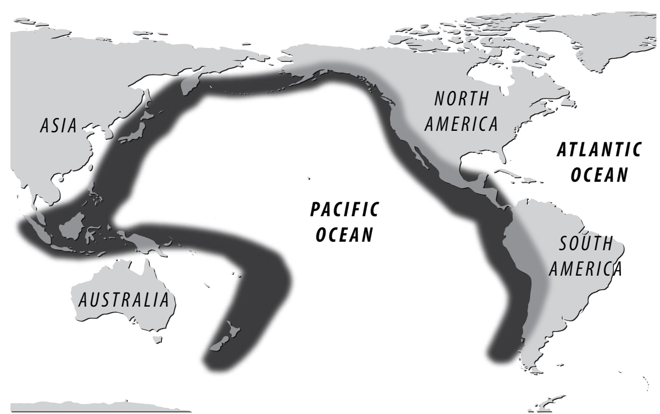
Geothermal energy does little damage to the environment. Another advantage is that geothermal plants don't have to transport fuel, like most power plants. Geothermal plants sit on top of their fuel source. Geothermal power plants have been built in deserts, in the middle of crops, and in mountain forests.

Geothermal plants produce almost no emissions because they do not burn fuel to generate electricity.

Residential Geoexchange Units

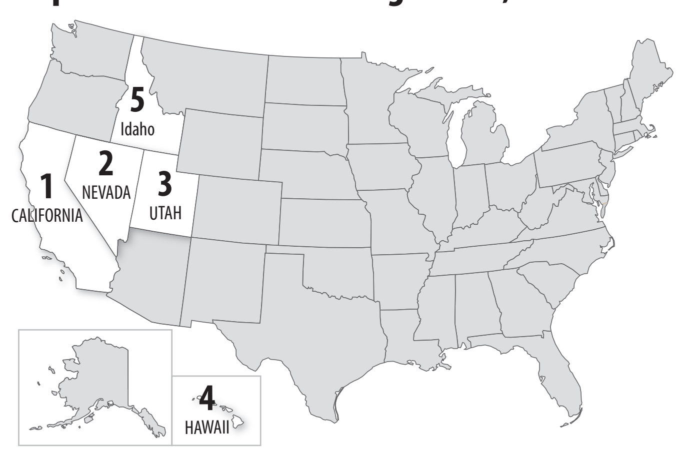


Ring of Fire



Most of the geothermal activity in the world occurs around the Pacific Ocean in an area called the Ring of Fire.

Top Geothermal Producing States, 2012



Data: Energy Information Administration

Hydropower

What Is Hydropower?

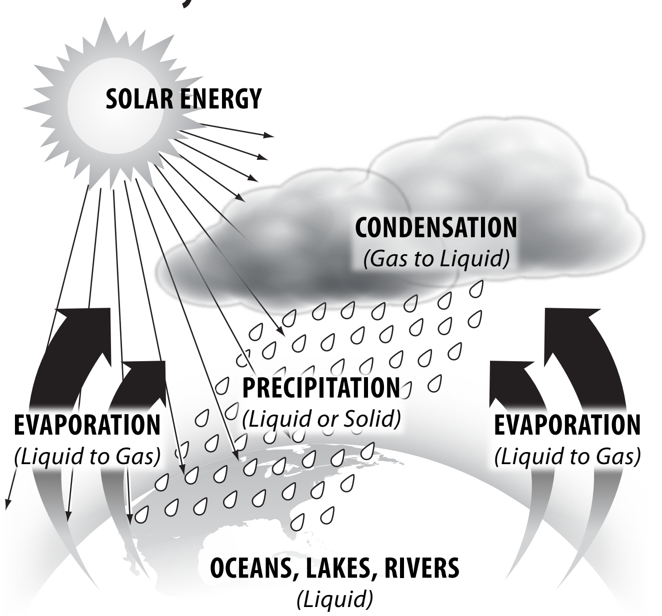
Hydropower (the prefix *hydro* means water) is energy that comes from the force of moving water.

The movement of water between the Earth and the atmosphere is part of a continuous cycle called the water cycle. The sun draws moisture up from the oceans and rivers, and this moisture condenses into clouds. The moisture is released from the clouds as rain or snow. The oceans and rivers are replenished with moisture, and the cycle starts again.

Gravity causes the water on the Earth to move from places of high ground to places of low ground. The force of moving water can be very powerful.

Hydropower is called a **renewable** energy source because it is replenished by snow and rainfall. As long as the sun shines and the rain falls, we won't run out of this energy source.

The Water Cycle



History of Hydropower

Water has been used as a source of energy for centuries. The Greeks used water wheels to grind wheat into flour more than 2,000 years ago. In the early 1800s, American and European factories used water wheels to power machines.

The water wheel is a simple machine. The wheel picks up water in buckets located around the wheel. The weight of the water causes the wheel to turn. Water wheels convert the energy of the moving water into useful energy to grind grain, drive sawmills, or pump water.

In the late 19th century, hydropower was first used on the Fox River in Appleton, WI to generate electricity. The first **hydroelectric power plant** was built in 1882. In the years that followed, many more hydropower dams were built. By the 1940s, most of the best sites in the United States for large dams had been developed.

At about the same time, fossil fuel power plants began to be popular. These plants could make electricity more cheaply than hydropower plants. It wasn't until the price of oil skyrocketed in the 1970s that people became interested in hydropower again.

Hydropower Dams

It is easier to build a hydropower plant on a river where there is a natural waterfall, which is why a hydropower plant was built at Niagara Falls. Building **dams** across rivers to produce artificial waterfalls is the next best way.

Dams are built on rivers where the terrain of the land produces a lake or **reservoir** behind it. Today there are about 84,000 dams in the United States, but only 2,200 were built specifically to generate electricity.

Most of the dams in the United States were built to control flooding, to irrigate farm land, or for recreation, not for electricity production. We could increase the amount of hydropower produced in this country by putting equipment to generate electricity on many of the existing dams.

Hydropower Plants

Hydropower plants use modern turbine **generators** to produce electricity just as coal, oil, or nuclear power plants do. The difference is in the source used to spin the turbine.

A typical hydropower plant is a system that has three main parts: a reservoir where water can be stored, a dam with gates to control water flow, and a power plant where the electricity is produced.

A hydropower plant uses the force of flowing water to produce electricity. A dam opens gates at the top to allow water from the reservoir to flow down large tubes called **penstocks**. At the bottom of the penstocks, the fast-moving water spins the blades of the turbines. The turbines are attached to generators to produce electricity, which is transported along transmission lines to a utility company.

Storing Energy

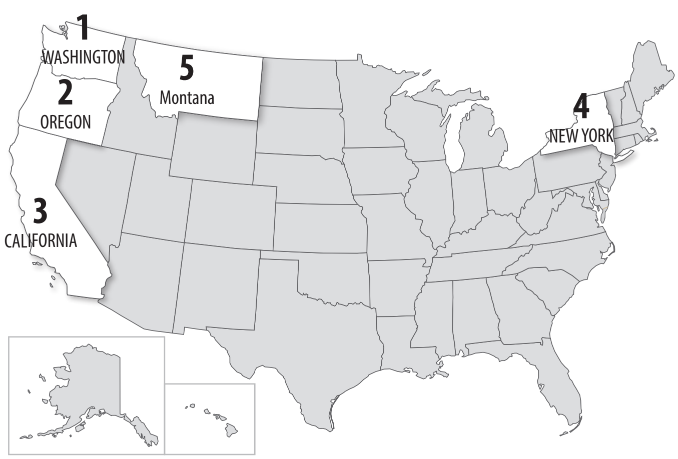
One of the biggest advantages of hydropower dams is their ability to store energy. After all, the water in the reservoir has **gravitational potential energy**. Water can be stored in a reservoir and released when electricity is needed. During the night, when consumers use less electricity, the gates can be closed and water held in the reservoir. Then, during the day, when consumers need more electricity, the gates can be opened so that the water can flow through the plant to generate electricity.

Amount and Cost of Hydropower

Depending upon the amount of rainfall during the year, hydropower can provide anywhere between five and ten percent of the country's electricity. In 2012, hydropower provided almost seven percent of the nation's electricity. Globally, hydropower is a significant energy source, producing almost 17 percent of the world's electricity. In South America, two-thirds of the electricity is produced by hydropower.

Hydropower is the cheapest way to generate electricity in the United States today. Hydropower is cheaper than electricity from coal or nuclear plants fo rmany reasons. The fuel— flowing water—does not have to be transported, and is free to use, unlike coal and uranium.

Top Hydropower Producing States, 2012



Data: Energy Information Administration

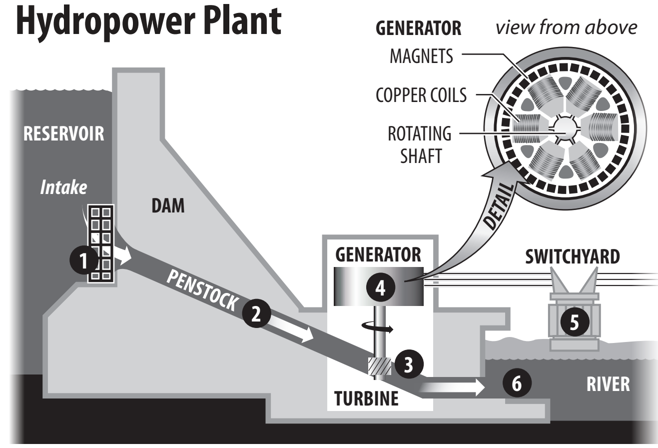
Hydropower and the Environment

Hydropower is a clean energy source. A hydropower plant produces no air pollution because it does not burn fuel, but it does affect the environment in other ways.

When dams are built, water patterns and the amount of flow in rivers are altered. Some wildlife and natural resources are also affected. Many dams today have **spillway gates** to control the flow of excess water, and incorporate **fish ladders**, elevators, and other devices to help fish swim up the river.

On the positive side, hydropower's fuel supply (flowing water) is clean and renewable—replenished by the water cycle. There are also other benefits. Dams can be designed to control flood water, and reservoirs provide lakes for boating, swimming, fishing, and other recreational activities.

Hydropower Plant



1. Water in a reservoir behind a hydropower dam flows through an intake screen, which filters out large debris, but allows fish to pass through.
2. The water travels through a large pipe, called a penstock.
3. The force of the water spins a turbine at a low speed, allowing fish to pass through unharmed.
4. Inside the generator, the shaft spins coils of copper wire inside a ring of magnets. This creates an electric field, producing electricity.
5. Electricity is sent to a switchyard, where a transformer increases the voltage, allowing it to travel through the electric grid.
6. Water flows out of the penstock into the downstream river.

Natural Gas

What Is Natural Gas?

Natural gas is a **fossil fuel** like petroleum and coal. Natural gas is called a fossil fuel because it was formed from the remains of ancient sea plants and animals. When the plants and tiny sea animals died hundreds of millions of years ago, they sank to the bottom of the oceans where they were buried by sediment and sand. This eventually turned into **sedimentary** rock. The layers of plant and animal matter and sedimentary rock continued to build until the pressure and heat from the Earth turned the remains into petroleum and natural gas.

Natural gas is trapped in underground rocks much like a sponge traps water in pockets. Natural gas is really a mixture of gases. The main ingredient is **methane**. Methane has no color, odor, or taste. As a safety measure, natural gas companies add an odorant, **mercaptan**, to the gas so that leaking gas can be detected (it smells like rotten eggs). People use natural gas mostly for heating. Natural gas should not be confused with gasoline, which is made from petroleum.

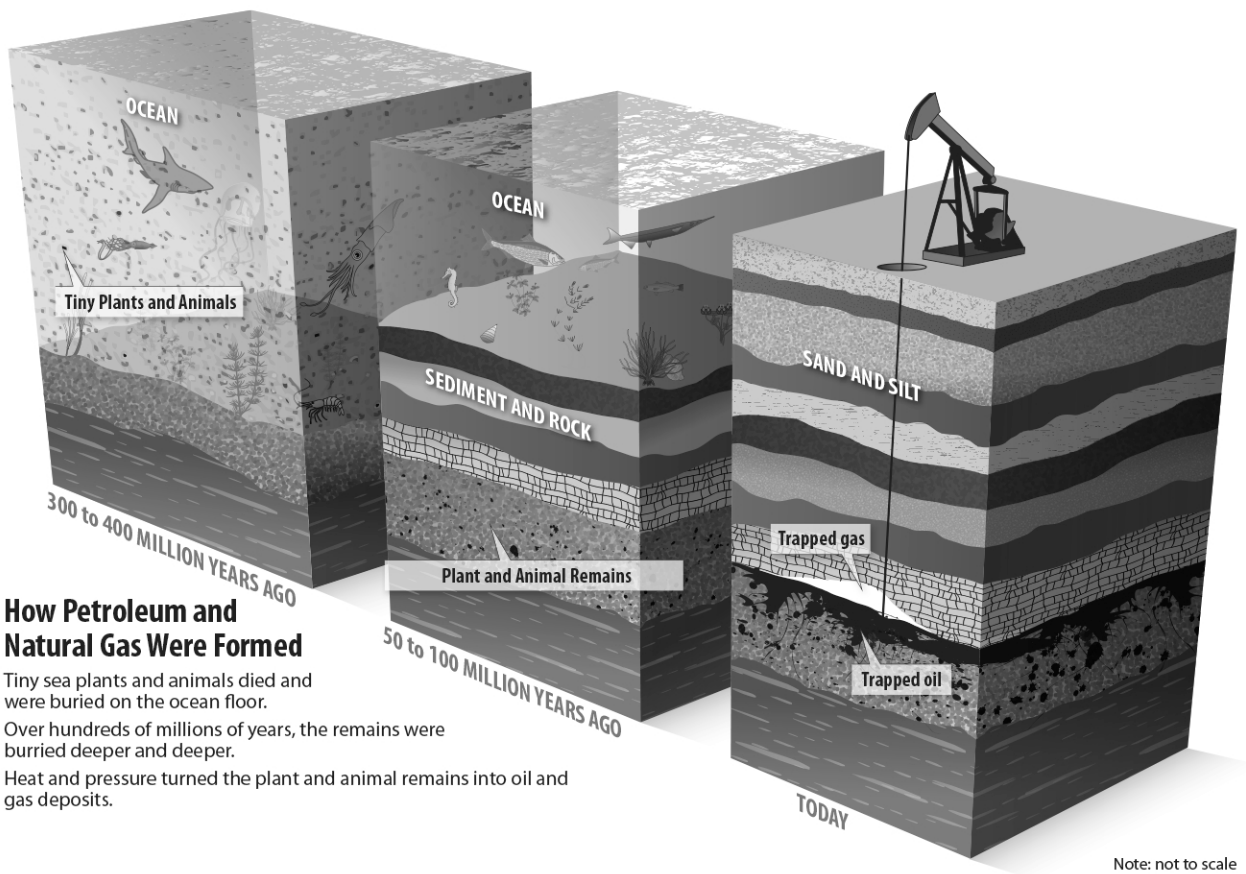
Natural gas is almost always considered **nonrenewable**, which means we cannot make more in a short time. However, there are some renewable sources of methane, such as landfills.

History of Natural Gas

The ancient people of Greece, Persia, and India discovered natural gas many centuries ago. The people were mystified by the burning springs created when natural gas seeped from cracks in the ground and was ignited by lightning. They sometimes built temples around these eternal flames and worshipped the fire.

About 2,500 years ago, the Chinese recognized that natural gas could be put to work. The Chinese piped the gas from shallow wells and burned it under large pans to evaporate sea water to make salt.

In 1816, natural gas was first used in America to fuel street lamps in Baltimore, Maryland. Soon after, in 1821, William Hart dug the United States' first successful natural gas well in Fredonia, New York. It was just 27 feet deep, quite shallow compared to today's wells. Today, natural gas is the country's second largest supplier of energy, after petroleum.



How Petroleum and Natural Gas Were Formed

Tiny sea plants and animals died and were buried on the ocean floor.

Over hundreds of millions of years, the remains were burried deeper and deeper.

Heat and pressure turned the plant and animal remains into oil and gas deposits.

Producing Natural Gas

Natural gas can be hard to find since it is trapped in **porous** rocks deep underground. Scientists use many methods to find natural gas deposits. They may look at surface rocks to find clues about underground formations. They may set off small explosions or drop heavy weights on the surface to record the sound waves as they bounce back from the rock layers underground.

Natural gas can be found in pockets by itself or in petroleum deposits. Natural gas wells average 8,600 feet (2.5 km) deep!

After natural gas comes out of the ground, it is sent to a plant where it is cleaned of impurities and separated into its various parts. Natural gas is mostly methane, but it also contains small amounts of other gases such as propane and butane.

Today natural gas is produced in 32 states, though just five states produce 70 percent of our supply. Natural gas is also produced **offshore**. About eight percent of natural gas production came from offshore wells in 2012. Scientists estimate that we have enough natural gas to last almost 100 years at current prices and rate of consumption.

Natural gas can also come from other sources, such as the methane gas found in coal. **Coal bed methane** was once considered just a safety hazard to miners, but now it is a valuable source of energy. Another source of natural gas is the gas produced in landfills. Landfill gas, a **biogas**, is considered a renewable source of natural gas since it comes from something continually produced—trash.

Shipping Natural Gas

Natural gas is usually shipped by **pipeline**. About two million miles of pipelines connect gas fields to cities, to homes, and to businesses. Natural gas is sometimes transported thousands of miles in these pipelines to its final destination. It takes about five days to move natural gas from Texas to New York.

Eventually, the gas reaches the city gate of a local gas utility. Smaller pipes carry the gas the last few miles to homes and businesses. A gas meter measures the volume of gas a consumer uses.

Who Uses Natural Gas?

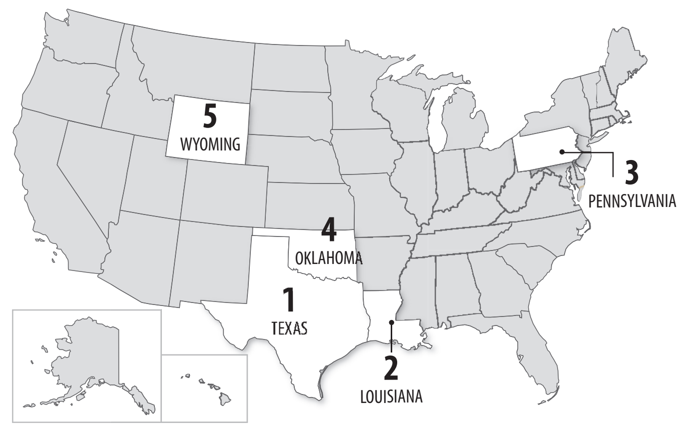
Just about everyone in the United States uses natural gas. Natural gas is used for more than 27 percent of U.S. energy. Industry burns natural gas for heat to manufacture goods. Natural gas is also used as an ingredient in fertilizer, glue, paint, laundry detergent, and many other items.

Residences, or homes, use natural gas for heating. Like residences, commercial buildings use natural gas mostly for heating. Commercial users include stores, offices, schools, churches, and hospitals.

Natural gas can also be used to generate electricity. It accounts for over 30 percent of U.S. electricity generated. Many new power plants are using natural gas as fuel because it is cleaner burning and can produce electricity quickly when it is needed for periods of high demand.

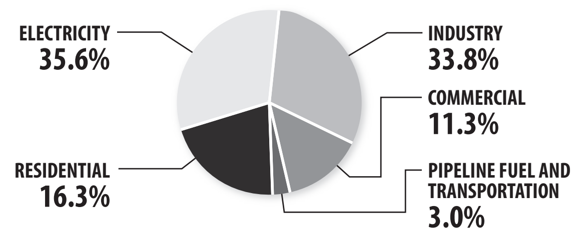
A small amount of natural gas is also used as fuel for automobiles. Natural gas is cleaner burning than gasoline, but to use it, vehicles must have special equipment.

Top Natural Gas Producing States, 2012



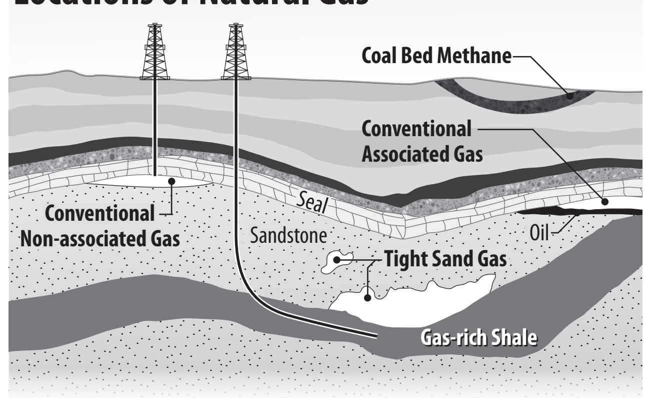
Data: Energy Information Administration

U.S. Natural Gas Consumption by Sector, 2012



Data: Energy Information Administration

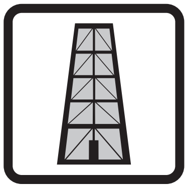
Locations of Natural Gas



Natural Gas and the Environment

Burning biomas or any fossil fuel, including natural gas, releases emissions into the air, including **carbon dioxide**, a **greenhouse gas**.

Natural gas and propane are the cleanest burning fossil fuels. Compared to coal and petroleum, natural gas releases much less sulfur, carbon dioxide, and ash when it is burned. Scientists are looking for new sources of natural gas and new ways to use it.



Petroleum

What Is Petroleum?

Petroleum is a **fossil fuel**. Petroleum is often called **crude oil**, or **oil.** It is called a fossil fuel because it was formed from the remains of tiny sea plants and animals that died hundreds of millions of years ago. When the plants and animals died, they sank to the bottom of the oceans.

Here, they were buried by thousands of feet of sand and sediment, which turned into **sedimentary** rock. As the layers increased, they pressed harder and harder on the decayed remains at the bottom. The pressure and some heat changed the remains and, eventually, petroleum was formed.

Petroleum deposits are locked in **porous** rocks almost like water is trapped in a wet sponge. When crude oil comes out of the ground, it can be as thin as water or as thick as tar. Petroleum is called a **nonrenewable** energy source because it takes hundreds of millions of years to form. We cannot make new petroleum reserves.

History of Oil

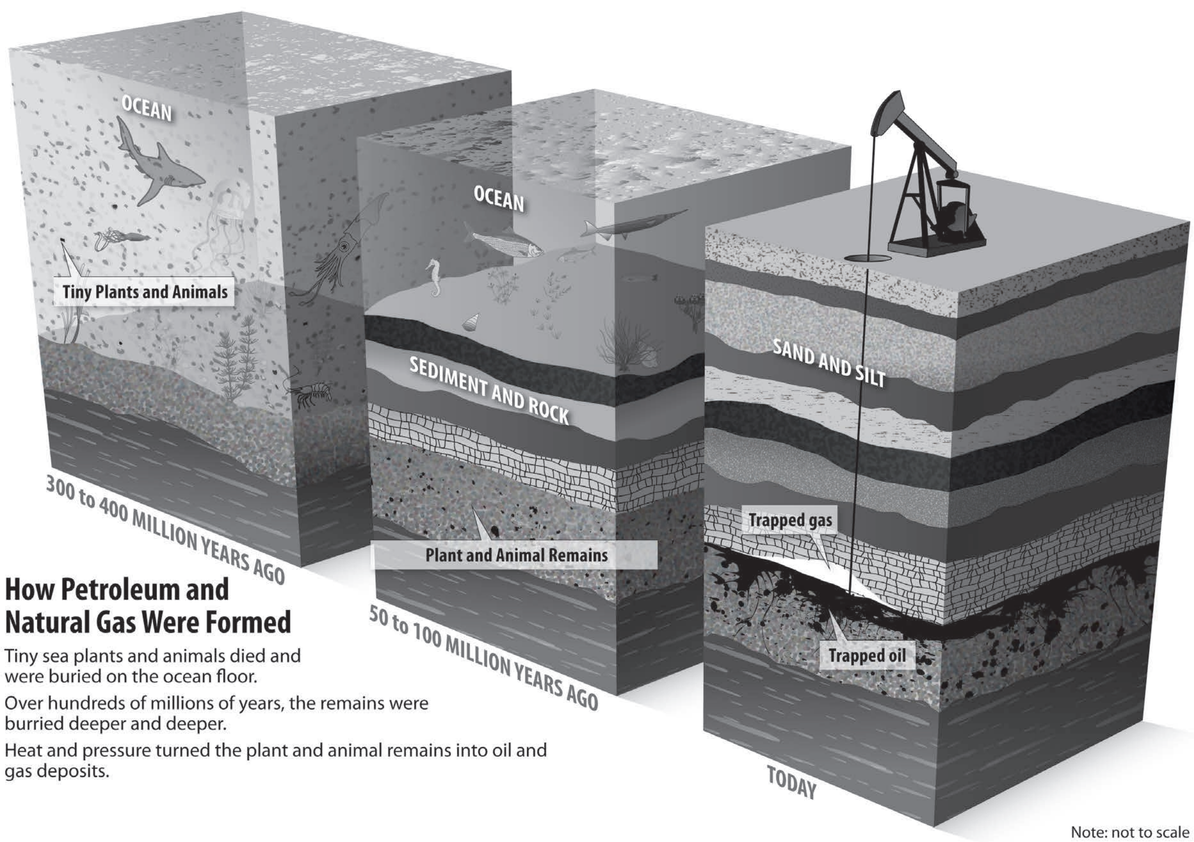
People have used petroleum since ancient times. The ancient Chinese and Egyptians burned oil to light their homes. Before the 1850s, Americans used whale oil to light their homes. When whale oil became scarce, people skimmed the oil that seeped to the surface of ponds and streams. The demand for oil grew and, in 1859, Edwin Drake drilled the first oil well near Titusville, Pennsylvania.

At first, the crude oil was refined or made into kerosene for lighting. Gasoline and other products made during refining were thrown away because people had no use for them. This all changed when Henry Ford began mass producing automobiles in 1913. Everyone wanted an automobile and they all ran on gasoline. Gasoline was the fuel of choice because it provided the greatest amount of energy in relation to cost and ease of use.

Today, Americans use more petroleum than any other energy source, mostly for transportation. Petroleum provides 34.6 percent of the energy we use.

Producing Oil

Geologists look at the types of rocks and the way they are arranged deep within the Earth to determine whether oil is likely to be found at a specific location. Even with new technology, oil exploration is expensive and often unsuccessful. Only about 60 percent of **exploratory wells** produce oil. When scientists think there may be oil in a certain place, a petroleum company brings in a **drilling rig** and raises an oil **derrick** that houses the tools and pipes they need to drill a well. The typical oil well is over one mile deep. If oil is found, a pump moves the oil through a pipe to the surface.



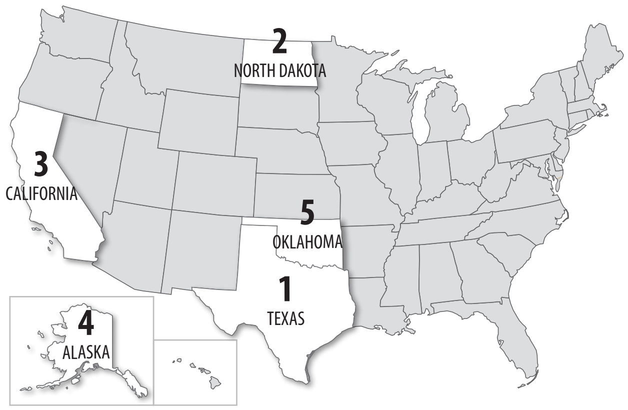
How Petroleum and Natural Gas Were Formed

Tiny sea plants and animals died and were buried on the ocean floor.

Over hundreds of millions of years, the remains were burried deeper and deeper.

Heat and pressure turned the plant and animal remains into oil and gas deposits.

Top Petroleum Producing States, 2012

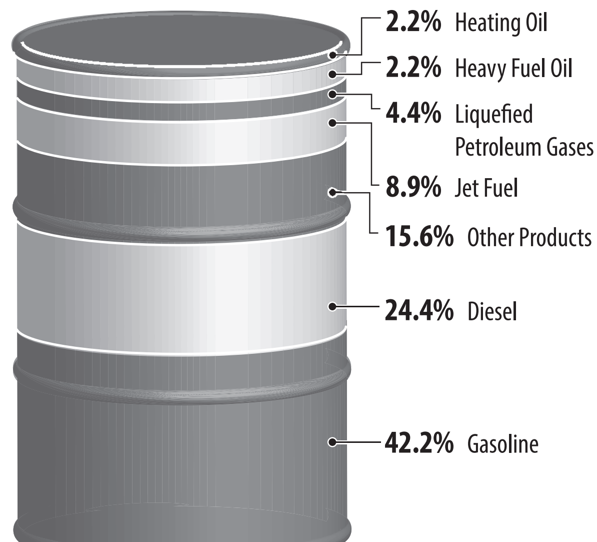


Data: Energy Information Administration

Other Petroleum Products

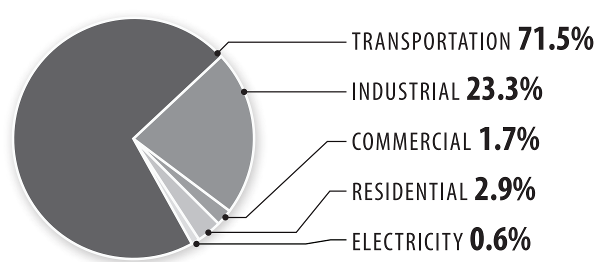
Ink	Enamel	Pantyhose	Fishing rods
Hand lotion	Movie film	Artificial limbs	Dice
Nail polish	Balloons	Antihistamines	Fertilizers
Heart valves	Antiseptics	Oil filters	Electrical tape
Toothbrushes	Aspirin	Ballpoint pens	Trash bags
Dashboards	Paint brushes	Skis	Insecticides
Crayons	Purses	Pajamas	Floor wax
Toothpaste	Sunglasses	Golf balls	Shampoo
Luggage	Footballs	Perfumes	Cold cream
Parachutes	Deodorant	Cassettes	Tires
Guitar strings	Glue	Contact lenses	Cameras
DVDs	Dyes	Shoe polish	Detergents

Products Produced From a Barrel of Oil, 2012



* Total does not equal 100% due to independent rounding.
Data: Energy Information Administration

Petroleum Consumption by Sector, 2012



Data: Energy Information Administration

About one-fifth of the oil the U.S. produces comes from **offshore** wells. Some wells are a mile under the ocean. Some of the rigs used to drill these wells float on top of the water. It takes a lot of money and technology to drill and find oil in the ocean.

Texas produces more oil than any other state, followed by North Dakota, California, Alaska, and Oklahoma. Americans use much more oil than we produce. Today, the U.S. imports about 46 percent of the oil it consumes from other countries.

From Well to Market

We can't use crude oil as it comes out of the ground. We must change it into fuels that we can use. The first stop for crude oil is at a petroleum **refinery**. A refinery is a factory that processes oil.

The refinery cleans and separates the crude oil into many fuels and products. The most important one is gasoline. Other petroleum products are diesel fuel, heating oil, and jet fuel. Industry uses petroleum as a **feedstock** to make plastics and many other products.

Shipping Petroleum

After the refinery, most petroleum products are shipped out through **pipelines**. There are about 95,000 miles (153,000 km) of underground pipelines in the United States transporting refined petroleum products. Pipelines are the safest and cheapest way to move big shipments of petroleum. It takes about 15 days to move a shipment of gasoline from Houston, Texas, to New York City. Petroleum can also be moved over water in a tanker.

Special companies called **jobbers** buy petroleum products from oil companies and sell them to gasoline stations and to other big users such as industries, power companies, and farmers.

Oil and the Environment

Petroleum products—gasoline, medicines, fertilizers, and others—have helped people all over the world, but there is a trade-off. Petroleum production, exploration, and the use of petroleum products may cause air and water pollution.

Drilling for and transporting oil can endanger wildlife and the environment if it spills into rivers or oceans. Leaking underground storage tanks can pollute groundwater and create noxious fumes. Processing oil at the refinery can contribute to air and water pollution. Burning gasoline to fuel our cars contributes to air pollution. Even the careless disposal of waste oil drained from the family car can pollute rivers and lakes.

The petroleum industry works hard to protect the environment. Gasoline and diesel fuel have been changed to burn cleaner. And oil companies work to make sure that they drill and transport oil as safely as possible.

Propane

What Is Propane?

Propane is an energy-rich gas that is related to petroleum and natural gas. Propane is usually found mixed with deposits of natural gas and petroleum underground. Propane is called a **fossil fuel** because it was formed hundreds of millions of years ago from the remains of tiny sea animals and plants.

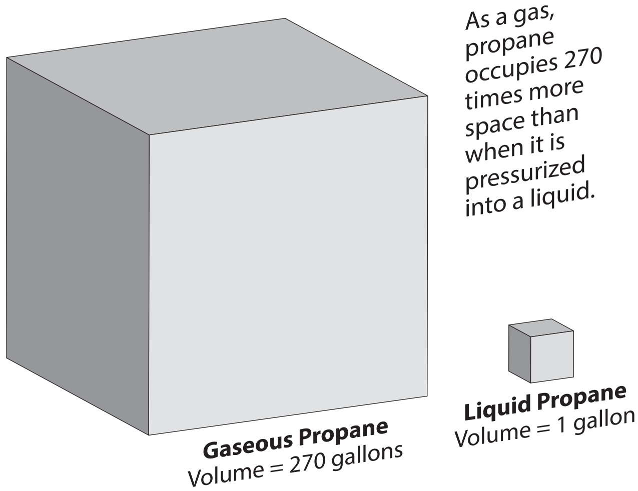
When the plants and animals died, they sank to the bottom of the oceans where they were buried by layers of sediment and sand that turned into **sedimentary** rock. Over time, the layers became thousands of feet thick. The layers were subjected to enormous heat and pressure, changing the remains into petroleum and natural gas deposits. Pockets of these fossil fuels became trapped in rocks like a sponge holds water.

Propane is one of the many fuels that are included in the **liquefied petroleum gas** (or **LPG**) family. In the United States, propane and LPG often mean the same thing, because propane is the most common type of LPG used. Just as water can be a liquid or a gas (steam), so can propane. Under normal conditions, propane is a gas. Under pressure, propane becomes a liquid.

Propane is stored as a liquid fuel in pressurized tanks because it takes up much less space in that form. Gaseous propane takes up 270 times more space than liquid propane. A thousand gallon tank holding gaseous propane would provide a family enough cooking fuel for one week. The same tank holding liquid propane would provide enough cooking fuel for over five years! Propane becomes a gas when it is released to fuel gas appliances.

Propane is very similar to natural gas. Like natural gas, propane is colorless and odorless. An odorant, called **mercaptan**, is added to propane so escaping gas can be detected. And like all fossil fuels—coal, petroleum, natural gas—propane is a **nonrenewable** energy source. That means we cannot renew our propane supplies in a short time.

Liquefied Propane



History of Propane

Propane has been around for millions of years, but it wasn't discovered until 1912. Scientists were trying to find a better way to store gasoline, which had a tendency to evaporate when it was stored.

An American scientist, Dr. Walter Snelling, discovered that propane gas could be changed into a liquid and stored at moderate pressure. Just one year later, the commercial propane industry began heating American homes with propane.

Producing Propane

Propane comes from natural gas and petroleum wells. Approximately half of the propane used in the United States comes from raw natural gas. Raw natural gas is about 90 percent **methane**, five percent propane, and five percent other gases. The propane is separated from the other gases at a natural gas processing plant.

The other half of our propane supply comes from petroleum refineries or is imported. Many gases are separated from petroleum at refineries. Since the U.S. imports 46 percent of the petroleum we use, much of the propane is separated from this imported oil.

Transporting Propane

How does propane get to consumers? It is usually moved through **pipelines** to **distribution terminals** across the nation. These distribution terminals are like warehouses that store goods before shipping it to stores. Sometimes in the summer, when people need less propane for heating, it is stored in large underground caverns.

From the distribution terminals, propane goes by railroad, trucks, barges, and supertankers to bulk plants. A **bulk plant** is where local propane dealers come to fill their small tank trucks. People who use very little propane—backyard barbecue cooks, for example—must take their propane tanks to dealers to be filled.

How Propane Is Used

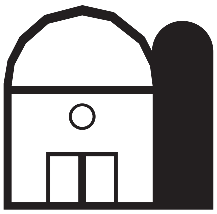
Propane provides the U.S. with less than two percent of its energy. Propane is used by industry, homes, farms, and businesses—mostly for heating. It is also used as a transportation fuel.

- **Industry**

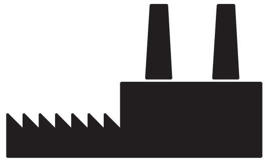
Over three-quarters of the propane we use is used by industry. Many industries find propane well-suited for special needs. Metal workers use small propane tanks to fuel cutting torches. Portable propane heaters give construction and road workers warmth in cold weather.

Propane is also used to heat asphalt for highway construction and repairs. And because propane burns so cleanly, forklift trucks powered by propane can operate safely inside factories and warehouses.

How Propane Is Used

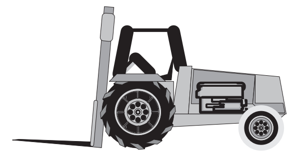


To heat barns and operate farm equipment



To make products and fuel industry

To fuel hot air balloons



To fuel machinery that is used indoors

To fuel backyard grills

To heat homes

To fuel fleet vehicles

To fuel appliances

- **Homes**

Propane is mostly used in rural areas that do not have natural gas service. Homes use propane for heating, hot water, cooking, and clothes drying. Many families have barbecue grills fueled by propane gas. Some families have recreational vehicles equipped with propane appliances.

- **Farms**

About 40 percent of America's farms rely on propane. Farmers use propane to dry crops, power tractors, and heat greenhouses and chicken coops.

- **Businesses**

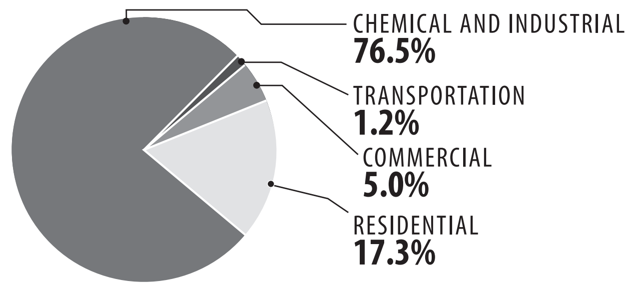
Businesses—office buildings, laundromats, fast-food restaurants, and grocery stores—use propane for heating and cooking.

- **Transportation Fuel**

Propane has been used as a transportation fuel for many years. Today, many taxicab companies, government agencies, and school districts use propane instead of gasoline to fuel their fleets of vehicles. Propane has several advantages over gasoline. First, propane is cleaner-burning and leaves engines free of deposits. Second, engines that use propane emit fewer pollutants into the air than engines that use gasoline.

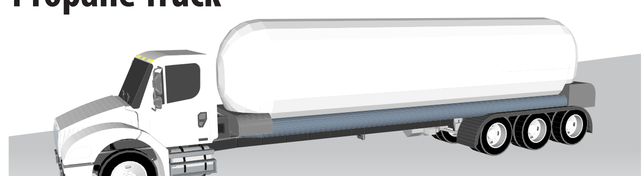
Why isn't propane used as a transportation fuel more often? For one reason, it's not as easy to find as gasoline. Have you ever seen a propane filling station? Second, automobile engines have to be adjusted to use propane fuel, and these adjustments can be costly. Third, there is a slight drop in miles traveled per gallon when propane is used to fuel vehicles.

U.S. Propane Consumption by Sector, 2012



Data: Energy Information Administration

Propane Truck



Bobtail trucks can carry 1,000 to 3,000 gallons of liquid propane to local distributors.

Propane and the Environment

Propane is a very clean burning fossil fuel, which explains its use in indoor settings. It was approved as an alternative fuel under the Clean Air Act, as well as the National Energy Policy Act of 1992.

Solar

What Is Solar Energy?

Every day, the sun radiates (sends out) an enormous amount of energy—called **solar energy**. It radiates more energy in one day than the world uses in one year. This energy comes from within the sun itself.

Like most stars, the sun is a big gas ball made up mostly of hydrogen and helium gas. The sun makes energy in its inner core in a process called nuclear **fusion**.

It takes the sun's energy just a little over eight minutes to travel the 93 million miles to Earth. Solar energy travels at the speed of light, or 186,000 miles per second, or 3.0×10^8 meters per second.

Only a small part of the visible **radiant energy** (light) that the sun emits into space ever reaches the Earth, but that is more than enough to supply all our energy needs. Every hour enough solar energy reaches the Earth to supply our nation's energy needs for a year! Solar energy is considered a **renewable** energy source due to this fact.

Today, people use solar energy to heat buildings and water and to generate electricity. Solar energy accounts for a very small percentage of U.S. energy. Solar energy is mostly used by residences and to generate electricity.

Solar Collectors

Heating with solar energy is not as easy as you might think. Capturing sunlight and putting it to work is difficult because the solar energy that reaches the Earth is spread out over a large area. The sun does not deliver that much energy to any one place at any one time.

The amount of solar energy an area receives depends on the time of day, the season of the year, the cloudiness of the sky, and how close you are to the Earth's Equator.

A **solar collector** is one way to capture sunlight and change it into usable heat energy. A closed car on a sunny day is like a solar collector. As sunlight passes through the car's windows, it is absorbed by the seat covers, walls, and floor of the car. The absorbed light changes into heat. The car's windows let light in, but they don't let all the heat out. A closed car can get very hot!

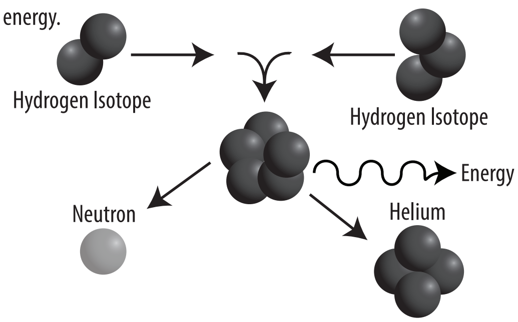
Solar Space Heating

Space heating means heating the space inside a building. Today, many homes use solar energy for space heating. A passive solar home is designed to let in as much sunlight as possible. It is like a big solar collector.

Sunlight passes through the windows and heats the walls and floor inside the house. The light can get in, but the heat is trapped inside. A **passive solar home** does not depend on mechanical equipment, such as pumps and blowers, to heat the house, whereas **active solar homes** do.

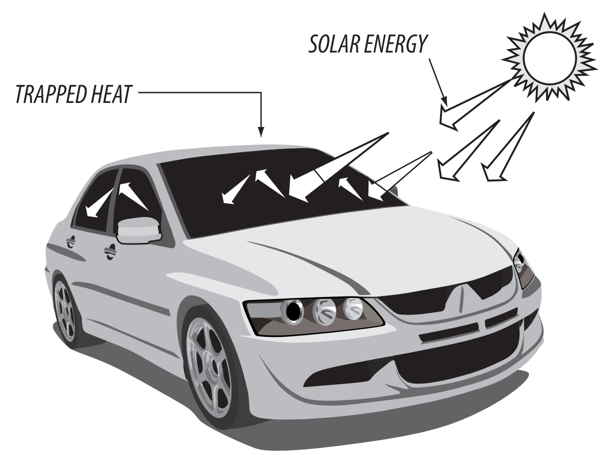
Fusion

The process of fusion most commonly involves hydrogen isotopes combining to form a helium atom with a transformation of matter. This matter is emitted as radiant energy.

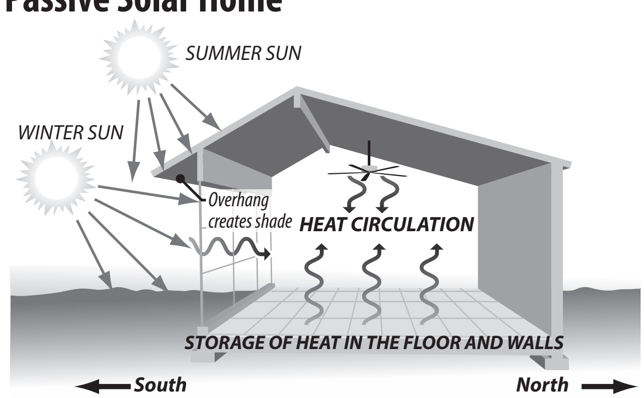


Solar Collector

On a sunny day, a closed car becomes a solar collector. Light energy passes through the window glass, is absorbed by the car's interior, and converted into heat energy. The heat energy becomes trapped inside.



Passive Solar Home



Solar Water Heating

Solar energy can be used to heat water. Heating water for bathing, dishwashing, and clothes washing is the second largest home energy cost. Installing a solar water heater can reduce your water heating bill by as much as 50 percent.

A solar water heater works a lot like solar space heating. In our hemisphere, a solar collector is mounted on the south side of a roof where it can capture sunlight. The sunlight heats water in a tank. The hot water is piped to faucets throughout a house, just as it would be with an ordinary water heater.

Solar Electricity

Solar energy can also be used to produce electricity. Two ways to make electricity from solar energy are photovoltaics and solar thermal systems.

▪ Photovoltaic Electricity

Photovoltaic comes from the words *photo,* meaning light, and *volt*, a measurement of electricity. Sometimes photovoltaic cells are called PV cells or **solar cells** for short. You are probably familiar with photovoltaic cells. Solar-powered toys, calculators, and roadside telephone call boxes all use solar cells to convert sunlight into electricity.

Solar cells are made up of **silicon**, the same substance that makes up sand. Silicon is the second most common substance on Earth. Solar cells can supply energy to anything that is powered by batteries or electrical power.

Electricity is produced when radiant energy from the sun strikes the solar cell, causing the electrons to move around. The action of the electrons starts an electric current. The conversion of sunlight into electricity takes place silently and instantly. There are no mechanical parts to wear out.

Compared to other ways of making electricity, photovoltaic systems are expensive and many panels are needed to equal the electricity generated at other types of plants.

It can cost 10 to 30 cents per kilowatt-hour to produce electricity from solar cells. Most people pay their electric companies about 12 cents per kilowatt-hour for the electricity they use, and large industrial consumers pay less. Solar systems are often used to generate electricity in remote areas that are a long way from electric power lines.

In 2009, the DeSoto Next Generation Solar Energy Center in Florida opened. It is the largest photovoltaic plant in the country, generating 25 megawatts of electricity—enough to power 3,000 homes.

▪ Solar Thermal Electricity

Like solar cells, solar thermal systems, also called **concentrated solar power (CSP)**, use solar energy to produce electricity, but in a different way. Most solar thermal systems use a solar collector with a mirrored surface to focus sunlight onto a receiver that heats a liquid. The super-heated liquid is used to make steam to produce electricity in the same way that coal plants do. There are CSP plants in California, Arizona, Nevada, Florida, Colorado, and Hawaii.

Solar energy has great potential for the future. Solar energy is free, and its supplies are unlimited. It does not pollute or otherwise damage the environment. It cannot be controlled by any one nation or industry. If we can improve the technology to harness the sun's enormous power, we may never face energy shortages again.

SOLAR WATER HEATER

SOLAR PANELS (PHOTOVOLTAIC)

SOLAR THERMAL ELECTRICITY

Image courtesy of U.S. Department of Energy

Parabolic troughs concentrate the sun's radiant energy, heating fluid that is used to create steam. The steam turns a generator, which produces electricity.

Uranium (Nuclear)

What Is Nuclear Energy?

Nuclear energy is energy in the **nucleus** of an **atom**. Atoms are building blocks of **elements**. There is enormous energy in the bonds that hold atoms together.

Nuclear energy can be used to make electricity, but first the energy must be released. It can be released from atoms in two ways: nuclear fusion and fission.

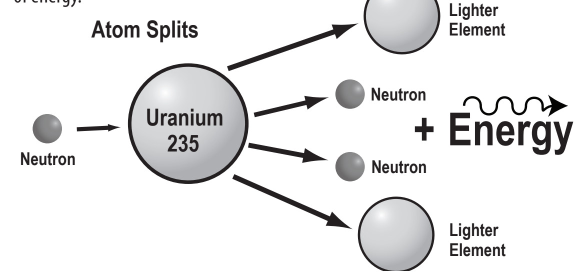
In nuclear **fusion**, energy is released when atoms are combined or fused together to form a larger atom. This is how the sun produces energy.

In nuclear **fission**, atoms are split apart to form smaller atoms, releasing energy. Nuclear power plants use nuclear fission to produce electricity.

The fuel most widely used by nuclear plants for nuclear fission is **uranium**. Uranium is **nonrenewable**, though it is a common metal found in rocks all over the world. Nuclear plants use uranium as fuel because its atoms are easily split apart. During nuclear fission, a small particle called a **neutron** hits the uranium atom and the atom splits, releasing a great amount of energy as heat and radiation. More neutrons are also released. These neutrons go on to bombard other uranium atoms, and the process repeats itself over and over again. This is called a **chain reaction.**

Fission

The splitting of the nucleus of an atom into nuclei of lighter atoms, accompanied by the release of energy.



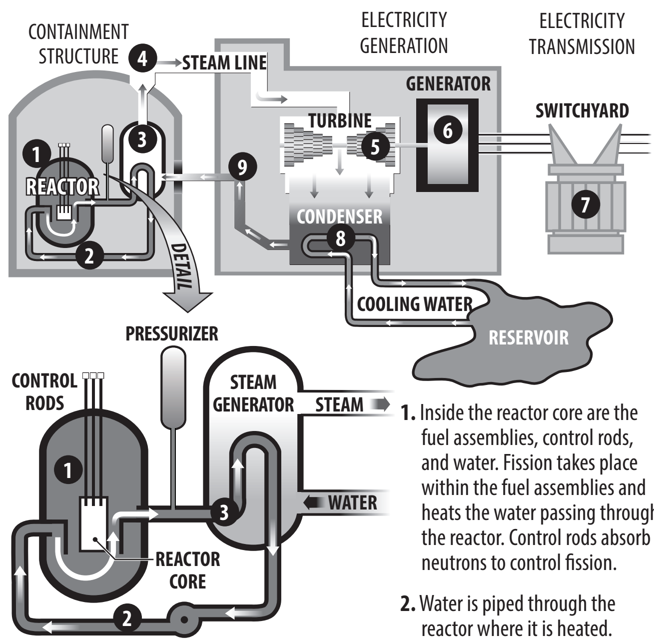
History of Nuclear Energy

Compared to other energy sources, fission is a very new way to produce energy. It wasn't until the early 1930s that scientists discovered that the nucleus of an atom is made up of particles called **protons** and neutrons.

A few years later, scientists discovered that the nucleus of an atom could be split apart by bombarding it with a neutron—the process we call fission. Soon they realized that enormous amounts of energy could be produced by nuclear fission.

During World War II, nuclear fission was first used to make a bomb. After the war, nuclear fission was used to generate electricity. Today, it provides 19.0 percent of the electricity used in the United States.

Pressurized Water Reactor



1. Inside the reactor core are the fuel assemblies, control rods, and water. Fission takes place within the fuel assemblies and heats the water passing through the reactor. Control rods absorb neutrons to control fission.

2. Water is piped through the reactor where it is heated.

3. It then travels to the steam generator where it heats a secondary system of water.

4. The steam generator keeps the steam at a high pressure. The steam travels through a steam line to the turbine.

5. The high pressure steam turns the turbine as it passes through, which spins a shaft. The steam then travels through the condenser where it is condensed by cooling water and is pumped back into the steam generator to repeat its cycle.

6. The turbine spins a shaft that travels into the generator. Inside the generator, the shaft spins coils of copper wire inside a ring of magnets. This generates electricity.

7. Electricity is sent to a switchyard, where a transformer increases the voltage, allowing it to travel through the electric grid.

8. The unused steam continues into the condenser where cool water from the environment (river, ocean, lake, reservoir) is used to condense it back into water. The cooling water never comes in direct contact with the steam, so it is safe to return to the environment.

How a Nuclear Plant Works

Most power plants burn fuel to produce electricity, but not nuclear power plants. Instead, nuclear plants use the heat given off during fission. Fission takes place inside the **reactor** of a nuclear power plant. At the center of the reactor is the core, which contains the uranium fuel.

The uranium fuel is formed into ceramic pellets. The pellets are about the size of your fingertip, but each one produces about the same amount of energy as 150 gallons (565 L) of oil. These energy-rich pellets are stacked end-to-end in 12-foot (3-4 m) metal **fuel rods**. A bundle of fuel rods is called a fuel assembly.

Fission generates thermal energy in a reactor just as coal generates thermal energy in a boiler. The thermal energy is used to boil water into steam. The steam turns huge **turbine** blades. As they turn, they drive **generators** that make electricity.

Afterward, the steam is changed back into water and cooled. Some plants use a local body of water for the cooling process; others use a separate structure at the power plant called a **cooling tower**.

Spent (Used) Nuclear Fuel

Every few years, the fuel rods must be replaced. Fuel that has been removed from the reactor is called **spent fuel**. Nuclear power plants do not produce a large quantity of waste, but this used fuel is highly **radioactive**.

The spent fuel is usually stored near the reactor in a deep pool of water called the spent fuel pool. Here, the spent fuel cools down and begins to lose most of its radioactivity through a natural process called **radioactive decay**.

In three months, the spent fuel will have lost 50 percent of its radiation; in a year, it will have lost about 80 percent; and in ten years, it will have lost 90 percent. Nevertheless, because some radioactivity remains for as long as 1,000 years, the spent fuel must be carefully isolated from people and the environment.

Used Nuclear Fuel Repository

Most scientists think the safest place to store spent nuclear fuel is in underground rock formations called **repositories**. In 1982, Congress agreed and passed the Nuclear Waste Policy Act. This law directed the Department of Energy to design and build America's first repository.

The U.S. Department of Energy (DOE) originally looked at Yucca Mountain, Nevada, to be the site of a national spent nuclear fuel repository. Some people supported the site at Yucca Mountain as a safe site for spent nuclear fuel. However, some people living in Nevada were worried about possible safety hazards and did not want the repository in their state.

Although it was at one time approved, the U.S. Department of Energy withdrew its Yucca Mountain application with the intention of pursuing new long-term storage solutions. Until a final storage solution is found, nuclear power plants will continue storing spent fuel at their sites in spent fuel pools or dry cask storage.

Nuclear Energy and the Environment

Nuclear power plants have very little impact on the environment unless there is an accident. Nuclear plants produce no air pollution or carbon dioxide, because no fuel is burned. Using nuclear energy may be one way to solve air pollution problems and reduce **greenhouse gas** emissions that contribute to global **climate change**.

Nuclear power plants do require a lot of water for cooling. If the water is taken from nearby rivers or lakes and returned at a higher temperature, it can disrupt the balance of organisms living in the water habitat.

The major challenge of nuclear power is storage of the radioactive spent fuel. Right now, all of the spent fuel is stored on site at the power plants. People also worry that an accident at a power plant could cause widespread damage and radioactive contamination.

People are using more and more electricity. Some experts predict that we will have to use nuclear energy to produce the amount of electricity people need at a cost they can afford.

Nuclear Safety

The greatest potential risk from nuclear power plants is the release of high-level **radiation** and radioactive material. Radiation is energy given off by some elements and energy transformations. There are natural and man-made sources of radiation that we are exposed to everyday. Very small amounts of radiation are harmless to humans. Very high levels of radiation can damage or destroy the body's cells and can cause serious diseases such as cancer, or even death.

In the United States, plants are specifically designed to contain radiation and radioactive material in the unlikely case of an accident. Emergency plans are in place to alert and advise nearby residents if there is a release of radiation into the local environment. Nuclear power plants have harnessed the energy from the atom for over 50 years in the United States.

In 1979, at the Three Mile Island facility in Pennsylvania, the top half of the uranium fuel rods melted when coolant water to one reactor was cut off in error. A small amount of radioactive material escaped into the immediate area before the error was discovered. Due to the safety and containment features of the plant design, multiple barriers contained almost all of the radiation. No injuries or fatalities occurred as a result of the error.

In 1986, in the Ukraine (former Soviet Union) at the Chernobyl nuclear power plant, two steam explosions blew the top off of Unit 4. A lack of containment structures and other design flaws caused the release of a large amount of radioactive material into the local community. More than 100,000 people were evacuated from their homes and about 200 workers were treated for radiation sickness and burns. Several people were killed immediately, or died shortly after, with others suffering longer term medical ailments.

On March 11, 2011, an earthquake and resulting tsunami struck Japan, killing and injuring tens of thousands of people. Prior to the earthquake, Japan generated a large percentage of its electricity from nuclear power. In the Fukushima prefecture (community), the Daiichi nuclear plant shut down as a result of the earthquake but suffered extraordinary damage from the tsunami. The damage caused a loss of power that was required to keep the reactor and fuel rods cool. The release of some radioactive material required that residents within a 12 mile radius of the plant be evacuated. Residents living between 12 and 19 miles from the affected power plant were asked to evacuate voluntarily. The Japanese Nuclear and Industrial Safety Agency, the International Atomic Energy Agency, health organizations, and the nuclear energy industry continue to investigate the area and restore it for residents. These groups are also monitoring the impact of the radiation released from the Daiichi nuclear power plant both on the local environment and around the world.

Nuclear energy remains a major source of electricity in the United States and around the globe. The safe operation of nuclear power plants is important to quality of life and to the health and safety of individuals worldwide.

Wind

What Is Wind?

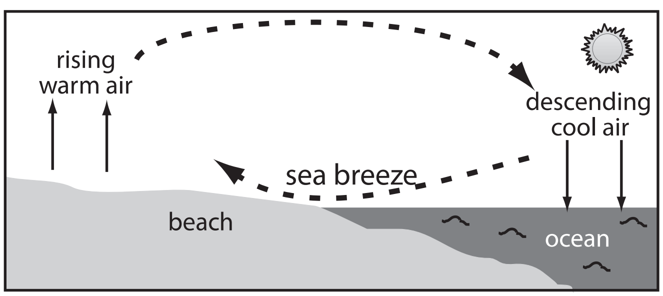
Wind is simply air in motion. It is caused by the uneven heating of the Earth's surface by radiant energy from the sun. Since the Earth's surface is made of very different types of land and water, it absorbs the sun's energy at different rates. Water usually does not heat or cool as quickly as land because of its physical properties.

An ideal situation for the formation of local wind is an area where land and water meet. During the day, the air above the land heats up more quickly than the air above water. The warm air over the land expands, becomes less dense and rises.

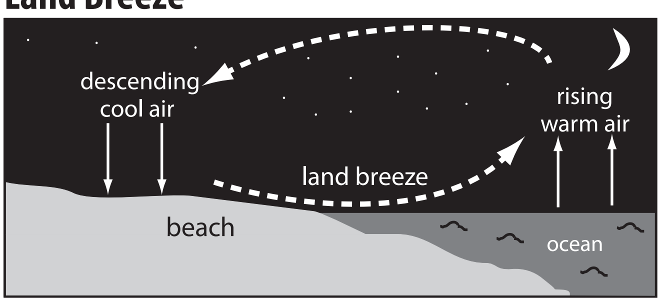
The heavier, denser, cool air over the water flows in to take its place, creating wind. In the same way, the atmospheric winds that circle the Earth are created because the land near the Equator is heated more by the sun than land near the North and South Poles.

Today, people use wind energy to make electricity. Wind is called a **renewable** energy source because the wind will blow as long as the sun shines.

Sea Breeze



Land Breeze



Wind Direction

A weather vane, or wind vane, is used to show the direction of the wind. A wind vane points toward the source of the wind. Wind direction is reported as the direction from which the wind blows, not the direction toward which the wind moves. A north wind blows from the north toward the south.

Wind Speed

It is important in many cases to know how fast the wind is blowing. Wind speed can be measured using a wind gauge or **anemometer**.

One type of anemometer is a device with three arms that spin on top of a shaft. Each arm has a cup on its end. The cups catch the wind and spin the shaft. The harder the wind blows, the faster the shaft spins. A device inside counts the number of rotations per minute and converts that figure into miles per hour. A display on the anemometer shows the speed of the wind.

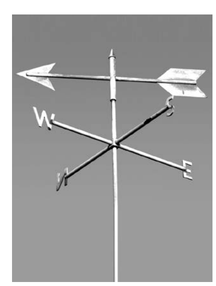
History of Wind Machines

Since ancient times, people have harnessed the wind's energy. Over 5,000 years ago, the ancient Egyptians used the wind to sail ships on the Nile River. Later, people built windmills to grind wheat and other grains. The early windmills looked like paddle wheels. Centuries later, the people in Holland improved the windmill. They gave it propeller-type blades, still made with sails. Holland is famous for its windmills.

In this country, the colonists used windmills to grind wheat and corn, to pump water, and to cut wood at sawmills. Today, people occasionally use windmills to grind grain and pump water, but they also use modern wind turbines to make electricity.

Windmill

Weather Vane



Anemometer

Today's Wind Turbines

Like old-fashioned windmills, today's **wind turbines** use blades to capture the wind's kinetic energy. Wind turbines work because they slow down the speed of the wind. When the wind blows, it pushes against the blades of the wind turbine, making them spin. They power a generator to produce electricity.

Most wind turbines have the same basic parts: blades, shafts, gears, a generator, and a cable. (Some turbines do not have gear boxes.) These parts work together to convert the wind's energy into electricity.

1. The wind blows and pushes against the blades on top of the tower, making them spin.
2. The turbine blades are connected to a low-speed drive shaft. When the blades spin, the shaft turns. The shaft is connected to a gear box. The gears in the gear box increase the speed of the spinning motion on a high-speed drive shaft.
3. The high-speed drive shaft is connected to a generator. As the shaft turns inside the generator, it produces electricity.
4. The electricity is sent through cables down the turbine tower to a transmission line.

The amount of electricity that a turbine produces depends on its size and the speed of the wind. Wind turbines come in many different sizes. A small turbine may power one home. Large wind turbines can produce enough electricity to power up to 1,000 homes. Large turbines are sometimes grouped together to provide power to the electricity grid. The grid is the network of power lines connected together across the entire country.

Wind Power Plants

Wind power plants, or **wind farms**, are clusters of wind turbines used to produce electricity. A wind farm usually has dozens of wind turbines scattered over a large area.

Choosing the location of a wind farm is known as **siting** a wind farm. The wind speed and direction must be studied to determine where to put the turbines. As a rule, wind speed increases with height, as well as over open areas with no windbreaks.

Turbines are usually built in rows facing into the **prevailing wind**. Placing turbines too far apart wastes space. If turbines are too close together, they block each other's wind.

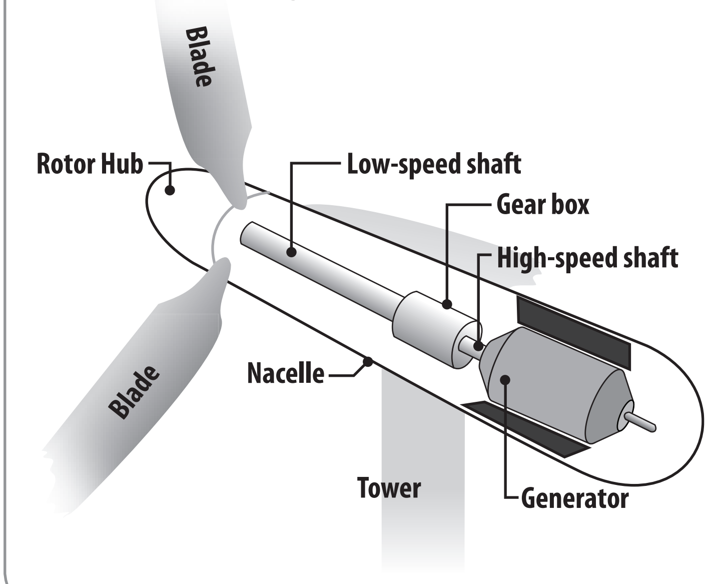
The site must have strong, steady winds. Scientists measure the winds in an area for several years before choosing a site. The best sites for wind farms are on hilltops, on the open plains, through mountain passes, and near the coasts of oceans or large lakes. Texas, the number one producer of wind energy in the U.S., has plentiful open space with steady winds.

The wind blows stronger and steadier over water than over land. There are no obstacles on the water to block the wind. There is a lot of wind energy available **offshore**.

Offshore wind farms are built in the shallow waters off the coast of major lakes and oceans. Offshore turbines produce more electricity than turbines on land, but they cost more to build and operate.

The first offshore wind farm in the United States, off the coast of Cape Cod, Massachusetts, was approved in April 2011. Construction of the Cape Wind project has yet to begin, but is expected to begin in the near future.

Wind Turbine Diagram



WIND FARM

Wind Production

Every year, wind produces only a small amount of the electricity this country uses, but the amount is growing every year. One reason wind farms don't produce more electricity is that they can only run when the wind is blowing at certain speeds. On Midwestern wind farms, the wind is optimum for producing electricity between 65 and 90 percent of the time.

Environmental Impacts

In some areas, people worry about the birds and bats that may be injured by wind turbines. Some people believe wind turbines produce a lot of sound, and some think turbines affect their view of the landscape.

On the other hand, wind is a clean, renewable energy source that produces no air pollution. And wind is free to use. Wind power may not be the perfect answer to our electricity needs, but it is a valuable part of the solution.

Climate Change

Earth's Atmosphere

Our Earth is surrounded by a blanket of gases called the **atmosphere**. Without this blanket, our Earth would be so cold that almost nothing could live. It would be a frozen planet. Our atmosphere keeps us alive and warm.

The atmosphere is made up of many different gases. Most of the atmosphere (99 percent) is oxygen and nitrogen. Less than half of one percent is a mixture of **greenhouse gases**. Greenhouse gases include water vapor, **carbon dioxide (CO_2)**, **methane**, **F-gases, ozone**, and nitrous oxide. Water vapor is the most common greenhouse gas, but can have varying levels of concentration depending on the climate.

Carbon dioxide is the gas we produce when we breathe and when we burn wood and fossil fuels. Methane is the main gas in natural gas. It is also produced when once-living matter decays, and from animal waste. The other greenhouse gases are produced by burning fuels and from other natural and human activity.

Sunlight and the Atmosphere

Rays of sunlight (**radiant energy**) shine down on the Earth every day. Some of these rays bounce off clouds and are reflected back into space. Some rays are absorbed by molecules in the atmosphere. About half of the sunlight passes through the atmosphere and reaches the Earth.

When the sunlight hits the Earth, most of it turns into thermal energy (heat). The Earth absorbs some of this thermal energy. The rest flows back out toward the atmosphere. This keeps the Earth from getting too warm.

When this thermal energy reaches the atmosphere, it stops. It can't pass through the atmosphere like sunlight. Most of the heat becomes trapped and flows back to the Earth. We usually think it's sunlight that warms the Earth, but actually it's this contained thermal energy that gives us most of our warmth.

The Greenhouse Effect

We call this trapping of thermal energy the **greenhouse effect**. A greenhouse is a building made of clear glass or plastic. In cold weather, we can grow plants in a greenhouse. The glass allows the sunlight into the greenhouse. The sunlight turns into heat when it hits objects inside. The heat becomes trapped. The radiant energy can pass through the glass; the thermal energy cannot.

The Greenhouse Effect

Radiant energy (light rays) shines on the Earth. Some radiant energy reaches the atmosphere and is reflected back into space. Some radiant energy is absorbed by the atmosphere and is transformed into thermal energy (heat) (dark arrows).

Half of the radiant energy that is directed at Earth passes through the atmosphere and reaches the Earth, where it is transformed into heat.

The Earth absorbs some of this heat.

Most of the heat flows back into the air. The atmosphere traps the heat.

Very little of the heat escapes back into space.

The trapped heat flows back to Earth.