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

NEED Mission Statement

The mission of The NEED Project is to promote an energy-conscious and educated society by creating effective networks of students, educators, business, government, and community leaders to design and deliver objective, multi-sided energy education programs.

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Energy Data Used in NEED Materials

NEED believes in providing teachers and students with the most recently reported, available, and accurate energy data. Most statistics and data contained within this guide are derived from the U.S. Energy Information Administration. Data is compiled and updated annually where available. Where annual updates are not available, the most current, complete data year available at the time of updates is accessed and printed in NEED materials. To further research energy data, visit the EIA website at **www.eia.gov**.

National Energy Education Development

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Intermediate Energy Infobook

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Standards Correlation Information

www.NEED.org/educators/curriculum-correlations

Next Generation Science Standards

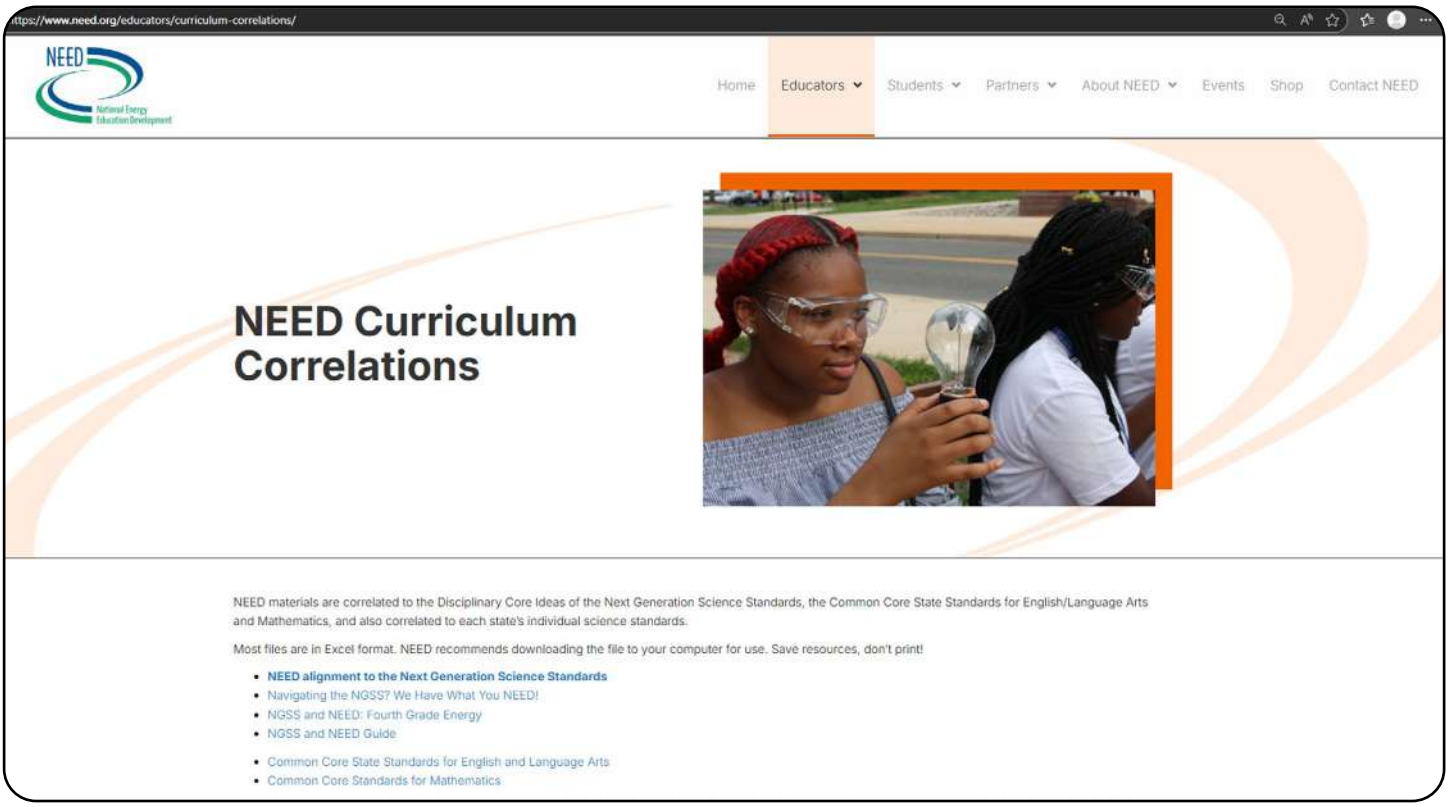
- This guide effectively supports many Next Generation Science Standards. This material can satisfy performance expectations, science and engineering practices, disciplinary core ideas, and crosscutting concepts within your required curriculum. For more details on these correlations, please visit NEED's curriculum correlations website.

Common Core State Standards

- This guide has been correlated to the Common Core State Standards in both language arts and mathematics. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED curriculum correlations website.

Individual State Science Standards

- This guide has been correlated to each state's individual science standards. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED website.



NEED Intermediate Curriculum Resources

For more in-depth information, inquiry investigations, and engaging activities, download these curriculum resources from **www.NEED.org/shop**.

INTRODUCTORY ACTIVITIES	Energy Games and Icebreakers Energy Polls
STEP ONE: Science of Energy	Energy Flows Energy Works Intermediate Science of Energy
STEP TWO: Sources of Energy	Energy Enigma Energy Expos Energy From Offshore Wind Energy From The Sun Energy From The Wind Energy From Uranium Energy Games and Icebreakers Energy of Moving Water Energy on Public Lands Exploring Ocean Energy and Resources Exploring Oil and Natural Gas Floating Offshore Wind Great Energy Debate H_2 Educate Intermediate Energy Infobook Activities Schools Going Solar Understanding Coal Wind for Schools
STEP THREE: Electricity and Magnetism	Baseload Balance Current Energy Affair Electroworks Intermediate Energy Infobook Activities Reliably Smart Sidekick Circuits The Science of Electricity
STEP FOUR: Transportation	Energy and Our Rivers Energy Expos Energy on the Move Exploring Hybrid Buses H_2 Educate Transportation Fuels Debate Transportation Fuels Enigma Transportation Fuels Live!



STEP FIVE: Efficiency and Conservation	Building Science Energy Conservation Contract Energy Expos Energy House Managing Home Energy Use Museum of Solid Waste and Energy Plug Loads School Energy Experts Today in Energy Understanding Climate Science
STEP SIX: Synthesis and Reinforcement	Energy Analysis Energy Around the World Energy Carnival Energy Careers Excursion Energy Games and Icebreakers Energy Jeopardy Energy Live! Energy Math Challenge Energy on Stage Global Trading Game Greek Mythology and Energy Mystery World Tour NEED Songbook This Mine of Mine Yesterday in Energy
STEP SEVEN: Evaluation	Energy Polls Question Bank
STEP EIGHT: Student Leadership and Outreach	Blueprint for Student Energy Teams Youth Awards Program Guide

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 or make a change.

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 one of 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.

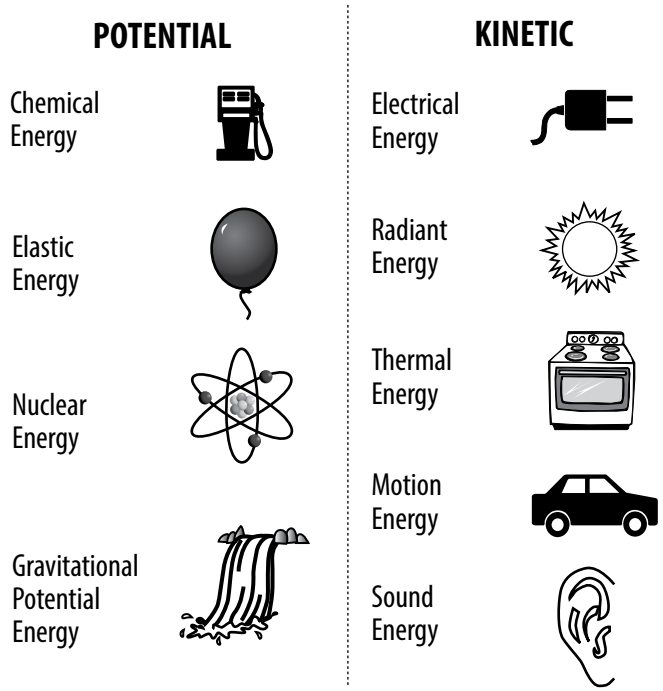
- **Chemical energy** is energy stored in the bonds of **atoms** and **molecules**. It is the energy that holds these particles together. Biomass, petroleum, natural gas, propane, and the foods we eat are examples of stored chemical energy.
- **Elastic energy** is energy stored in objects by the application of a force. Compressed springs, balloons, 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.

Forms of 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.

VAN DE GRAAFF GENERATOR



Image courtesy of Wikimedia Commons via EgorovaSvetlana

Van de Graaff generator produces lightning.

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Conservation of Energy

Your parents may tell you to conserve energy. "Turn off the lights," they probably say. To scientists, **energy conservation** is not just about saving energy. The **Law of Conservation of Energy** says that energy is neither created nor destroyed. When we use energy, it doesn't disappear. We change one form of energy into another. Energy is always transforming.

A car engine burns gasoline, converting the chemical energy in gasoline into motion energy. Solar cells change radiant energy into electrical energy. Energy changes form, but the total amount of energy in the universe stays the same.

Efficiency

Energy efficiency is the amount of useful energy you get from a system. A perfect, energy-efficient machine would change all the energy put in it into useful work—a technological impossibility today. Converting one form of energy into another form always involves a loss of usable energy.

Most energy transformations are not very efficient. The human body is a good example of this. Your body is like a machine, and the fuel for your machine is food. Food gives you the energy to move, breathe, and think.

Your body isn't very efficient at converting food into useful work. Most of the energy in your body is transformed and released as thermal energy (heat). You can really feel that heat when you exercise! This is very much like most energy transfers. The loss of usable energy is often in the form of thermal energy (heat).

Sources of Energy

We use many different energy sources to do work for us. They are classified into two groups: renewable and nonrenewable.

In the United States, most of our energy comes from **nonrenewable** energy sources. Coal, natural gas, petroleum, propane, and uranium are nonrenewable energy sources. They are used to make electricity, heat our homes, move our cars, and manufacture all kinds of products. These energy sources are called nonrenewable because their supplies are limited. Petroleum, a **fossil fuel**, for example, was formed hundreds of millions of years ago from the remains of ancient sea plants and animals. We can't make more petroleum deposits in a short time.

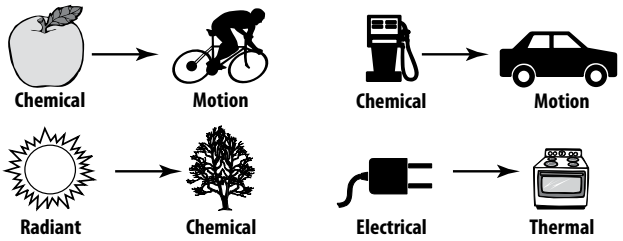
Renewable energy sources include biomass, geothermal energy, hydropower, solar energy, and wind energy. They are called renewable because they are replenished in a short time. Day after day, the sun shines, the wind blows, and the rivers flow. We use renewable energy sources mainly to make electricity.

Electricity

Electricity is different from the other energy sources because it is a **secondary source of energy**. We must use another energy source to produce electricity. In the U.S., natural gas is the number-one energy source used for generating electricity.

Electricity is sometimes called an **energy carrier** because it is an efficient and safe way to move energy from one place to another, and it can be used for so many tasks. As we use more technology, the demand for electricity grows.

Energy Transformations



U.S. Energy Consumption by Source, 2025

NONRENEWABLE, 90.9%

Petroleum 37.3%
Uses: transportation, manufacturing - Includes Propane

Natural Gas 36.0%
Uses: electricity, heating, manufacturing - Includes Propane

Coal 9.1%
Uses: electricity, manufacturing

Uranium 8.5%
Uses: electricity

Propane
Uses: heating, manufacturing

*Propane consumption figures are reported as part of petroleum and natural gas totals.

RENEWABLE, 9.0%

Biomass 5.0%
Uses: electricity, heating, transportation

Wind 1.6%
Uses: electricity

Solar 1.4%
Uses: electricity, heating

Hydropower 0.9%
Uses: electricity

Geothermal 0.1%
Uses: electricity, heating

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

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 we used. Today, biomass provides us about 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 byproducts from agriculture.

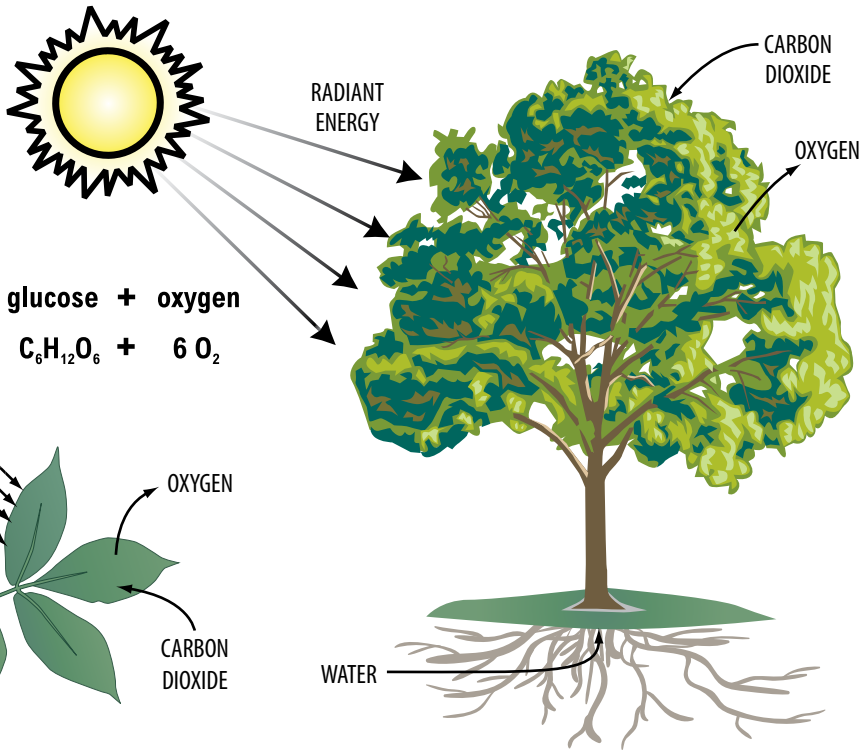
Industry is the biggest biomass consumer today; it uses nearly half of biomass to make products. Transportation uses 35 percent of biomass by consuming **ethanol** and other fuels, like biodiesel or sustainable aviation fuel. Power companies use biomass to produce electricity. Almost seven percent of biomass is used to generate electricity today.

Homes and businesses are the third-biggest users; about one in ten homes burns wood in fireplaces and stoves for additional heat. Less than two percent use wood as their main heating fuel. Most use a source other than wood for heating.

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.

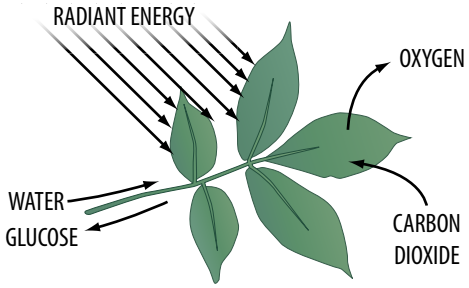
Photosynthesis

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

$6\ H_2O + 6\ CO_2 +$ radiant energy $\longrightarrow C_6H_{12}O_6 + 6\ O_2$



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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 and timber scraps, 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

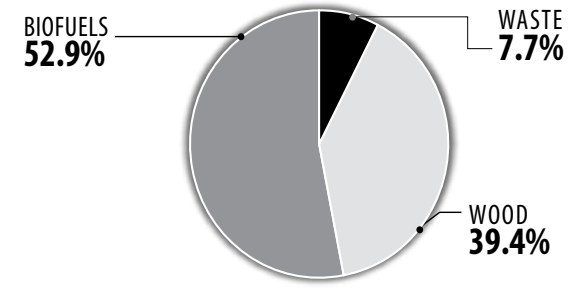
We can add yeast (a fungus) to biomass to produce an alcohol called ethanol. For centuries, people have fermented crops to make alcoholic drinks like beer and wine. Wine is fermented from grapes. Wheat, corn, grasses, and many other crops can be used to make ethanol.

Ethanol is sometimes made from corn to produce a motor fuel. Because of the benefits to farmers, Henry Ford supported using ethanol to power cars. 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

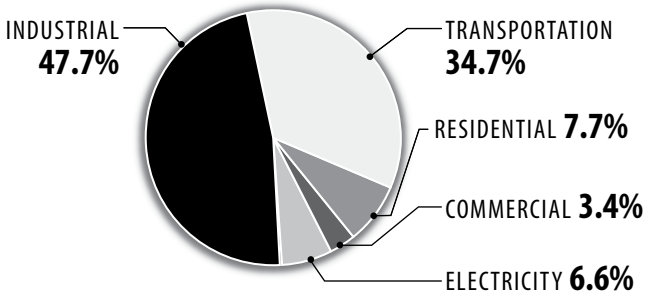
Conversion means changing a material into something else. Today, we can convert biomass into gas and liquid fuels. We do this by heating or adding chemicals to the biomass. The gas and liquid fuels can then be burned to produce heat or electricity, or they can be used as fuels for automobiles. In India,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

U.S. Sources of Biomass, 2025



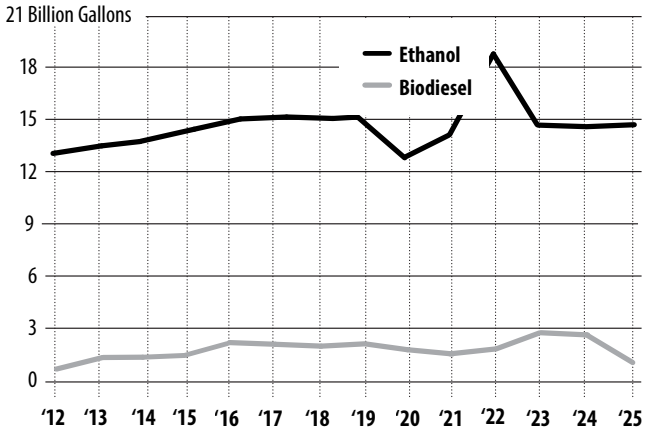
Data: Energy Information Administration
* Total may not equal 100% due to independent rounding.

U.S. Biomass Consumption by Sector, 2025



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

U.S. Consumption of Biofuels, 2025



Data: Energy Information Administration

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 dioxide, which can cause **acid rain**. However, burning biomass does release carbon dioxide, and waste-to-energy plants can release small amounts of other pollutants.

Growing plants for biomass fuel may help reduce **greenhouse gases**, since plants use carbon dioxide and produce oxygen as they grow. Carbon dioxide is an important greenhouse gas. However, growing corn uses a lot of energy, and ethanol lowers the mileage of cars burning ethanol-blended gasoline.

Coal

What Is Coal?

Coal is a **fossil fuel** formed from the fossilized remains of plants that lived and died millions to 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 or more 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.

A few millions to four hundred 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, a **sedimentary** rock, over time.

History of Coal in America

Indigenous Americans used coal long before the first settlers arrived in the New World. The Hopi Tribe 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.

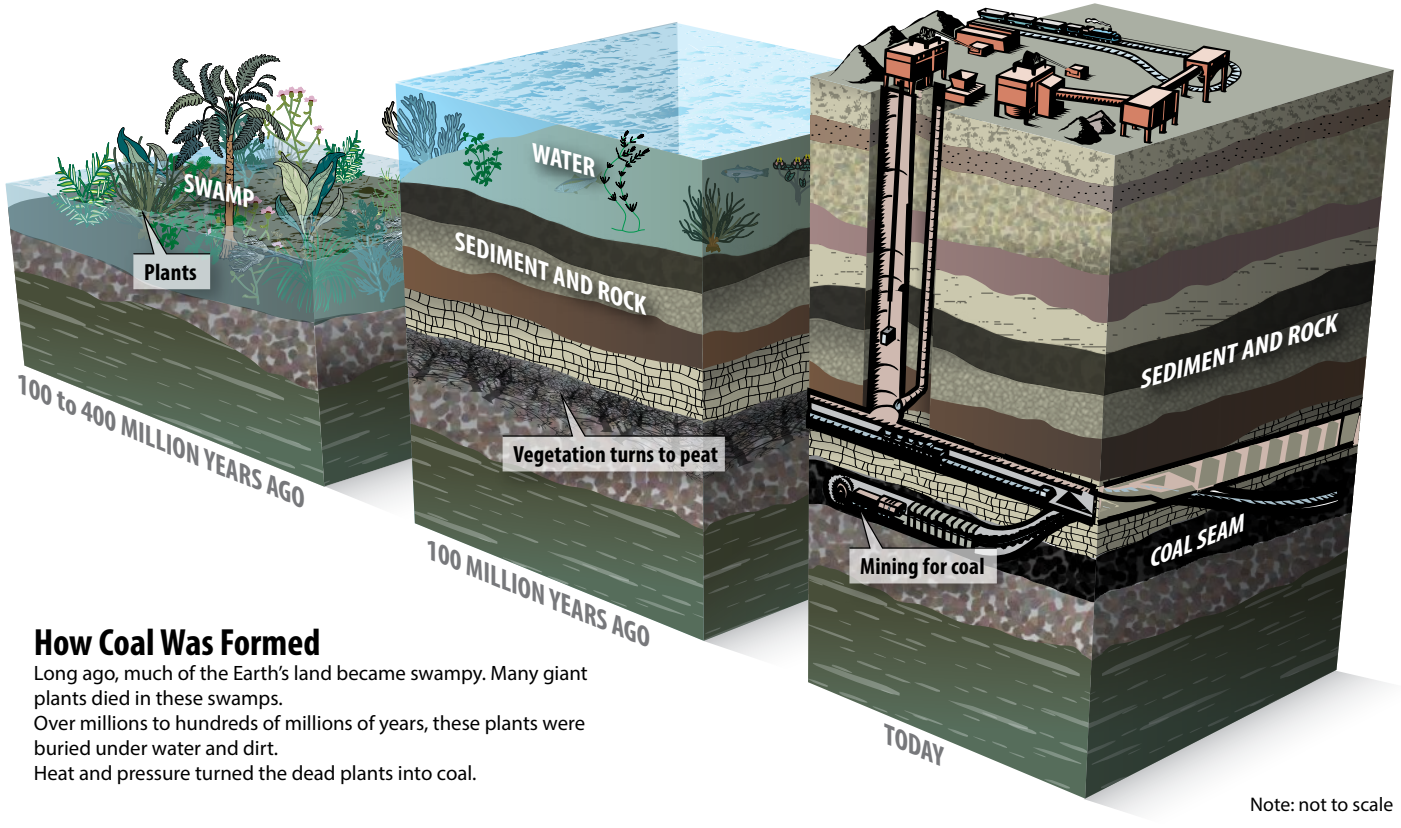
Coal became a powerhouse by the 1800s. People used coal to manufacture goods and to power steamships and railroad engines. By the time of the American Civil War, people also used coal to make iron and steel. And by the end of the 1800s, people began using coal to make electricity.

Today, coal provides 9.1 percent of America's energy needs, and 16.6 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 60 percent 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 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.



How Coal Was Formed

Long ago, much of the Earth's land became swampy. Many giant plants died in these swamps.
Over millions to hundreds of millions of years, these plants were buried under water and dirt.
Heat and pressure turned the dead plants into coal.

Note: not to scale

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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 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 over 400 years.

Coal production is the amount of coal that is mined and sent to market. Coal is mined in 21 states. Wyoming mines the most, followed by West Virginia, Pennsylvania, Illinois, and Montana.

How Coal Is Used

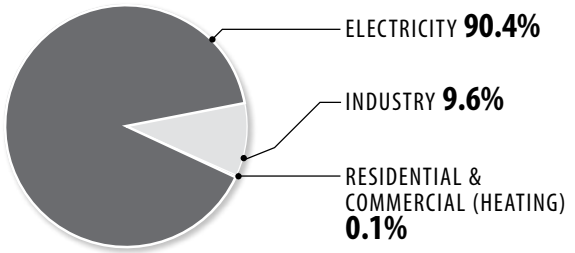
Roughly 90 percent of the coal mined in the U.S. today is used to make electricity. The steel and iron industries use coal for **smelting** metals. Other industries use coal, too. Paper, brick, limestone, and cement industries all use coal to make products. Very little coal is used for heating homes 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.

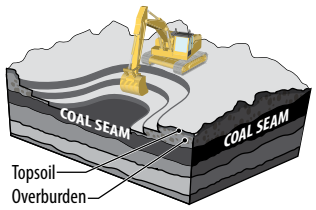
Coal companies look for low-sulfur coal to mine. They work to remove sulfur and other impurities from the coal. Power plants install machines called **scrubbers** to remove most of the sulfur from coal smoke so it doesn't get into the air. Other byproducts, like the ash that is left after coal is burned,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

U.S. Coal Consumption by Sector, 2025

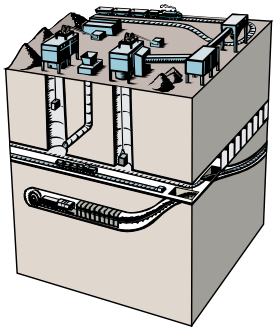


Data: Energy Information Administration
*Total does not equal 100% due to independent rounding.

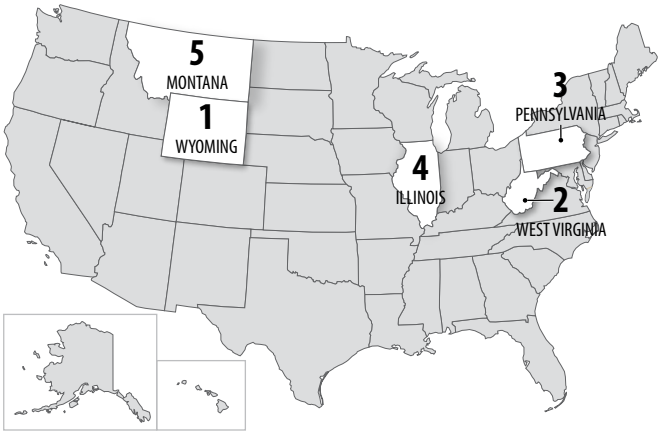
Surface Mining



Deep Mining



Top Coal-Producing States, 2024



Data: Energy Information Administration
*2024 is the most current data available at the time of publication.

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 molten iron surrounding a solid-like 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.

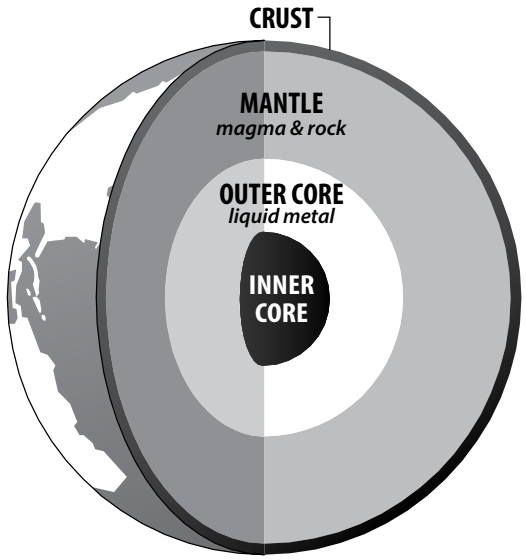
Surrounding the outer core is the **mantle**, which is about 1,800 miles (2,900 km) thick and made of **magma** and rock. The outermost layer of the Earth, the land that forms the continents and ocean floors, is called the **crust**. The crust is three to five miles (5-8 km) thick under the oceans and 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 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 relatively 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 power plant began operating in 1960 at The Geysers in northern California. There are now geothermal power plants in seven states. Most of these geothermal power plants are in California, with the remainder in Nevada, Utah, Oregon, Hawaii, Idaho, and New Mexico. Hawaii's facility on the Big Island needed to be capped in 2018 due to volcanic activity. The plant returned to operational status by 2021 but is constantly on alert due to the active nature of the Kilauea Volcano.

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 be used either for making electricity or heating.

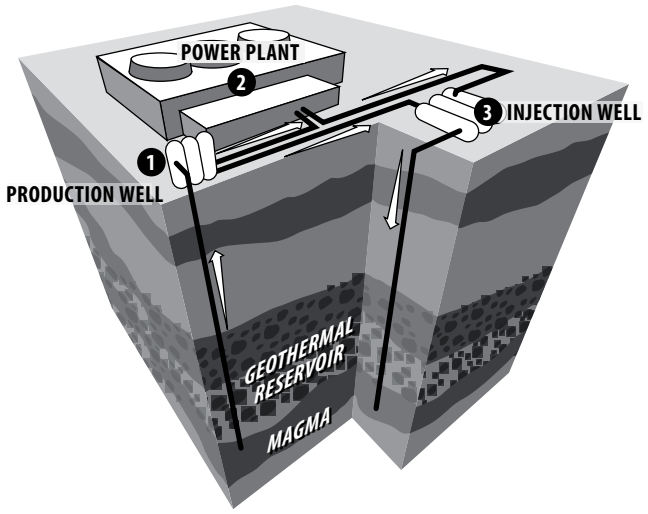
▪ Low-Temperature Resources: Heating

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. Roughly two million homes and buildings in the U.S. use **geoexchange systems**. Almost 85 percent of the homes and businesses in Iceland use geothermal energy for space heating.

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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 spin a shaft. This shaft is attached to the generator. The generator 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.

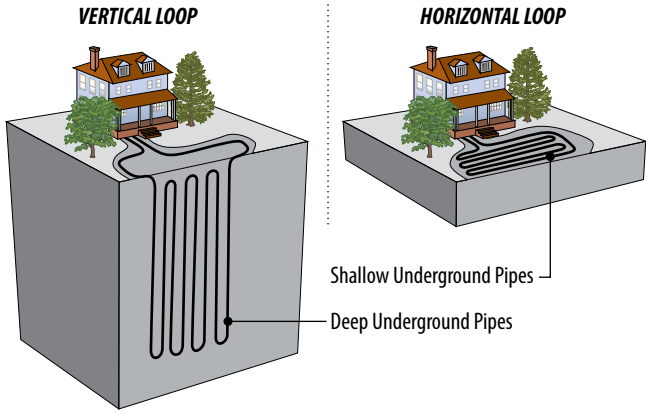
Geothermal energy produces only a small percentage of U.S. electricity. Today, it produces a little less than 16 billion kilowatt-hours, or less than one percent of the electricity produced in this country.

Geothermal Energy and the Environment

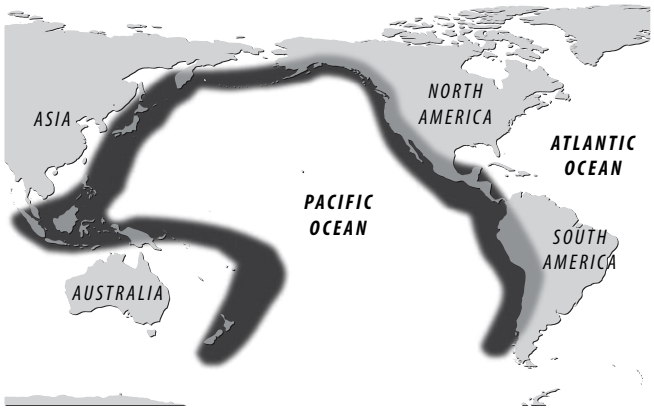
Geothermal energy does little damage to the environment. Another advantage is that geothermal power plants don't have to transport fuel like most power plants. Geothermal power plants sit on top of their fuel source. Geothermal power plants have been built in deserts, in the middle of crops, and in mountain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

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

Residential Geoexchange Units

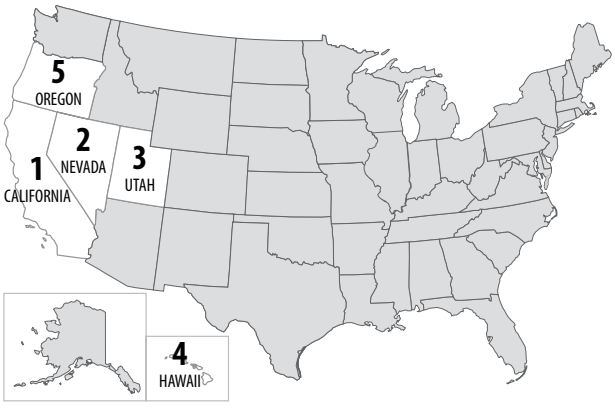


Ring of Fire



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, 2024



Data: Energy Information Administration
*2024 is the most current data available at the time of publication.

Hydropower

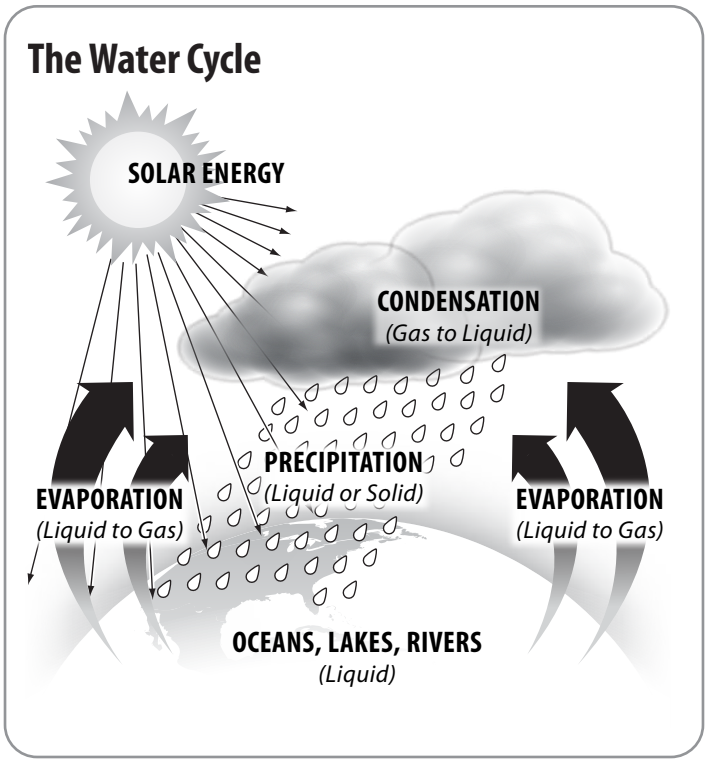
What Is Hydropower?

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.



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 more than 92,000 dams in the United States, but only about 2,200 were built specifically to generate electricity on a large scale.

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.

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Storing Energy

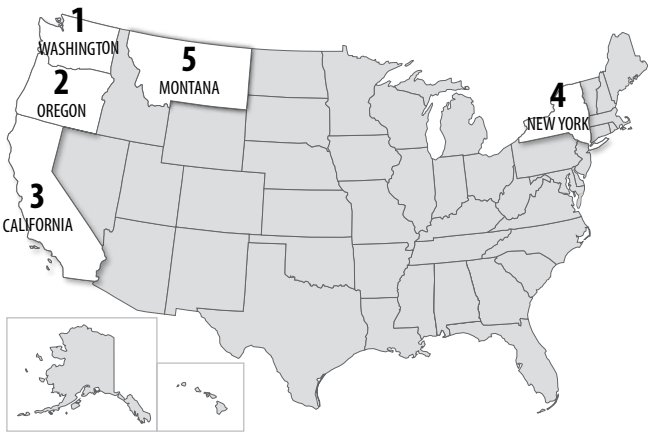
One of the biggest advantages of hydropower dams is their ability to store energy. After all, the water in the reservoir has **gravitational potential energy**. Water can be stored in a reservoir and released when electricity is needed. During the night, when consumers use less electricity, the gates 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. Plants that use elevation to pump water back up at low demand and generate electricity again at periods of higher demand are called **pumped storage facilities**.

Amount and Cost of Hydropower

Depending upon the amount of rainfall during the year, hydropower can provide anywhere between five and 10 percent of the country's electricity. In 2025, hydropower provided about 5.5 percent of the nation's electricity. Globally, hydropower is a significant energy source, producing nearly 15 percent of the world's electricity. In South America, a little more than half of the electricity (54%) 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 for many reasons. The fuel—flowing water—does not have to be transported and is free to use, unlike coal and uranium.

Top Hydropower-Producing States, 2025



Data: Energy Information Administration

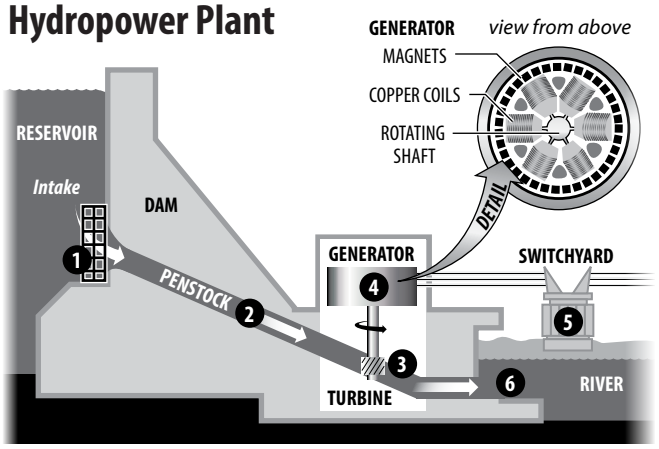
Hydropower and the Environment

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



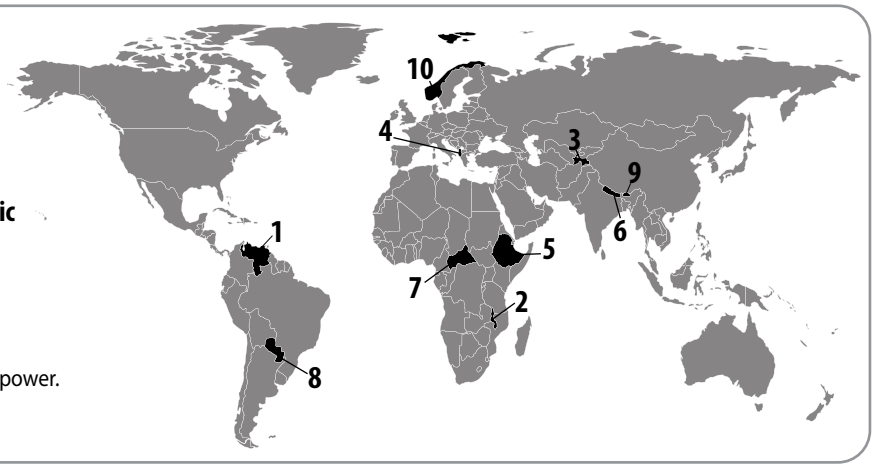
1. Water in a reservoir behind a hydropower dam flows through an intake screen, which filters out large debris but allows fish to pass through.
2. The water travels through a large pipe, called a penstock.
3. The force of the water spins a turbine at a low speed, allowing fish to pass through unharmed.
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.

Top Ten Hydropower Countries

The countries below get over 90% of their electricity from hydropower.

1. **Venezuela**
2. **Malawi**
3. **Tajikistan**
4. **Albania**
5. **Ethiopia**
6. **Nepal**
7. **Central African Republic**
8. **Paraguay**
9. **Bhutan**
10. ***Norway**

*Norway gets about 89.6% percent of its electricity from hydropower.
Data: EIA



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 fossilized 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.

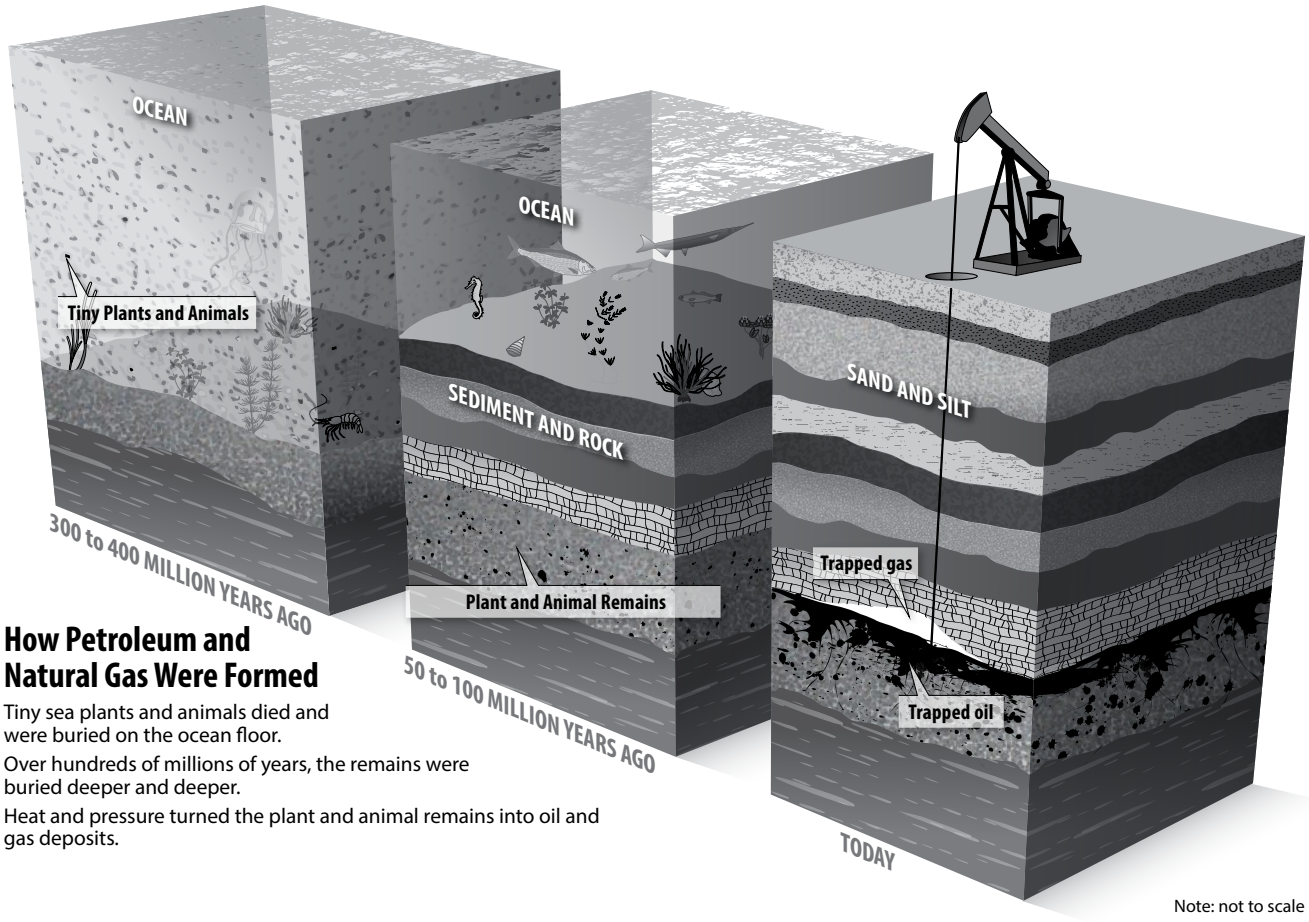
Natural gas is almost always considered **nonrenewable**, which means we cannot make more in a short time. However, there are some renewable sources of methane, such as landfills.

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, NY. 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 buried deeper and deeper.

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

Note: not to scale

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Producing Natural Gas

Natural gas can be hard to find since it is often trapped in **porous** rocks deep underground. Geologists 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 more than 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 33 states, though just five states produce about 74 percent of our supply. Natural gas is also produced **offshore**. A little less than three percent of natural gas production came from offshore wells in 2024.

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 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**. Over three million miles of pipelines connect gas fields to cities, homes, and businesses. Natural gas is sometimes transported thousands of miles in these pipelines to its final destination. It can take up to a week to move natural gas from Texas to New York. Natural gas can be transported by ship over longer distances if it is compressed and liquefied as liquefied natural gas (LNG).

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?

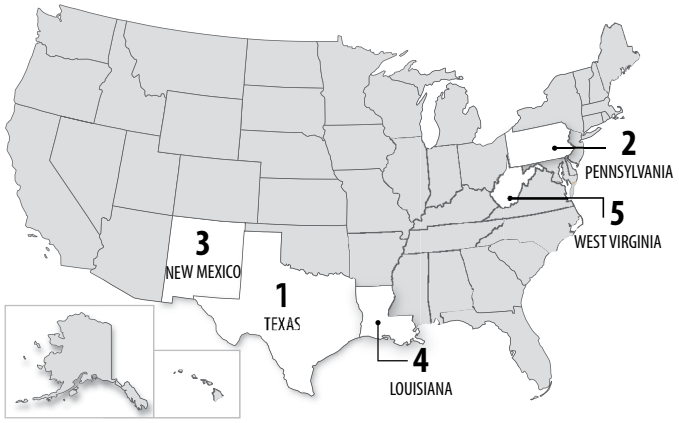
Just about everyone in the United States uses natural gas. Natural gas is used for 36 percent of U.S. energy. Industry burns natural gas for heat to manufacture goods. Natural gas is also used as an ingredient in fertilizer, glue, paint, laundry detergent, and many other items.

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 is also used to generate electricity. It accounts for 40.8 percent of U.S. electricity generated. Many new power plants are using natural gas as fuel because it is cleaner burning than coal and petroleum and can produce electricity quickly when it is needed for periods of high demand.

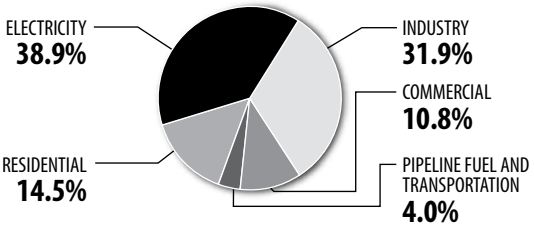
A small amount of natural gas is used as fuel for automobiles. Natural gas is cleaner burning than gasoline, but to use it, vehicles must have special equipment.

Top Natural Gas-Producing States, 2025



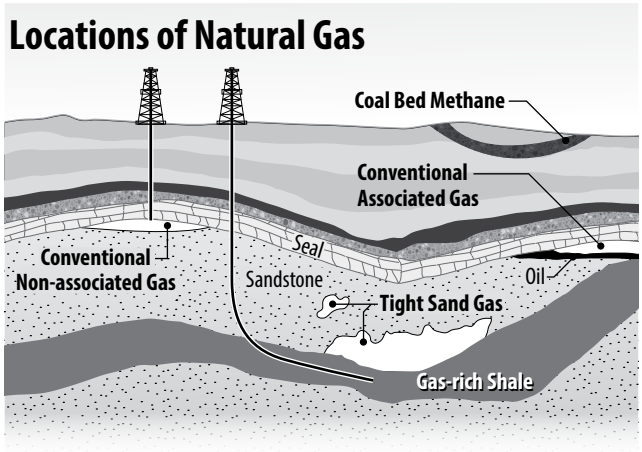
Data: Energy Information Administration

U.S. Natural Gas Consumption by Sector, 2025



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

Locations of Natural Gas



Natural Gas and the Environment

Burning 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. However, methane, if released into the atmosphere before burning, is a very potent greenhouse gas.

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 fossilized 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. Petroleum reserves cannot be replenished within our own lifetime.

History of Oil

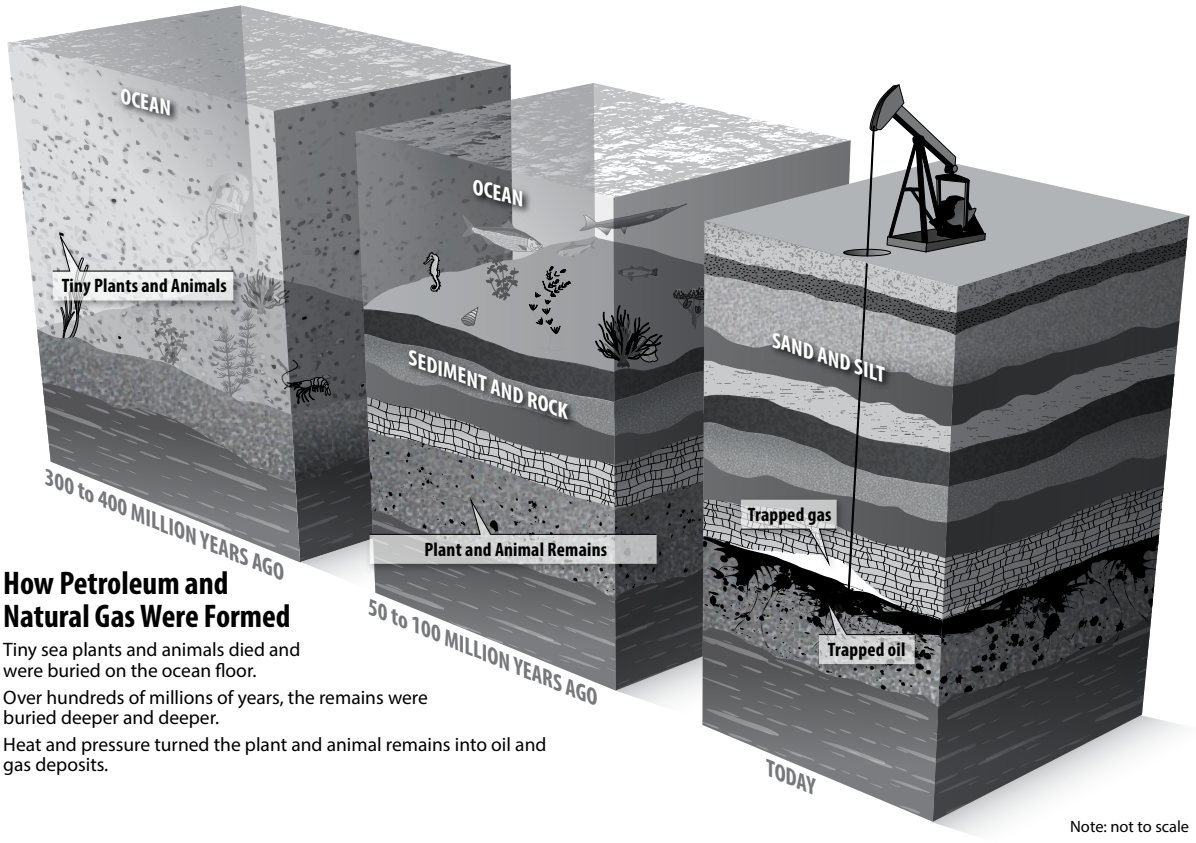
People have used petroleum since ancient times. The ancient Chinese and Egyptians burned oil to light their homes. Before the 1850s, Americans used whale oil to light their homes. When whale oil became scarce due to overfishing, people skimmed the oil that seeped to the surface of ponds and streams.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

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 automobiles, which 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 37.3 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. Between 60 and 75 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.

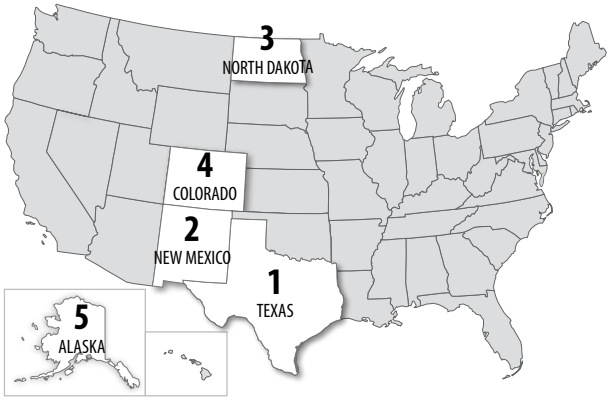
Over hundreds of millions of years, the remains were buried deeper and deeper.

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

Note: not to scale

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Top Petroleum-Producing States, 2025



Data: Energy Information Administration

About 14 percent 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 New Mexico, North Dakota, Colorado, and Alaska. Americans still use more oil than we produce. Today, the U.S. imports 39 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 190,000 miles (305,775 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 can take two to three weeks to move a shipment of gasoline from Houston, Texas, to New York City. Petroleum can also be moved over water in a tanker.

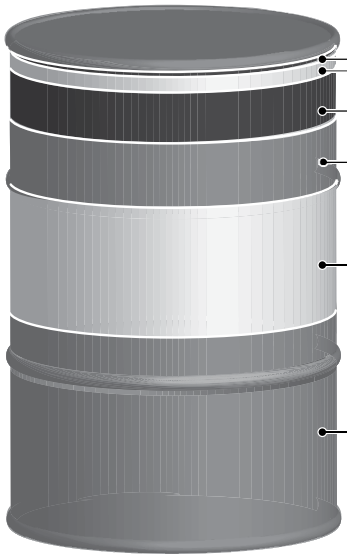
Special companies called **jobbers** buy petroleum products from oil companies and sell them to gasoline stations and to other big users such as industries, power companies, and farmers.

Oil and the Environment

Petroleum products—gasoline, medicines, fertilizers, and others—have helped people all over the world, but there is a tradeoff. Petroleum production, exploration, and the use of petroleum products cause air and water pollution and create greenhouse gas emissions.

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.

Products Produced from a Barrel of Oil, 2025

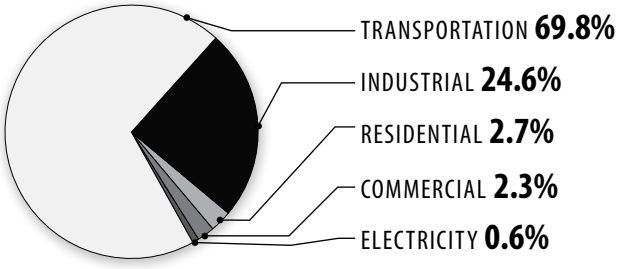


Data: Energy Information Administration
*Total may not equal 100% due to independent rounding.

Other Petroleum Products



U.S. Petroleum Consumption by Sector, 2025



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

The petroleum industry must commit to and work toward protecting the environment. Gasoline and diesel fuel have been changed to burn cleaner. And oil companies must 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 included in raw petroleum and natural gas. Propane is found underground mixed with deposits of natural gas and petroleum. Propane is called a fossil fuel because it was formed hundreds of millions of years ago from the fossilized remains of tiny sea animals and plants.

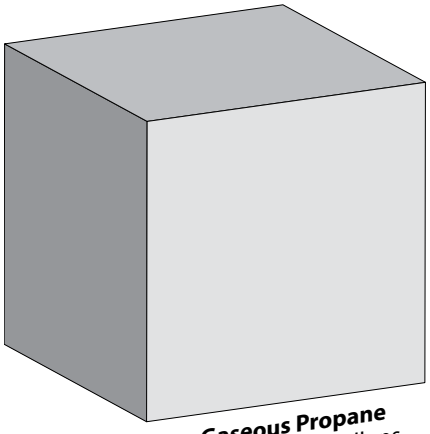
When the plants and animals died, they sank to the bottom of the oceans where they were buried by layers of sediment and sand that turned into sedimentary rock. Over time, the layers became thousands of feet thick. The layers were subjected to enormous heat and pressure, changing the remains into petroleum 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 **hydrocarbon gas liquids (HGL)** family. Propane is a special type of HGL called **liquefied petroleum gas (LPG)**. Propane is the most common LPG. 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 period of time.

Liquefied Propane



As a gas, propane occupies 270 times more space than when it is pressurized into a liquid.

Gaseous Propane
Volume = 270 gallons

Liquid Propane
Volume = 1 gallon

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. About 77 percent 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 remainder of our propane supply comes from petroleum refineries or is imported. Many gases are separated from petroleum at refineries. Since the U.S. imports 39 percent of the petroleum we use, much of the propane is separated from this imported oil. About 14 percent of the U.S. propane supply is imported.

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 them 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 a small percentage of its energy. Propane is used by industry, homes, farms, and businesses—mostly for heating. It is also used as a transportation fuel.

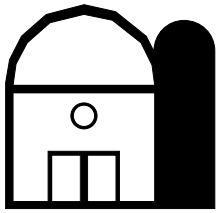
- **Industry**

About 41 percent 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 keep construction and road workers warm in cold weather.

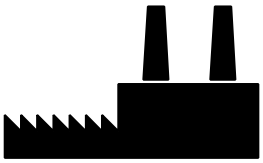
Propane is also used to heat asphalt for highway construction and repairs. And because propane burns so cleanly, forklift trucks powered by propane can operate safely inside factories and warehouses.

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How Propane Is Used



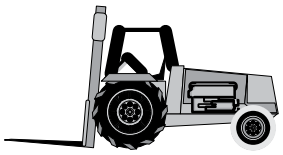
To heat barns and operate farm equipment



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 often used in rural areas that do not have access to natural gas service. Homes use propane for heating, hot water, cooking, and clothes drying. Propane is commonly used by people in rural, suburban, and urban areas to fuel barbecue grills. Some families have recreational vehicles equipped with propane appliances.

▪ Farms

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

▪ Businesses

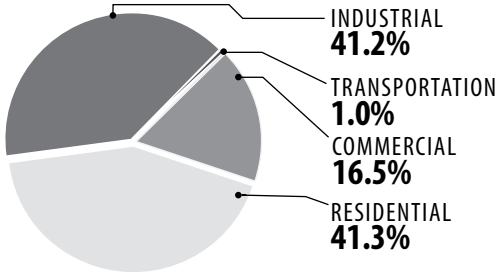
Businesses—office buildings, laundromats, fast-food restaurants, and grocery stores—use propane for heating and cooking.

▪ 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.

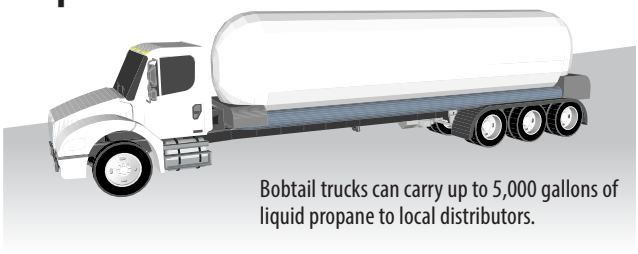
Why isn't propane used as a transportation fuel more often? For one reason, it's not as easy to find as gasoline. Have you ever seen a propane filling station? Second, automobile engines have to be adjusted to use propane fuel, and these adjustments can be costly. Third, there is a slight drop in miles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

U.S. Propane Consumption by Sector, 2025



Propane is used very little for electricity generation. If used for electric power, often it is in off-grid applications.
Data: Energy Information Administration
*Total may not equal 100% due to independent rounding.

Propane Truck



Bobtail trucks can carry up to 5,000 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. However, burning propane still produces carbon dioxide, a greenhouse gas.

Solar

What Is Solar Energy?

The sun radiates tremendous amounts of energy into space. Only a tiny fraction of that **solar energy** reaches Earth, but it is powerful enough to warm the planet. The energy comes from inside 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 (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—just over one percent (1.4%). Solar energy is mostly used by residences and to generate electricity. Solar accounted for 6.7 percent of U.S. electricity in 2025.

Solar Collectors

Despite the enormous amount of solar energy, 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!

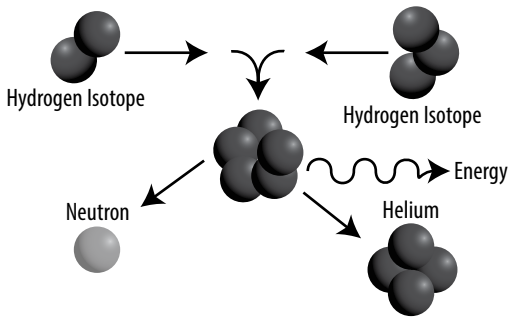
Solar Space Heating

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.

A **passive solar home** is designed to allow sunlight through windows to provide heat for the walls and floor of the house. It also uses architectural features to block the sun in warmer weather, to avoid excess heat when not needed. Materials like stone or concrete are warmed by the sunlight and radiate it slowly into the home at night. This home design does not rely on specialized equipment like pumps or blowers.

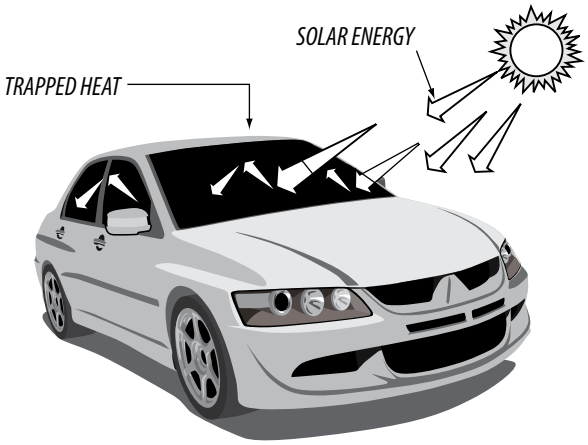
Fusion

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.

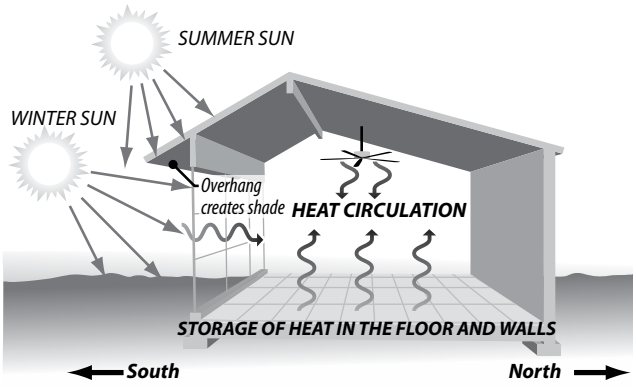


Solar Collector

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 is then converted into heat energy. The heat energy becomes trapped inside.



Passive Solar Home



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An **active solar home**, on the other hand, uses special equipment, such as solar collectors, to heat the interior or heat water. A solar collector is an enclosed box that is dark on the inside and covered with glass. The dark colors inside absorb energy and get hot. Air or water flows through collectors and are heated by the dark interior surface. That warm fluid is then distributed inside the house using a pump or fan, heating the home.

Solar Water Heating

Solar energy can be used to heat water for bathing and washing dishes and clothes. Water heating is the second-largest home energy cost after heating and cooling the home. Installing a solar water heater can reduce your water heating bill by as much as 50-80 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 electric 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 can be more expensive, and many panels are needed to equal the electricity generated at other types of plants.

It can cost five to 20 cents per kilowatt-hour to produce electricity from solar cells. Most people pay their electric companies about 17 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 late 2015, the Solar Star power plant in California opened. At the time, it was the world's largest photovoltaic power plant, generating 579 megawatts of electricity—enough to power about 255,000 homes. Today, much larger solar facilities operate in countries such as China, India, and the United Arab Emirates, with some sites capable of generating several thousand megawatts of electricity.

SOLAR WATER HEATER



Image courtesy of Adobe Stock/Anna Baranova

SOLAR PANELS (PHOTOVOLTAIC)



Image courtesy of Adobe Stock/bilanol

SOLAR THERMAL ELECTRICITY



Image courtesy of Adobe Stock

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

▪ 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. Three states—California, Arizona, and Nevada—have large-scale CSP facilities. Power producers are finding that photovoltaics with storage are much less expensive to install and maintain than solar thermal systems.

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.

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**.

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 17.7 percent of the electricity used in the United States.

How a Nuclear Plant Works

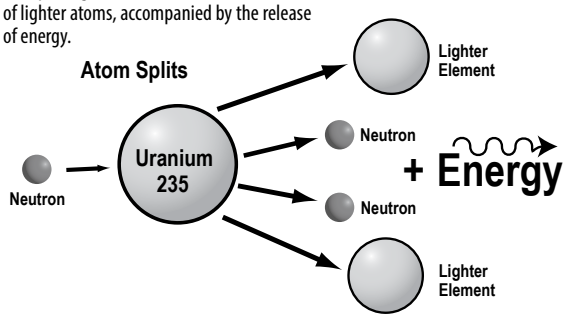
Most power plants burn fuel to produce electricity, but not nuclear power plants. Instead, nuclear plants use the thermal energy produced during fission. Fission takes place inside the **reactor** of a nuclear power plant. At the center of the reactor is the core, which contains the uranium fuel.

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.

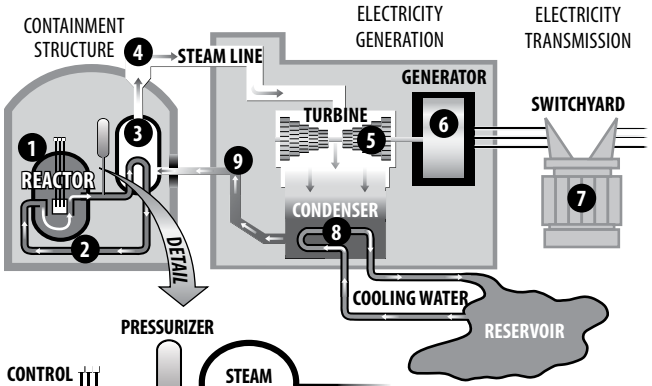
Fission generates thermal energy in a reactor similar to the way coal generates thermal energy in a boiler. The thermal energy is used to boil water into steam. The steam turns huge turbine blades. As they turn, they drive generators that make electricity.

Fission

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



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. Water 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.
9. The resulting water is pumped out of the condenser with a series of pumps, reheated and pumped back to the reactor vessel.

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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.

Spent Fuel Repository

In 1982, Congress 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, NV, to be the site of a national spent nuclear fuel repository. Some people supported the site at Yucca Mountain and others did not. The DOE withdrew this location as a possible site, with intentions of pursuing a long-term solution. 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

Constructing a nuclear power plant requires tremendous amounts of concrete. Manufacturing concrete releases a lot of carbon dioxide. However, once constructed, nuclear power plants have very little impact on the environment unless there is an accident. Nuclear plants produce no air pollution or carbon dioxide while operating 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 more nuclear energy to produce the amount of electricity people need at a cost they can afford. Electricity from nuclear energy is currently being generated in 28 states at 54 power plants with a total of 94 reactors. Two more power plants are scheduled to restart and begin producing power again by 2028. A third facility is under construction in Wyoming.

Nuclear Safety

The greatest potential risk from nuclear power plants is the release of high-level radiation and radioactive material. 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 in unit 2 when coolant 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 and no injuries or fatalities occurred as a result of the error. In response to the incident at Three Mile Island, the U.S. nuclear industry made upgrades to plant design and equipment requirements. Operator and staff training requirements were strengthened, and the U.S. Nuclear Regulatory Commission took on a greater role in emergency preparedness and routine inspections. Lessons learned from Three Mile Island were shared with the international nuclear industry. Three Mile Island unit 1 was decommissioned in 2019 for economic reasons but is set to restart in 2027 as the Crane Clean Energy Center.

In 1986, in Ukraine (former Soviet Union) at the Chernobyl nuclear power plant, two steam explosions blew the top off of one of the units. 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 200,000 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 thereafter, with others suffering longer-term medical ailments. This region has once again become a focus of concern due to military conflict in the areas surrounding Ukraine's power plants. Safe operating procedures have been followed to minimize risks where allowable.

On March 11, 2011, an earthquake and resulting tsunami struck Japan, killing and injuring tens of thousands of people. In the Fukushima prefecture (community), the Daiichi nuclear plant shut down as a result of the earthquake but suffered extraordinary damage from the tsunami. This damage included the loss of backup power generation necessary to keep the reactor and the fuel rods contained in it 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 as it is restored and residents return and will monitor the impact of the radiation released from the Daiichi nuclear power plant 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.

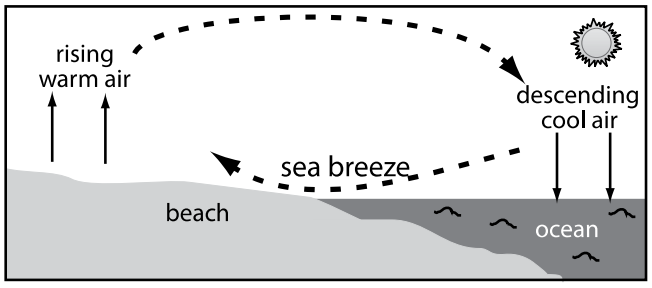
The heavier, denser, cool air over the water flows in to take its place, creating wind. In the same way, the atmospheric winds that circle the Earth are created because the land near the Equator is heated more by the sun than land near the North and South Poles.

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. Wind only accounts for a small amount of U.S. energy consumption—1.6%—but it is one of the fastest growing renewable sources of energy, and generates 10.5 percent of U.S. electricity.

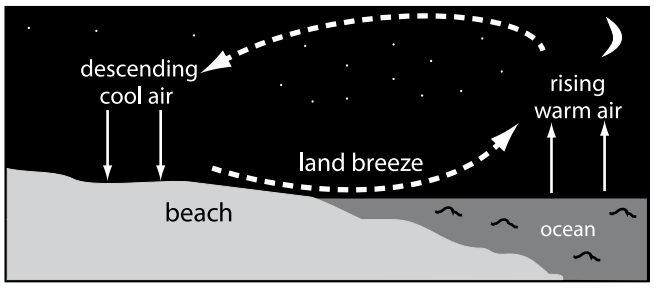
Wind Direction

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.

Sea Breeze



Land Breeze



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 (the Netherlands) improved the windmill. They gave it propeller-type blades, still made with sails. The Netherlands 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.

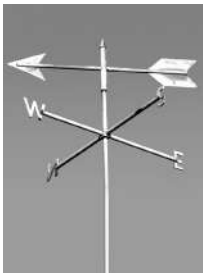
Today's Wind Turbines

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 the rotor spin. The parts of a turbine work together to power a generator to produce electricity.

Windmill



Weather Vane



Anemometer



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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. The blades catch the wind and spin the rotor.
2. The rotor is connected to a low-speed shaft. When the rotor spins, 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 shaft. All of the gears are housed inside the nacelle.
3. The high-speed 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 transformer and then 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 and over open areas with no windbreaks.

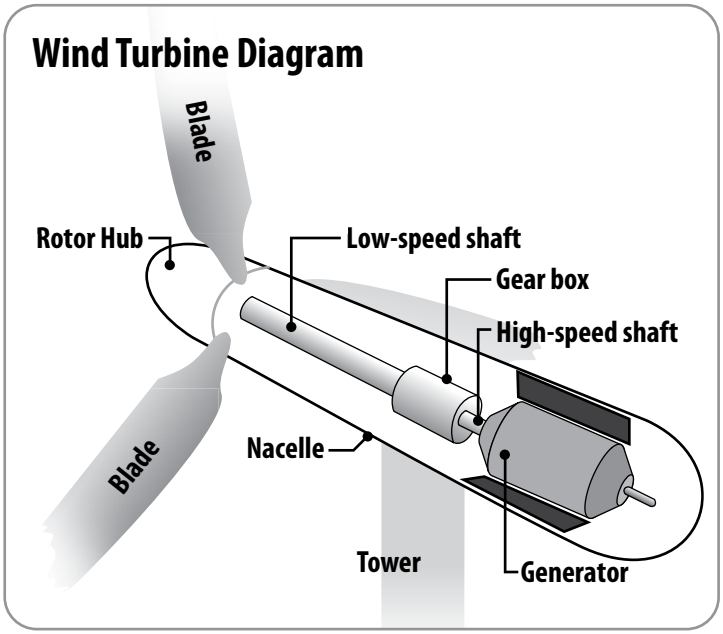
Turbines are usually built in rows facing into the **prevailing wind**. Placing turbines too far apart wastes space. If turbines are too close together, they block each other's wind.

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 Midwest and Rocky Mountain states are also prime states for wind energy production.

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 using fixed turbines. In deeper waters, floating structures can be used. 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 Block Island, Rhode Island, began operating in 2016. It includes five turbines that can power about 17,000 homes. A two-turbine offshore wind project began operating off the coast of Virginia in 2020. Since then, offshore wind development has expanded rapidly in the United States, with larger wind farms generating electricity and additional projects planned in coastal waters.



Wind Production

Wind supplies about one-tenth of the electricity in the United States. That number continues to grow, especially as offshore wind projects are completed. Other countries rely on wind for an even larger share of their electricity. Denmark, for example, gets more than half of its electricity from wind.

One challenge of using wind energy is that it is not available all the time. Wind turbines generate electricity only when the wind is blowing within a certain range of speeds. Because wind speeds change throughout the day and from season to season, the amount of electricity a wind farm produces also changes. Offshore winds are generally stronger and steadier than onshore winds, but they may not be constant all the time.

Environmental Impacts

Wind energy is not free from effects on wildlife and the environment around turbines, which can affect birds, bats, and marine mammals. People living nearby might hear turbine noise, and communities have concerns about changes to the landscape. All interested parties—engineers, scientists, landowners, utilities, wildlife experts, and community members—must work together to minimize these impacts as new projects are developed.

Using wind energy does have some environmental benefits, too. Wind turbines generate electricity without air pollution or greenhouse gases, and wind is a renewable resource. Like all energy sources, wind power involves trade-offs that must be carefully considered.

WIND FARM



Image courtesy of Adobe Stock/Imagevixen

Climate Change

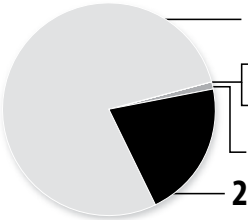
Earth's Atmosphere

Our Earth is surrounded by a protective blanket of gases called the **atmosphere**. It protects us from some of the harmful rays from the sun. The atmosphere also keeps us warm at night, just like a blanket keeps you warm while you sleep.

The atmosphere is made of many different gases. Nitrogen and oxygen make up most of the atmosphere, but there are also some water vapor, argon, carbon dioxide, and other gases in very small amounts.

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. Radiant energy reaching the surface of the Earth is transformed into thermal energy, warming it. That thermal energy (heat) is radiated back out toward space. Some of the gases in the atmosphere, called greenhouse gases, absorb and release thermal energy. This is how the atmosphere keeps us warm when our part of the planet is turned away from the sun.

Atmospheric Composition, Dry Air



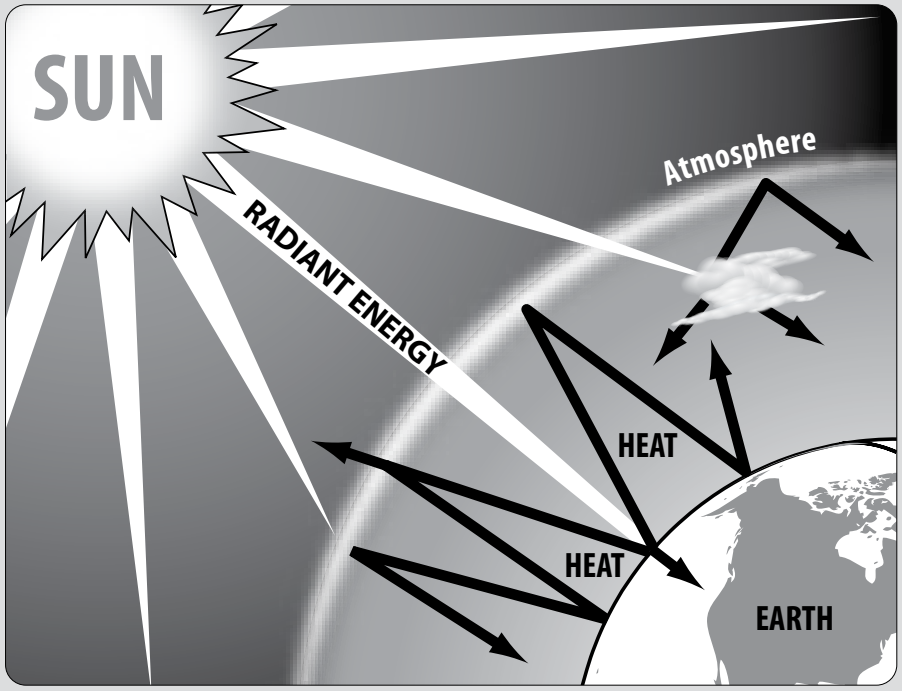
Water vapor varies widely from region to region and according to the time of year. The average is about one percent and can be anywhere from trace amounts to four percent of atmospheric volume.

The Greenhouse Effect

A greenhouse is a building that is made mostly of glass or clear plastic. It is used to keep sensitive plants warm during cold weather. The glass allows sunlight inside, which is absorbed by plants, soil, and other objects inside and transformed into thermal energy. Much of the heat remains inside, keeping the air warm.

Earth's atmosphere works in a similar way. Radiant energy from the sun passes through the atmosphere. Some of it is reflected back into space. Some of the rays are absorbed by molecules in the atmosphere and the rest is absorbed by land and water on Earth's surface, where it is transformed into thermal energy. The warmed surface then radiates thermal energy back toward space.

Greenhouse gases absorb some of the thermal energy and re-radiate it in all directions. Some of that energy remains in the atmosphere, helping keep Earth's surface and atmosphere warm. Without greenhouse gases, Earth would be much colder at night and many forms of life would not be able to survive.



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Greenhouse Gases

Earth's atmosphere is a mixture of many gases. Nitrogen and oxygen make up most of the atmosphere, but they are not greenhouse gases. Carbon dioxide, methane, water vapor, nitrous oxide, and fluorinated gases (F-gases) are greenhouse gases, even though they are present in much smaller amounts. The impact of a gas is not determined by the amount present. Greenhouse gases make up only a small portion of the atmosphere, but they have a big impact on Earth's temperature.

Greenhouse gases are naturally occurring. Carbon dioxide is produced during cellular respiration. Methane forms when organic matter decays where little oxygen is available. Water vapor is part of the water cycle and is present in the atmosphere around the world. Before humans began burning large quantities of fossil fuels for energy, the natural processes that added and removed these gases generally allowed for the presence of these gases to be balanced.

When coal, oil, and natural gas are removed from the ground and burned for energy, carbon dioxide is released into the atmosphere. Today, fossil fuels provide more than four-fifths of the nation's energy. They are used to generate electricity, heat buildings, manufacture products, and power transportation. Every time fossil fuels are burned, more carbon dioxide is added to the atmosphere.

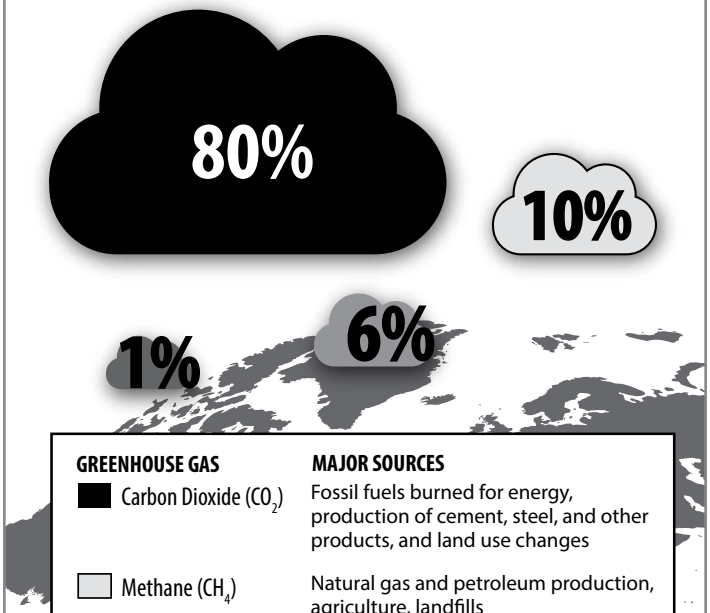
Climatologists, scientists who study Earth's climate, conclude that human activities are causing climate change today. Scientists call these human-caused emissions **anthropogenic** emissions. Since the Industrial Revolution, the amount of carbon dioxide in the atmosphere has increased by more than 50 percent, mostly from using fossil fuels for energy.

Carbon dioxide is not the only greenhouse gas of concern. Methane is also increasing in the atmosphere. Methane is released during fossil fuel production and can escape from natural gas systems, coal mines, and oil wells. It is also produced in landfills and by bacteria that help large mammals digest food.

Nitrous oxide and F-gases make up the smallest fractions of greenhouse gas emissions. However, they remain in the atmosphere for a long time and can heat the atmosphere much more than carbon dioxide.

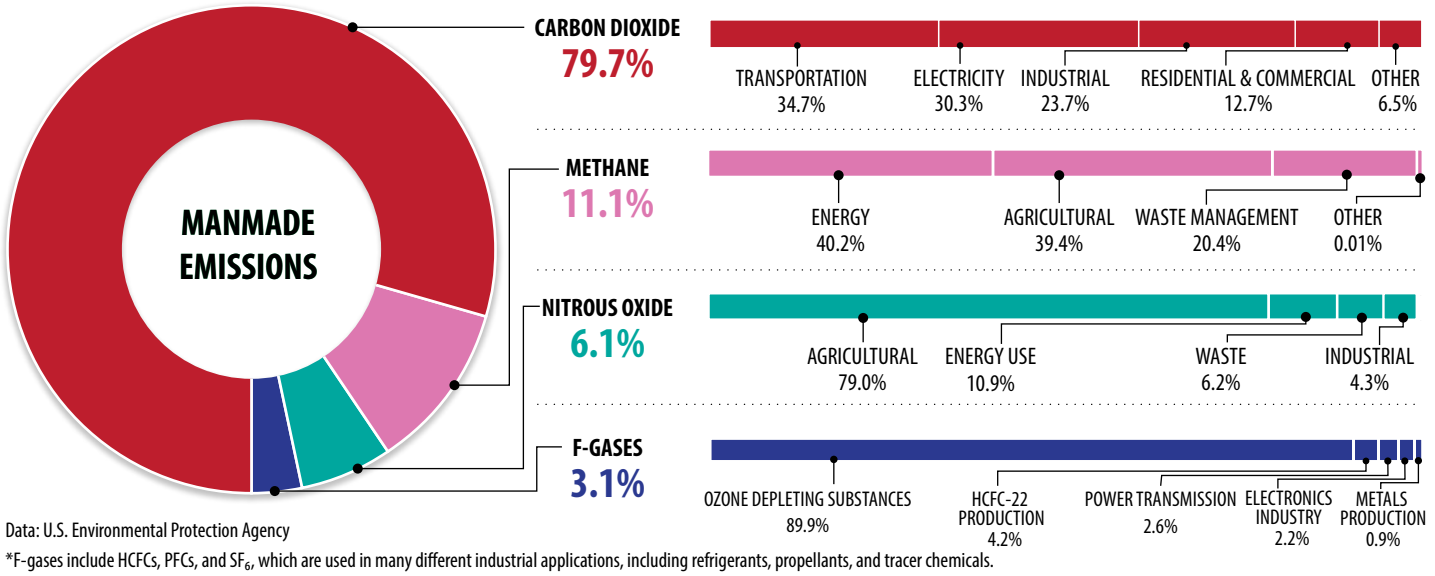
Although greenhouse gases are very different from one another, they all share one important property: each absorbs and releases thermal energy effectively. As long as greenhouse gases are emitted into the atmosphere, they will continue to absorb thermal energy and Earth's average temperature will continue to rise.

Greenhouse Gases, Emissions, and Sources of Emissions

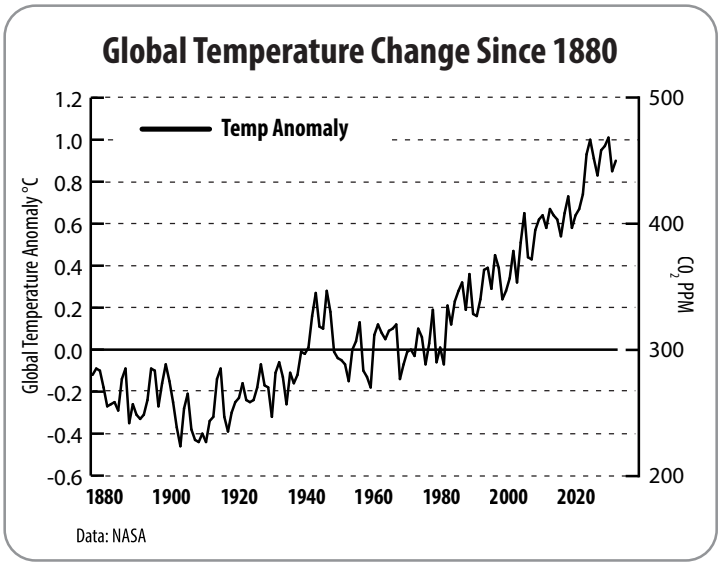


*Total does not equal 100 due to independent rounding.
Data: EIA and EPA

U.S. GREENHOUSE GAS EMISSIONS, 2022



Data: U.S. Environmental Protection Agency
*F-gases include HCFCs, PFCs, and SF_6, which are used in many different industrial applications, including refrigerants, propellants, and tracer chemicals.
**Totals may not equal 100% due to independent rounding.
***2022 is the most recently updated, aggregate data for this information at the time of publication.



Global Climate Change

Higher levels of greenhouse gases in the atmosphere are going to have an effect all around the world. What happens on this side of the planet affects the other side, too. Think about how difficult it would be to keep ink poured into a pool from spreading. Methane escaping from a pipeline in North America finds its way to the Eastern Hemisphere and spreads all over. Carbon dioxide emitted by a coal power plant in India is moved by trade winds to the rest of the planet. Once greenhouse gases are out, they can impact everyone.

With so many gas molecules floating around, absorbing heat, it just makes sense that temperatures would increase. Climatologists compare current average temperatures with the average between 1901 and 2001—a 100-year data set. From 1850 until 1940, temperatures were below normal. Between 1940 and 1980, some years were warmer than average, and some were cooler. However, since 1980, all years have been above average, and the hottest years have been in the last 10, since 2015. Temperatures are rising, and the rate at which they are rising is also going up. In other words, it's hotter outside, and it's getting hotter, faster. In 2000, global average temperatures were about 0.5°C above the 100-year average. Today, they're more than 1.0°C higher.

Impacts of Climate Change

What difference does 1.0°C make? Water freezes at 0°C but remains liquid at 1°C. That small difference can have big impacts. One degree can have an impact on several key ecosystems. It can mean the difference between snow that melts slowly, replenishing groundwater, and rain that runs off quickly into rivers and streams. It can mean the difference between **permafrost** remaining frozen and ground thawing in Arctic regions. When permafrost thaws, dead vegetation below the surface decomposes, releasing more greenhouse gases. Those gases can lead to more warming, which can lead to more thawing, and so it goes. This is called a **positive feedback loop** because the results feed into the causes, making the effects larger. Just 1°C increase can also mean the difference between enough sea ice for polar bears to hunt and too little ice to support them.

A higher global average temperature means many places become warmer, including some of the hottest places on Earth. Hotter summers lead to drier soil and prolonged periods of drought. Warmer oceans lead to stronger tropical storms, which in turn produce heavier rainfall and more widespread flooding from storm surge. A hotter planet is a more energized planet, and the systems that rely on energy are more active.

Human health suffers from climate change, too. People living in cities, which stay hotter overnight than rural areas, show increased breathing problems, especially in people with asthma. Their energy bills increase, too, as they operate more air conditioning or fans to try to stay cool. Higher energy costs and long periods of hot days can also affect mental health and well-being. Climate change rarely helps, and it often hurts many people.

MUIR GLACIER TIMELAPSE



Top image courtesy of William Osgood Field/National Snow and Ice Data Center
Bottom image courtesy of Bruce F. Molnia/ National Snow and Ice Data Center

In 1997 the US Geological Survey (USGS) initiated the Repeat Photography Project. Photographers positioned themselves in the same location as photographs taken in the early 20th century and captured an image of that location for comparison. Repeat Project photographs present a compelling argument for how glaciers in North America have been greatly affected by climate change. This photograph pair shows Muir Glacier in Alaska, northwest of Juneau and near Glacier Bay National Park and Preserve.

Solutions for a Changing Climate

Climate change presents challenges, but scientists, engineers, and policymakers are developing solutions that reduce greenhouse gas emissions. Many companies and governments are already adopting some of these strategies. Families and individuals can also take steps to reduce energy consumption and greenhouse gas emissions.

Using more renewable energy is one strategy that is already underway. In 2025, renewable sources provided about 25 percent of our nation's electricity. Many states have set goals to increase the use of renewable energy in the coming decades. When combined with storage systems, renewable energy sources can help us reduce our reliance on fossil fuels.

Reducing the amount of energy consumed, especially electricity, is another important strategy. Industry, government, businesses, and households are all being encouraged to use energy more efficiently. Making wise decisions with energy consumption will reduce greenhouse gas emissions without requiring major changes in technology.

New technologies are also part of the solution. Researchers are developing more efficient solar systems, lower-carbon building materials, and low-carbon transportation systems like hydrogen fuel cell buses for cities and electric vehicles for individuals.

There is no perfect solution that will fix the whole system, and there is no one group of people who should be expected to change everything. Addressing climate change requires many solutions and people working together.

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Hydrogen

What Is Hydrogen?

Hydrogen is the lightest and simplest **element**. One hydrogen atom contains one proton and one electron. Hydrogen is the most plentiful element in the universe, but it is often found combined with other elements like carbon and oxygen.

Our sun, like other stars, gets its energy from hydrogen. Stars are giant masses of plasma, which is a state of matter so hot that electrons have separated from the nuclei of atoms. Under these conditions, hydrogen nuclei can combine to form helium nuclei. This process, called fusion, produces radiant energy.

Hydrogen gas is **diatomic**—it exists as an element in pairs of atoms, H_2. Hydrogen gas is produced in tiny amounts by natural processes on Earth, but not in large enough quantities to meet our energy needs. Most hydrogen on Earth is combined with other elements. Hydrogen is commonly produced from water (H_2O) and hydrocarbons. A **hydrocarbon** is a compound made only of hydrogen and carbon.

Hydrogen has the highest energy per kilogram of any other common fuel. However, it requires a lot more space to store than other fuels.

Hydrogen Production

Most hydrogen produced for industrial use today comes from hydrocarbons by a process called steam reforming. High-temperature steam (H_2O) reacts with methane to produce hydrogen and carbon dioxide.

Scientists have been working on other ways to produce hydrogen. One method uses renewable energy to split water into hydrogen and oxygen. Called **electrolysis**, this process uses electrical energy from wind, hydropower, or solar energy to break the hydrogen-oxygen bond. Other methods include using algae and bacteria to produce hydrogen.

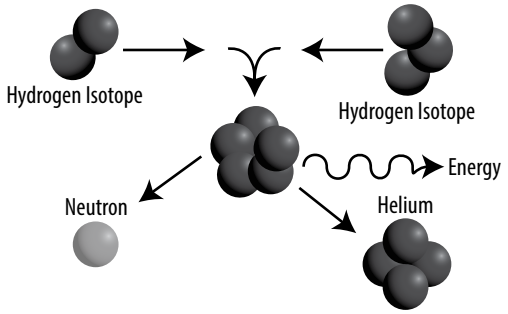
Energy Carriers

An **energy carrier** is something that is produced from an energy source, then transported to another place where the energy is used. Gasoline is an energy carrier because it is produced from petroleum, then carried to a car's fuel tank where it powers the car. Electricity is an energy carrier in a similar way. It is generated at a power plant, then transported through power lines to your home. Energy carriers are also known as secondary sources of energy, because they are derived from primary sources like petroleum or wind.

Hydrogen is another energy carrier. Most of it is produced from methane, the hydrocarbon that makes up most of natural gas. It is stored in a tank or pushed through a pipeline to the place where it is needed, then used for energy. However, it can be produced from almost any energy source, including nuclear, wind, solar, or coal.

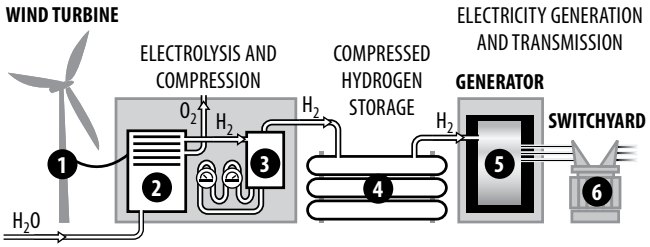
Fusion

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.



Wind to Hydrogen

The National Renewable Energy Laboratory and Xcel Energy launched an innovative wind-to-hydrogen (Wind2H_2) project that uses electricity from wind turbines (or photovoltaic panels) to produce and store hydrogen, offering what may become an important new template for future energy production.

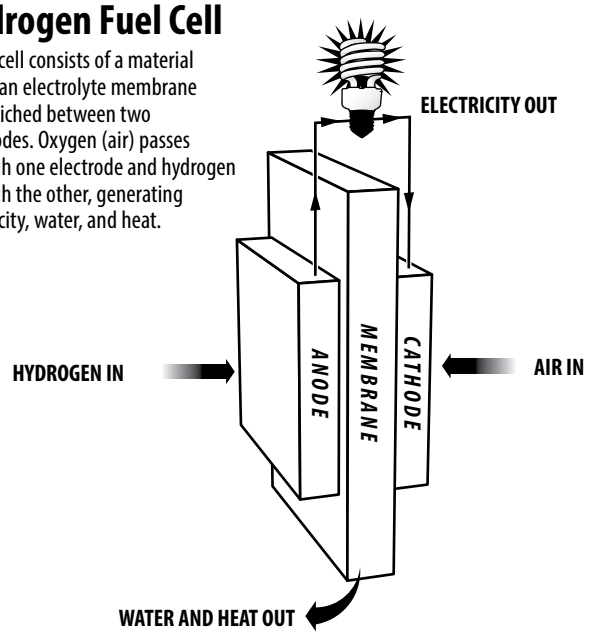


How it works:

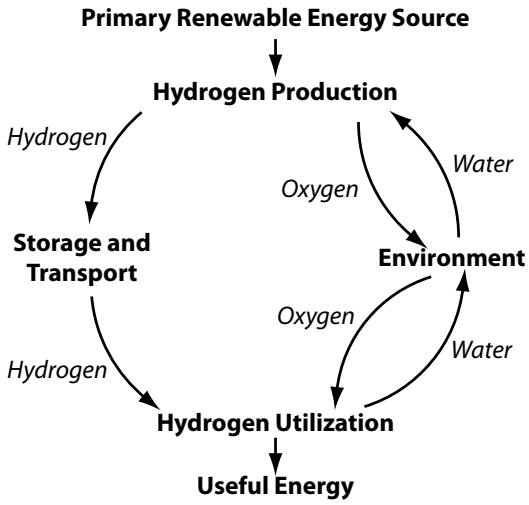
1. Wind turbines use the wind's energy to generate electricity. Electricity is transported to the electrolysis unit.
2. Electricity is used to split water (H_2O) into hydrogen (H_2) and oxygen (O_2).
3. The hydrogen diaphragm compressor compresses the hydrogen gas produced from the electrolyzers at 150 psi (pounds per square inch) to the storage pressure of 3,500 psi.
4. The hydrogen can be stored and used later to generate electricity from an internal combustion engine or a fuel cell. The steel tanks can store up to 85 kilograms of hydrogen at 3,500 psi.
5. The internal combustion engine runs on stored hydrogen and generates electricity that will be sent onto the utility grid for use during peak demand.
6. Electricity is sent to a switchyard, where a transformer increases the voltage, allowing it to travel through the electric grid.

Hydrogen Fuel Cell

A fuel cell consists of a material called an electrolyte membrane sandwiched between two electrodes. Oxygen (air) passes through one electrode and hydrogen through the other, generating electricity, water, and heat.



Hydrogen Life Cycle



ARTEMIS I SPACE LAUNCH SYSTEM AND ORION SPACECRAFT



Image courtesy of NASA

Hydrogen was used as the fuel for NASA space shuttles and rockets, beginning in the 1980s. While the U.S. shuttles have since been retired, hydrogen is still used internationally to launch satellites and as a space fuel. The NASA Artemis project will use hydrogen as a propellant. Hydrogen is a perfect fuel for space travel, as it has very high energy density while keeping weight down.

Uses of Hydrogen

Hydrogen is already used by industry in refining, metal treatment, and food processing. NASA uses a lot of hydrogen in its space program. Liquid hydrogen and liquid oxygen were used in Saturn V rockets and the Space Shuttle program to propel the spacecraft into orbit.

Fuel cells are a relatively new way to use hydrogen as an energy source. A fuel cell separates the protons from the electrons and uses the electrons in a circuit to power a device. They can be very small or quite large, and fuel cells can be stacked like batteries can to produce more DC electricity. The 2010 Vancouver Winter Olympics included hydrogen fuel cell buses to transport guests from one venue to another. When hydrogen is used in a fuel cell vehicle, the only direct emission is water vapor.

Challenges to Using Hydrogen

The drawbacks to using hydrogen in fuel cells include the high cost of fuel cell manufacturing and the need for very large storage tanks. Hydrogen takes up a great deal of space compared to gasoline, so vehicles need large, high-pressure tanks to store enough fuel for long trips.

Another challenge is in hydrogen **infrastructure**. Fueling stations, pipelines, and production facilities are already in place for gasoline and diesel fuel. These combine to form part of petroleum's infrastructure. No such system is in place for hydrogen, and no company is going to invest in it unless there are customers ready to purchase hydrogen. There won't be any demand for a vehicle that cannot be easily refueled. And automakers are not going to produce a vehicle nobody is going to buy. It's a chicken-egg problem. First, engineers and scientists need to figure out how to store more hydrogen in less space. After that, the infrastructure problem can be tackled.

The Future of Hydrogen

Before hydrogen can take its place as the eleventh energy source used in the United States, the challenges described above need to be solved. Storage space must be decreased, manufacturing costs must come down, and infrastructure must be in place before the car-buying public will purchase hydrogen fuel cell vehicles. As more people become aware of the effects of climate change, they will look for ways to **decarbonize** their transportation by using energy sources that do not produce carbon dioxide. Hydrogen-powered vehicles meet this need and could be in demand.

HYDROGEN-FUELED VEHICLE



Image courtesy U.S. Department of Energy

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Electricity

If someone mentions energy, do you automatically think about electricity? If so, you're not alone. You probably do not pay much attention to electricity until there is a power outage. Electricity is behind almost everything we do in modern life, from keeping us warm and safe to entertaining us.

Electrons

Everything is made of atoms. Atoms contain three particles within them: **protons**, which have a positive charge; **neutrons**, which have no electric charge; and **electrons**, which have a negative charge. At the center, an atom has a **nucleus** made of protons and neutrons, and electrons that are moving around the nucleus a significant distance away. The electrons are the particles that transfer energy when we use electricity.

Electrons are always moving. In a conductor like a wire, electrons can easily pass energy from one atom to another. This transfer of energy through moving electrons is electric current. The more electrons passing energy through the wire, the higher the current.

Electrons and Magnets

If you lay two flat **magnets** on a table and begin to push one toward the other, at some point the magnets will jump together. What allows one magnet to know another is nearby? The answer is a **magnetic field**. This is a region surrounding a magnet that pulls on anything else magnetic, like a nail or another magnet. We label magnets with poles that show us how the magnetic field is arranged. One pole is north, and the other is south. The magnetic field moves away from the north pole and toward the south pole.

Any moving, charged particle creates a magnetic field. Because electrons have an electric charge and are always moving, each electron acts like a tiny magnet. In most materials, these tiny magnets point in different directions and cancel each other out. In some materials, many of them line up in the same direction, creating a magnet.

Moving charged particles create magnetic fields, and magnetic fields can move charged particles. This relationship is called **electromagnetism**. Magnetism and electricity are always linked together; you cannot have one without the other; you cannot have one without the other.

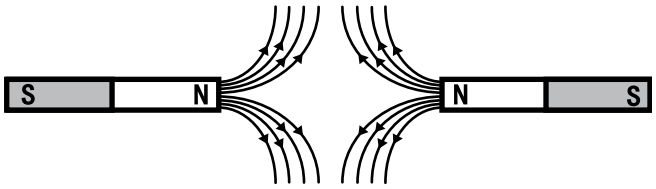
Generating Electricity

A **generator** is a device that transforms rotational motion into electricity. Generators have coils of wire and magnets. The magnets move in relation to the coils of wire, which forces electrons to move inside the wire coils. The wires are often made of a material like copper—a conductor with electrons that are able to move freely or are loosely held. This is how electricity is generated at a power plant regardless of the energy source (except in solar cells). The **turbine** spins, the magnetic field changes, and electricity is generated.

The difference in power plants is not in the generator, but what spins the generator. Two items can be used to provide spinning motion—steam or direct force. In thermal power plants, a fuel is used to heat water into high-pressure steam. Natural gas, coal, uranium, biomass, and geothermal energy are used in thermal power plants. The steam pushes on blades of a turbine, causing it to spin. That spinning motion is transferred into the generator. The other option is to just push on the turbine directly with water or air—hydropower or wind energy. In a hydroelectric plant, water pushes on enormous turbine blades inside the plant. In a wind turbine, the long, narrow blades are pushed by moving air. Whether a thermal power plant, a hydropower plant, or a wind turbine, the electricity delivered to our homes and schools is generated this way.

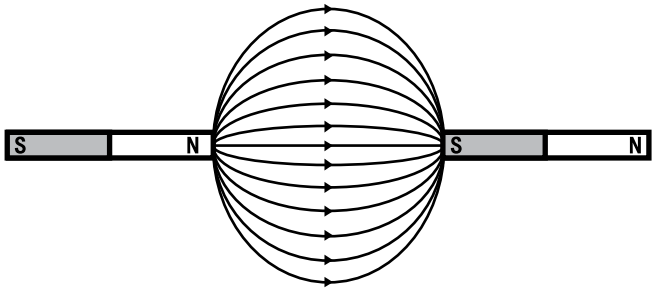
Magnets with Like Poles

Like poles of magnets (N-N or S-S) repel each other.

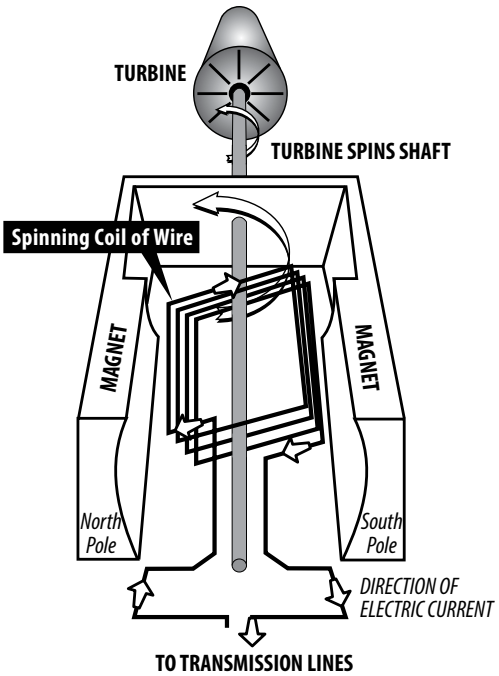


Magnets with Opposite Poles

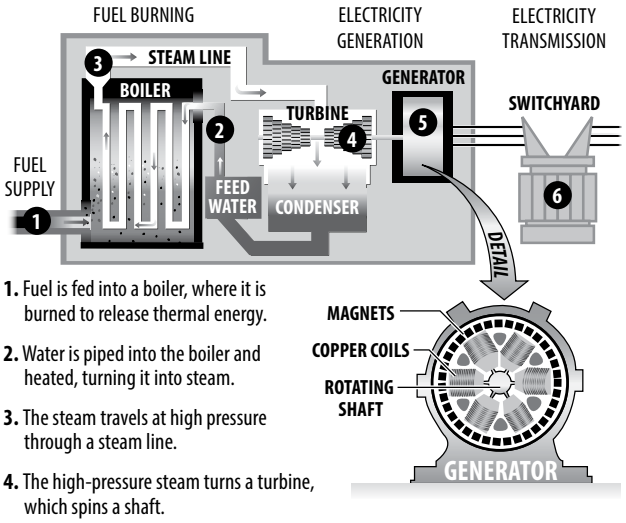
Opposite poles of magnets (N-S) attract each other.



Turbine Generator



Thermal Power Plant



1. Fuel is fed into a boiler, where it is burned to release thermal energy.
2. Water is piped into the boiler and heated, turning it into steam.
3. The steam travels at high pressure through a steam line.
4. The high-pressure steam turns a turbine, which spins a shaft.
5. Inside the generator, the shaft spins coils of copper wire inside a ring of magnets. This creates an electric field, producing electricity.
6. Electricity is sent to a switchyard, where a transformer increases the voltage, allowing it to travel through the electric grid.

Batteries Produce Electricity

A battery produces electricity using two different metals in a chemical solution. A chemical reaction between the metals and the chemicals frees more electrons in one metal than in the other. One end of the battery is attached to one of the metals; the other end is attached to the other metal. The end that frees more electrons develops a positive charge, and the other end develops a negative charge because it attracts the free, negatively charged electrons. If a wire is attached from one end of the battery to the other, electrons flow through the wire to balance the electrical charge. A **load** is a device that does work or performs a job. If a load—such as a light bulb—is placed along the wire, the electricity can do work as it flows through the wire. In the Electric Circuits diagram to the right, electrons flow from the negative end of the battery through the wire to the light bulb. The electricity flows through the wire in the light bulb and back to the battery.

Electric Circuits

Electricity travels in pathways or closed loops of conducting wire called **circuits**. Electrons cannot move through a circuit unless there is a complete path for them to follow. An open circuit is a loop with a gap or break in it. Switches are commonly used to open or close circuits, turning devices off or on. The simplest circuit has one power source, like a battery, and one device to power, like a small light bulb. Your home's wiring is a somewhat complicated collection of wired circuits that are located in the walls or between floors and all connect to a breaker box or fuse box, where electricity enters your home. Circuits can be series, where everything is in the same loop, one after another. Circuits can also be parallel, where there are many loops connected to the same power supply. Circuits can also be both series and parallel, especially when multiple devices are connected to the same power supply.

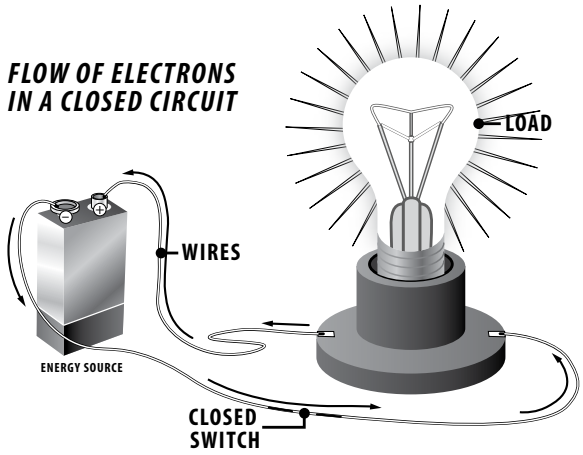
BATTERIES



Image courtesy of Adobe Stock

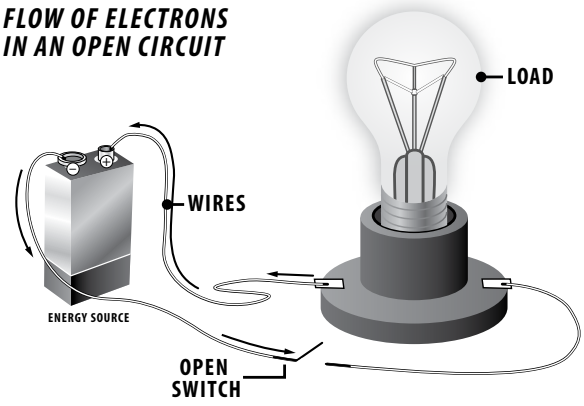
Electric Circuits

FLOW OF ELECTRONS IN A CLOSED CIRCUIT



A closed circuit is a complete path allowing electricity to flow from the energy source to the load.

FLOW OF ELECTRONS IN AN OPEN CIRCUIT



An open circuit has a break in the path. There is no flow of electricity because the electrons cannot complete the circuit.

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Electricity

Moving Electricity

Using electricity as much as we do is possible because we can easily move it from one place to another. Power plants generate electricity and electric utilities deliver it to your home several miles away. Let's follow the path of electricity from a power plant to a light bulb in your home.

First, the electricity is generated at a power plant. It travels through a wire to a **transformer** that steps up, or increases, the **voltage**. Power plants step up the voltage because less electricity is lost along the power lines when it is at a higher voltage.

The electricity is then sent to a nationwide network of **transmission lines**. This is called the **electric grid**. Transmission lines are the huge tower lines you see along the highway. The transmission lines are interconnected, so if one line fails, another can take over the load.

Step-down transformers, located at **substations** along the lines, reduce the voltage for safe distribution through local power lines. Substations are small fenced-in buildings that contain transformers, switches, and other electrical equipment.

The electricity is then carried over **distribution lines** that deliver electricity to your home. These distribution lines can be located overhead or underground. The overhead distribution lines are the power lines you see along streets.

Before the electricity enters your house, the voltage is reduced again at another transformer, usually a large gray metal box mounted on an electric pole. This transformer reduces the electricity to the 120 or 240 volts that are used to operate the appliances in your home.

Electricity enters your home through a three-wire cable. Wires are run from the circuit breaker or fuse box to outlets and wall switches in your home. An electric meter measures how much electricity you use so that the utility company can bill you.

Measuring Electricity

The utility electric meter measures how much electrical energy we use. Electrons are far too small to count directly, so scientists developed other ways to measure electricity.

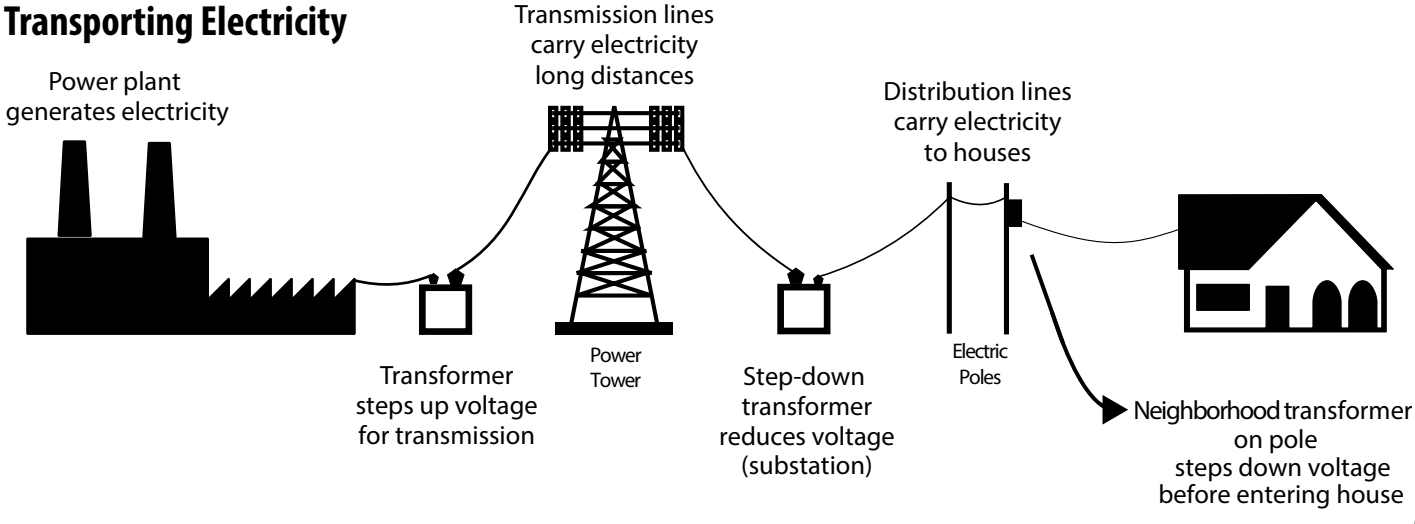
One important measurement is **current**, which describes how many electrons are moving through a circuit, measured in **amperes** or amps. Another is voltage, measured in volts, voltage, which describes how much energy each electron can transfer. Some devices need a large number of electrons moving through them, while others need each electron to carry a lot of energy. Some devices, like large air conditioners, need both. Voltage and current work together to determine **power**, which describes how quickly electrical energy is transferred or used. Power is measured in **watts (W)**. A **kilowatt (kW)** is 1,000 watts.

Electrical energy depends on both power and time. A device that uses a lot of power for a short time may use the same amount of electrical energy as a device that uses less power for a longer time. Electric utilities measure electrical energy in **kilowatt-hours (kWh)**, which is the unit used on electric bills.

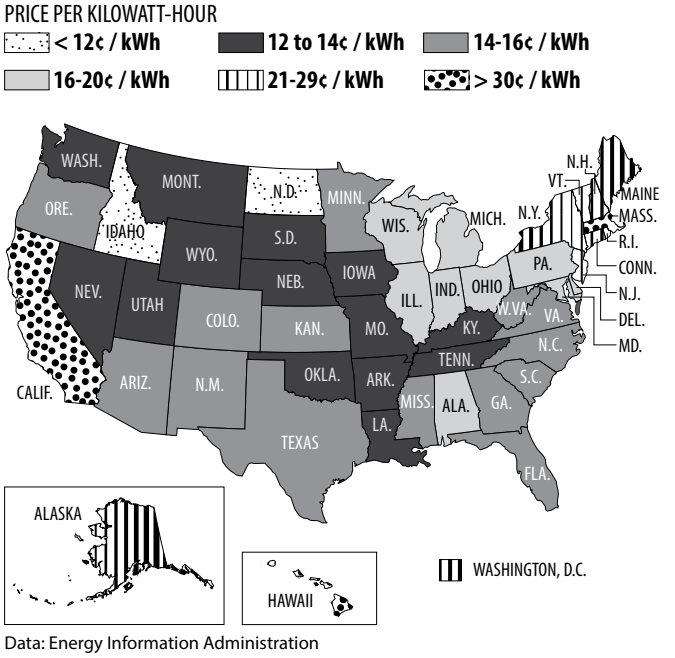
Paying for Electricity

The electricity delivered to homes and businesses across the country may be standardized, but the price is not. The price paid by electric utility customers depends on the cost of the fuel, the location, the cost of the building, power lines, and other equipment, and the efficiency of the system. Most electricity in the U.S. is generated using natural gas, uranium, coal, and wind. Each of these energy sources has different costs, and the power plants using them have different construction costs. Nuclear power plants and dams for hydropower are very expensive to build, but uranium fuel is very inexpensive compared to natural gas and coal. Flowing water and the wind are free! Even though sunlight is free, the cost to purchase, install, and maintain large solar systems can keep the cost of electricity from solar in line with other fuels.

Transporting Electricity



Average Residential Price for Electricity, 2025



Data: Energy Information Administration

The amount of electricity a customer uses will also influence the price paid for each kilowatt-hour. Industrial customers use an enormous amount of electricity, while residential customers tend to use the least. The average price residential customers in the United States pay is about 17 cents per kilowatt-hour, but the price ranges from as little as 12 cents in North Dakota to as much as 41 cents in Hawaii. State and local regulations, the number of customers, availability of energy sources, and other factors determine how much a customer pays. Commercial customers, like government buildings, schools, and businesses, pay about 13 cents per kilowatt-hour, and industrial customers pay about nine cents.

How Much Is a Watt?



1 WATT
Small LED flashlight



1.5 KILOWATTS = 1500 WATTS
Blow dryer



3 TO 5 MEGAWATTS = 3,000,000 to 5,000,000 WATTS
Diesel-electric locomotive engines



2 GIGAWATTS = 2,000,000,000 WATTS
Peak output of the Hoover Dam

You may now be wondering what a kilowatt-hour means in daily life. Let's calculate the cost of watching TV. To find the amount of energy consumed, multiply the power needed to run the TV by the amount of time you used it.

Energy (E) = Power (P) x Time (t)

If your TV uses 200 watts, and you watch TV for three hours, you would use the formula as follows:

energy = power x time (E = P x t)

energy = 200 W x 3 hour = 600 Wh

One watt-hour is a very small amount of electrical energy. Usually, we measure electric power in larger units called kilowatt-hours (kWh) or 1,000 watt-hours (kilo = thousand). To calculate the cost of watching TV for three hours, you would change the watt-hours into kilowatt-hours, then multiply the kilowatt-hours used by the cost per kilowatt-hour, as shown below:

$$600\ \text{Wh} \times \frac{1\ \text{kW}}{1{,}000\ \text{W}} = 0.600\ \text{kWh}$$

$$0.600\ \text{kWh} \times \$0.17 = \$0.102 \approx \$0.10$$

Therefore, it would cost about a dime to watch TV for three hours.

The cost of electricity looks like it's very inexpensive for one kilowatt-hour of electricity. And truthfully, 10 cents to watch a movie on TV isn't much. However, if you watch TV for three hours every day for a year, the electricity would be $36.50. Add taxes and other service charges to that. Now think about every device running in your home—appliances, electronics, the microwave, hair styling appliances—many of these devices use a lot more than 200 watts. The cost adds up quickly! That is why adults are always reminding kids to turn off the lights when they leave a room.

TRANSMISSION LINES



Image courtesy of Adobe Stock/ Volodymyr Shevchuk

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History of Electricity

Starting with Ben

Many people think Benjamin Franklin discovered electricity with his famous kite-flying experiments in 1752. Franklin is famous for tying a key to a kite string during a thunderstorm, proving that static electricity and lightning were indeed the same thing. However, that isn't the whole story of electricity. Electricity was not "discovered" all at once. At first, electricity was associated with light. People wanted a cheap and safe way to light their homes, and scientists thought electricity might be a way.

A Different Kind of Power: The Battery

Learning how to produce and use electricity was not easy. For a long time there was no dependable source of electricity for experiments. Finally, in 1800, Italian scientist Alessandro Volta made a great discovery. He soaked paper in salt water, placed zinc and copper on opposite sides of the paper, and watched the chemical reaction produce an electric current. Volta had created the first electric cell.

By connecting many of these cells together, Volta was able to "string a current" and create a battery. It is in honor of Volta that we rate batteries in **volts**. Finally, a safe and dependable source of electricity was available, making it easy for scientists to study electricity.

A Current Began

An English scientist, Michael Faraday, was the first to realize that an electric current could be produced by passing a magnet through a copper wire. It was an amazing discovery. Almost all the electricity we use today is made with magnets and coils of copper wire in giant power plants.

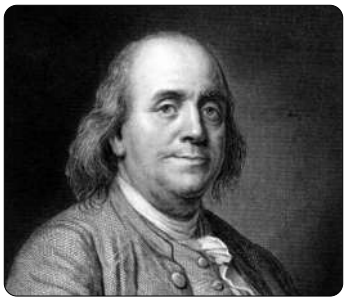
Both the electric generator and electric motor are based on this principle. A generator converts motion energy into electricity. A motor converts electrical energy into motion energy.

Mr. Edison and His Light

In 1879, Thomas Edison focused on inventing a practical light bulb, one that would last a long time before burning out. The problem was finding a strong material for the filament, the small wire inside the bulb that conducts electricity. Finally, Edison used ordinary cotton thread that had been soaked in carbon. This filament didn't burn at all—it became incandescent; that is, it glowed.

The next challenge was developing an electrical system that could provide people with a practical source of energy to power these new lights. Edison wanted a way to make electricity both practical and inexpensive. He designed and built the first electric power plant that was able to produce electricity and carry it to people's homes.

Edison's Pearl Street Power Station started up its generator on September 4, 1882, in New York City. About 85 customers in lower Manhattan received enough power to light 5,000 lamps. His customers paid a lot for their electricity, though. In today's dollars, the electricity cost $5.00 per kilowatt-hour! Today, electricity costs about 17 cents per kilowatt-hour for residential customers, about 13 cents for commercial, and about nine cents for industry.



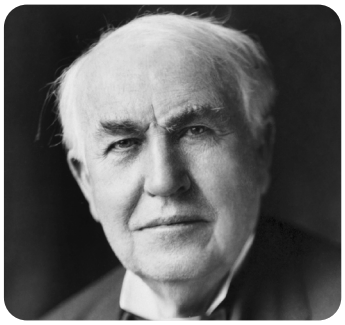
Benjamin Franklin
Image courtesy of NOAA Photo Library



Michael Faraday
Image courtesy of Wikimedia Commons



Alessandro Volta
Image courtesy of Teylers Museum



Thomas Edison
Image courtesy of Wikimedia Commons

The Question: AC or DC?

The turning point of the electric age came a few years later with the development of **alternating current (AC)** power systems. Croatian-born scientist Nikola Tesla came to the United States to work with Thomas Edison. After a falling out, Tesla discovered the rotating magnetic field and created the alternating current electrical system that is used very widely today. Tesla teamed up with engineer and businessman George Westinghouse to patent the AC system and provide the nation with power that could travel long distances—a direct competition with Thomas Edison's DC system. Tesla later went on to form the Tesla Electric Company, invent the Tesla Coil, which is still used in science labs and in radio technology today, and design the system used to generate electricity at Niagara Falls.

Now using AC, power plants could transport electricity much farther than before. While Edison's **direct current (DC)** plant could only transport electricity within one square mile of his Pearl Street Power Station, the Niagara Falls plant was able to transport electricity over 200 miles!

Electricity didn't have an easy beginning. While many people were thrilled with all the new inventions, some people were afraid of electricity and wary of bringing it into their homes. They were afraid to let their children near this strange new power source. Many social critics of the day saw electricity as an end to a simpler, less hectic way of life. Poets commented that electric lights were less romantic than gaslights. Perhaps they were right, but the new electric age could not be dimmed.

In 1920, about two percent of U.S. energy was used to make electricity. In 2025, with the increasing use of technologies powered by electricity, it was 35 percent.



Energy Consumption

We use energy every day. We eat food that was grown, processed, and transported to stores. We use energy to cook meals and clean up afterward. We wear clothes and shoes that were manufactured and shipped to us. We use artificial lighting throughout the day all year long. We ride in cars, trucks, buses, trains, and planes. We live in houses and work in businesses and schools made from building materials made at industrial facilities. We use energy to stay warm indoors, and we enjoy watching movies and TV shows and playing video games. The way humans have used energy has changed through history, but one thing will always be true: people use a lot of energy.

The U.S. Department of Energy divides the way we use energy into categories called **sectors**. Everything included in a sector shares similar characteristics. The sectors of the economy are **residential** (homes); **commercial** (businesses and other similar buildings); **industrial** (manufacturing complexes); **transportation** (vehicles); and **electric power** generation.

Residential and Commercial Sectors

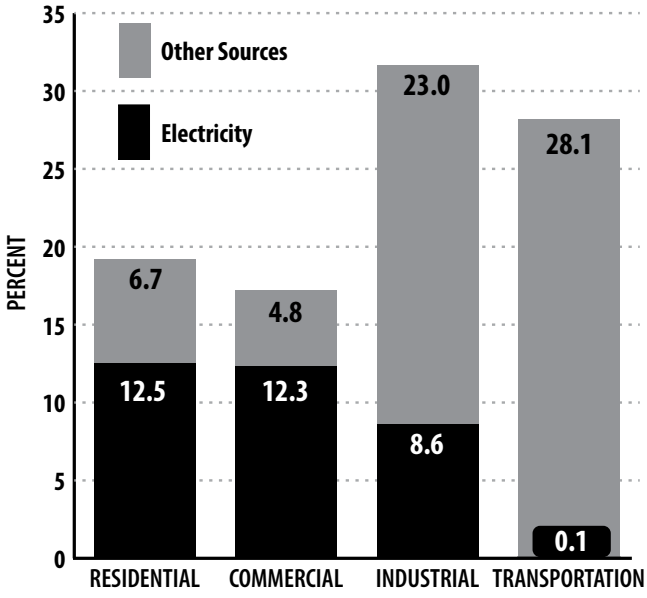
The residential and commercial sectors are often grouped together because they both use energy in similar ways. Most of the energy these two sectors use is electricity, but residential and commercial buildings use energy from other sources, too. Homes and businesses use energy for heating, cooling, lighting, and operating appliances and office machines. In the last 50 years, improvements in technology and manufacturing have helped reduce energy use.

▪ Heating and Cooling

The biggest energy use in residential and commercial buildings is for keeping the interior of buildings comfortable. Heating and air conditioning use about 43 percent of all the energy used in homes, and about 51 percent in commercial buildings. The three fuels used most often for heating are natural gas, electricity, and propane. A little less than one-half of the nation's homes are heated by natural gas. Roughly 40 percent of homes use electricity for heating, and about five percent use propane. Commercial buildings follow a similar pattern: 44 percent use natural gas for heating, 43 percent use electricity, and a little less than 13 percent use propane.

Some buildings are heated and cooled by district energy systems. A district energy system uses one central facility to provide hot or chilled water (or in some cases, steam) to many buildings through underground pipes. Another way buildings stay comfortable is with geoexchange systems, also called ground-source heat pumps. These systems use the nearly constant temperature a few feet underground to provide heating and cooling.

U.S. Energy Consumption by Sector, 2025



Data: EIA

▪ Lighting

The first lighting used in all buildings was incandescent lighting. This very inefficient design changes most of the electricity into heat rather than light. In the mid-1900s, fluorescent lighting became common. A more efficient fluorescent light design was introduced in 1988, and fluorescent lighting became the most widely used lighting in commercial buildings. Incandescent lights remained dominant in homes. In 2007, legislation required better energy efficiency in all areas, including lighting, and new technologies were developed.

INCANDESCENT BULB **LED BULB**

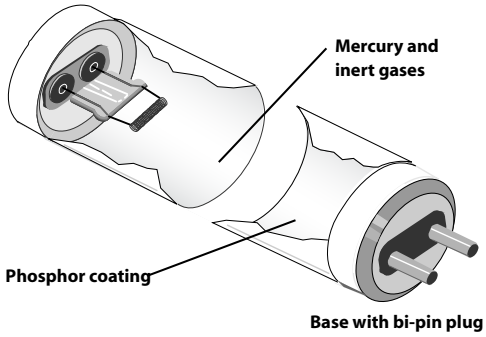




LEDs offer better light quality than incandescent bulbs, last 25 times as long, and use less energy than compact fluorescent lamps (CFLs). LEDs now have a wide array of uses because technology has improved and costs have decreased. Some may still use incandescent, fluorescent, or halogen bulbs in their fixtures at home.

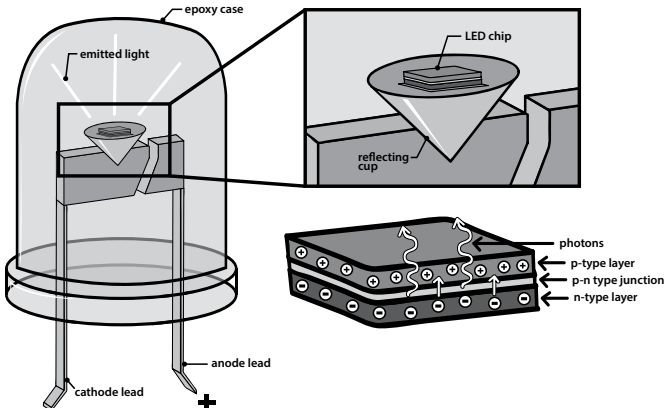
Today, **light-emitting diode** (LED) lighting is most common in homes and newly constructed or renovated commercial buildings. Residential customers spend about $89 annually just to operate lights. About 10 percent of all energy consumed in commercial buildings is for lighting, which is about 17 percent of the electricity used by schools. The actual dollar amount spent varies widely because some commercial buildings, like small coffee shops, are quite small while others, like museums and hospitals, are huge.

Fluorescent Tube Lamp



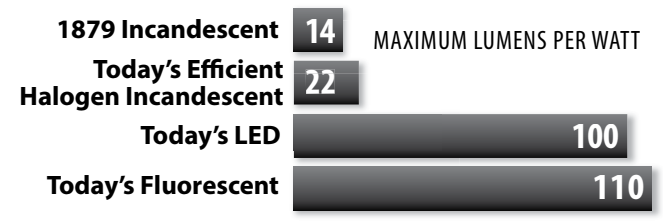
In fluorescent tubes, a very small amount of mercury mixes with inert gases to conduct the electric current. This allows the phosphor coating on the glass tube to emit light.

Inside an LED



LEDs offer better light quality than incandescent bulbs and halogens, last 25 times as long, and use even less energy than CFLs. LEDs now have a wide array of uses because technology has improved and costs have decreased. CFLs are not as available in stores, and their use has drastically decreased, like the use of halogen bulbs. Some may still use these bulbs in their fixtures at home. They come in several shapes and sizes.

Lighting Efficiency



Data: Madison Gas and Electric

▪ Appliances

Appliances have made our lives cleaner, easier, and safer. Water heaters use the most energy in this category—about five percent in commercial buildings and 15 percent in residential buildings. Most homes use the same energy source for home heating and water heating.

Refrigerators and freezers are the next-largest energy consumer. These appliances use a substance called a refrigerant to move thermal energy from inside the appliance to the surrounding room. Air conditioners use a similar process, moving thermal energy outdoors.

Additional appliances include dishwashers, washing machines, dryers, humidifiers, dehumidifiers, ranges, cooktops, ovens, microwaves, and many small, plug-in devices like fans, coffee makers, and crock pots. When electronics like TVs, cable boxes, and gaming systems are added, the amount of energy—primarily as electricity—we consume to live our lives becomes overwhelming.

HOUSEHOLD APPLIANCES



Images courtesy of Adobe Stock

Appliances range from kitchen essentials to TV's.

▪ Smart Things

There is no question that the internet has dramatically changed modern life. As home internet access has become commonplace, manufacturers developed products that could connect to home networks and be controlled remotely.

The modern smart-home era began when the Nest® smart thermostat was introduced. This Wi-Fi-connected control system allows the user to change settings with a smartphone. It also has the ability to recognize patterns in users' behavior and make adjustments, saving energy. Smart light bulbs from Philips were introduced about a year later, followed by smoke detectors, cameras, and door locks. In 2014, the Amazon Alexa burst onto the scene and rapidly grew in popularity. About half of all homes in the U.S. have at least one smart device, with the most popular items being smart TVs, voice assistants, and doorbell cameras.

The energy consumption of the "smart" part of Wi-Fi-enabled electronics and appliances is difficult to determine. Surveys of home energy use do not typically separate smart devices from ordinary devices. However, smart things can be very useful when it comes to saving energy. Utilities frequently offer rebates for customers who allow the utility to adjust their smart thermostats during periods of high electricity demand. People who manage large buildings and campuses take advantage of the remote control capabilities of smart devices, especially thermostats and lighting, as an energy-saving strategy. Smart devices are not only convenient, they can help us track and control energy consumption.

Industrial Sector

The facilities that make both raw and finished products—factories, foundries, and refineries—make up the industrial sector. In 2025, 32.9 percent of U.S. energy consumption, including electricity, was used to make products and materials. American industry accounts for about 17 percent of the world's total manufacturing output. Every industry uses energy, but six industries account for the most energy use.

▪ Petroleum Refining

Crude oil is a mixture of many compounds. To be useful, the compounds must be separated at a refinery. The compounds in petroleum are separated by boiling point, and all that boiling requires a lot of thermal energy. Most of the energy used by the refinery comes from the petroleum itself. Petroleum refining is the second-largest energy consumer in the industrial sector.

▪ Steel Manufacturing

Steel is made from iron ore in a steel mill. Most iron ore mined in the United States comes from the Lake Superior region, especially northern Minnesota and Michigan's Upper Peninsula. The ore is often transported to steel mills by ships on the Great Lakes. At the mill, iron ore is heated in a blast furnace, and the molten iron is mixed with different elements to make steel. Different types of steel contain different amounts and combinations of elements, giving them different properties.

When making steel, energy costs are about 15 percent of the total production cost. Since 1990, the steel industry has reduced its energy consumption by improving technology, closing older plants, and the increasing use of recycled steel. Recycling steel uses 75 percent less energy than making it from iron ore.

ALEXA



Image courtesy of Adobe Stock

PETROLEUM REFINERY



Image courtesy of BP

STEEL PRODUCTION



Image courtesy of Adobe Stock/ Tayiba Photography

▪ Aluminum Manufacturing

Aluminum manufacturing begins by mining **bauxite**, a mineral rich in aluminum. Bauxite is then heavily processed to produce aluminum. Manufacturing aluminum is very energy-intensive. The aluminum industry has significantly reduced the amount of energy needed to produce aluminum, mostly through aluminum recycling. Recycling aluminum uses 95 percent less energy than producing the same amount of aluminum from bauxite.

▪ Paper Manufacturing

The U.S. uses enormous amounts of paper every day, and energy is required in every step of the paper-making process. Energy is used to chip, grind, and cook the wood into pulp, and more is needed to roll and dry the pulp into paper. Forestry, paper, and paper products manufacturing is the third-largest energy consumer in the industrial sector.

The pulp and paper industry reduced the amount of fossil fuels used by using better technology and **cogeneration** systems, which provide heat and electricity. Over 60 percent of the fuel used to power the cogeneration equipment comes from wood waste, a renewable energy source.

▪ Chemical Manufacturing

The chemical industry plays a huge role in modern daily life, creating soap, paint thinner, medicines, cleaning products, fertilizers, food containers and wraps, and the raw materials used to make plastics. A lot of food products also include ingredients produced by chemical manufacturing. Because it produces such a wide variety of products, chemical manufacturing is the largest energy consumer in the industrial sector.

Manufacturing chemicals uses a lot of electricity, petroleum, and natural gas. Some of the petroleum and natural gas are used as raw materials for making other products and not for energy.

▪ Cement Manufacturing

Imagine how much time and money would be spent to build bridges, power plants, and dams from stone. Concrete is made from cement, water, sand, and gravel and is a major component of many of the large structures you see around you.

Using a lot of concrete has two major drawbacks. First, Portland cement is made from a chemical reaction that uses limestone and produces carbon dioxide as a byproduct. That does not include any carbon dioxide produced from the energy sources used to make it. Second, making concrete requires an enormous amount of energy to make and transport cement, mix concrete, and haul it where it is used. A lot of the cement made in the United States is exported.

New technologies have reduced the fossil fuel consumption in the cement manufacturing industry. Today, about 16 percent of the energy used to make cement comes from alternative energy sources such as used tires. Used tires have about 25 percent more energy than coal. The American Cement Association is looking for ways to reduce the carbon dioxide produced from cement manufacturing and concrete production. They hope to be carbon-free by 2050.

PAPER RECYCLING



Image courtesy of National Laboratory of the Rockies

Transportation Sector

The United States is a nation on the move. We move ourselves from home to work or school or on vacation. We visit friends and relatives. We attend sporting events and concerts. We go shopping and out to eat. We visit museums and places of worship. And sometimes, we just get out of the house for its own sake. Moving people and their goods is the business of the transportation sector, and it requires a lot of energy. In 2025, about 29 percent of all of the energy consumed in the U.S. was used to move people, goods, and even energy.

▪ The Automobile

Few technologies have influenced American life as much as the automobile. While large cities in Europe and Asia were developed before any modern transportation was contemplated, many of the large cities in the United States were developed and expanded around the idea that people would primarily use cars to get around. The automobile is the primary transportation method people use and the largest consumer of transportation energy in the U.S. today.

TRAFFIC CONGESTION



Image courtesy of Adobe Stock/ Goran Jakus

Americans' relationship with the automobile changed dramatically during the twentieth century. Early drivers rarely traveled far from home, relying on trains for longer journeys. As automobiles improved and the nation's highway system expanded, long-distance driving became practical, and the great American road trip became part of the culture.

The oil embargoes of the 1970s brought a new concern: fuel economy. For the first time, many consumers began paying close attention to how much gasoline their vehicles used. Automakers responded by designing cars that were lighter, more aerodynamic, and propelled by engines with improved fuel efficiency. Today's cars drive almost twice as far on a gallon of gasoline as the vehicles of the 1970s. Furthermore, vehicle technology has improved to include alternative fuels, hybrid-electric vehicles, and fully electric vehicles, which reduces energy consumption in the transportation sector.

▪ Commercial Transportation

Passenger vehicles are typically owned and operated by individuals for their own needs. Commercial vehicles are owned by businesses, governments, and corporations to transport manufactured goods and provide services. Trucks are used to move goods. In fact, almost every product is carried at some point in a truck. Most trucks, from large pickups to the biggest semi-tractor trailers, run on diesel fuel. Trains are also used to carry goods on land. Locomotives run on electricity from diesel-powered generators to pull freight on our nation's railroads. Many large industrial complexes have railroad tracks running through them to facilitate receiving raw materials and shipping finished products.

On water, ships and barges are used to carry items. Bulk products like coal are carried by barge and moved around by tugboats. A tug can move several barges at one time. Ships might have large holds below deck to carry bulk items like grain or iron ore, or they might have wide, flat decks upon which steel containers with finished goods are stacked. Most ships run on a specially formulated diesel fuel.

If you need transportation in a hurry, you will probably ship your package by air. Jet planes have gone through many design changes over the last 50 years. Today's jets are faster and more efficient, and can move dozens of passengers or tons of freight several hundred miles in a matter of hours. It is 10 times more expensive to transport goods via plane than by truck or train.

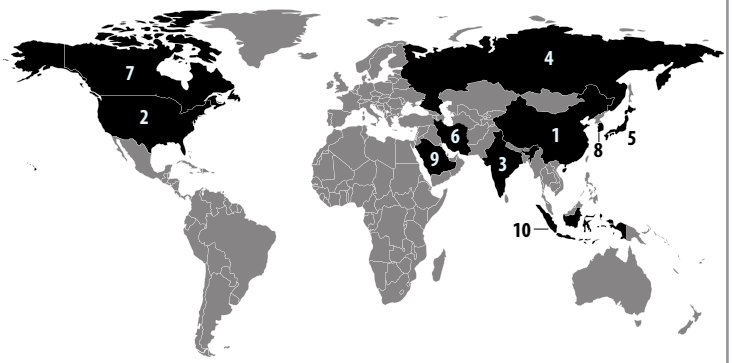
▪ Public Transportation

Moving people in large groups by bus and train is the job of public transportation. This category is different from commercial transportation because the buses and trains are typically owned and operated by a municipal or state government, not a private company. Passengers walk to a station and board a bus or train that takes them to another station. The people might transfer to another bus or train, or they might have arrived at their destination. Many city train systems, especially those that run underground, are electric. Buses have traditionally been fueled by diesel fuel, compressed natural gas, or propane. New bus technology includes electric buses or those running on hydrogen fuel cells.

Global Energy Consumption

Energy consumption patterns in the United States are not the same for all countries. In fact, from continent to continent and country to country, energy consumption depends greatly on the natural resources available, political stability, and economic conditions. China and India have greatly expanded access to energy in recent decades as their economies have grown, increasing energy use per person. Countries with a lot of petroleum or natural gas reserves, like Saudi Arabia and Kuwait, rely heavily on petroleum and natural gas. Japan and South Korea have few domestic energy resources and must import much of the energy they consume. Brazil, a nation with a mix of rural, suburban, and urban populations and a wide range of income levels, obtains about half of its energy from renewable sources like biomass and hydropower. Access to energy can be very limited if an area is going through conflict or experiencing poverty.

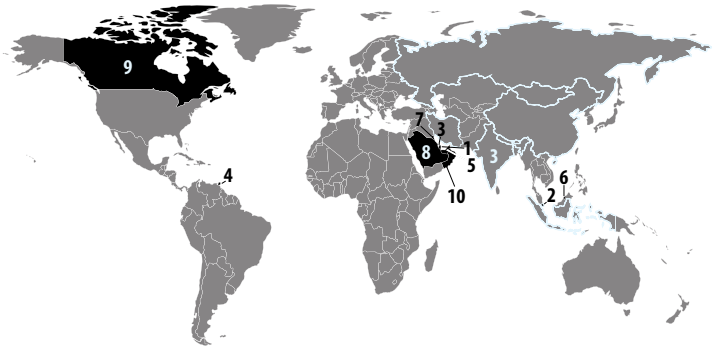
Top Ten Energy Consumers, 2024



1. China
2. United States
3. India
4. Russia
5. Japan
6. Iran
7. Canada
8. South Korea
9. Saudi Arabia
10. Indonesia

Data: EIA

Top Ten Countries, Energy Consumption per Capita, 2024



1. Qatar
2. Singapore
3. Bahrain
4. Trinidad & Tobago
5. United Arab Emirates
6. Brunei
7. Kuwait
8. Saudi Arabia
9. Canada
10. Oman

Data: EIA

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Energy Efficiency and Conservation

Americans consume about 15 percent of the world's energy, but we make up roughly four percent of the world's population. The average American consumes just under four times the world average per capita consumption of energy. Keeping our buildings comfortable, moving ourselves around, and powering all of our appliances and electronics don't just cost a lot of money. They take a toll on the environment.

Making the Case for Saving Energy

More than 80 percent of the world's energy comes from fossil fuels. Burning fossil fuels releases carbon dioxide (CO_2) into the atmosphere. The buildup of CO_2 and other greenhouse gases is the primary cause of the climate change occurring today. As temperatures rise and extreme weather events become more common, energy demands for heating and cooling are also rising. Improving energy efficiency and reducing unnecessary energy consumption conserves resources, lowers energy costs, and reduces greenhouse gas emissions.

Energy Efficiency

Energy efficiency refers to the amount of energy a device uses when operating. Some refrigerators use less energy than others, but all keep food cold. A large truck with a big engine and a small car with a smaller engine will both get you to the store, but the truck uses more fuel to do it. Energy efficiency means choosing devices that use less energy.

Professionals trying to save energy evaluate the heating, ventilation, and air conditioning (HVAC) system, the lighting, and the other devices that are top energy consumers, such as water heaters and refrigerators. Replacing an existing device for one that is more efficient is known as an upgrade. When deciding on an upgrade, compare the amount of energy saved to the cost.

Energy Conservation

Conserving a resource does not mean we can never use it. Conservation involves using the resource wisely so it lasts as long as possible. **Energy conservation** means we are changing our behavior to use less energy and use it wisely.

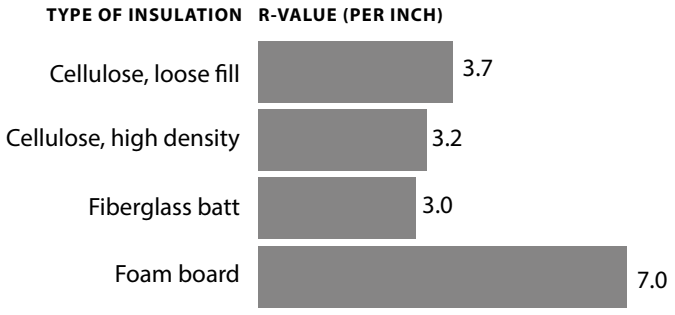
There are times when replacing something with a more efficient model is not possible. That does not mean saving energy is impossible. Small changes in things we do can often reduce energy consumption by 10 to 15 percent, and sometimes as much as 30 percent.

Building Envelope

All buildings, from the tiniest of tiny homes to the largest of factories, have an envelope. Like a paper envelope surrounds documents, a building envelope surrounds the things we want to keep separate from the outdoor environment. A building envelope keeps us and our stuff warm, dry, and protected. Walls, windows, doors, the roof, and flooring are all parts of the building envelope.

A building envelope keeps the inside at a comfortable temperature with insulation. Different **insulation** materials, like fiberglass and expandable foam, have different properties. Some are better insulators than others. Insulation is described by its **R-value**. This is a number that tells you how well the insulation blocks the movement of heat. A higher R-value material is a better insulator.

Insulation R-Values





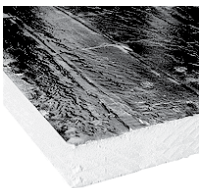
3.0
Fiberglass Batt



3.7
Cellulose, Loose Fill



3.2
Cellulose, High Density



7.0
Foam Board

Openings in the building envelope are called breaks. Besides windows and doors, breaks include openings that allow electricity, water lines, and other connections inside. Without breaks, the building envelope would just be a closed, dark box that nobody could go into. This would not be very practical. All breaks need to be sealed well to keep outside air from getting inside, or inside air from getting out. Air moving through a break in the building envelope is called **air infiltration**. **Caulking** is used around window and door frames. **Weatherstripping** is used inside the frames to make sure they are sealed well when closed. Openings for electrical, water, and cooling lines are usually sealed with foam so air and insects cannot get in. A hidden source of air infiltration is often the box in the wall where switches and electric outlets are connected. Foam gaskets can be put around the switch and outlet behind the cover to block air from moving through these boxes.

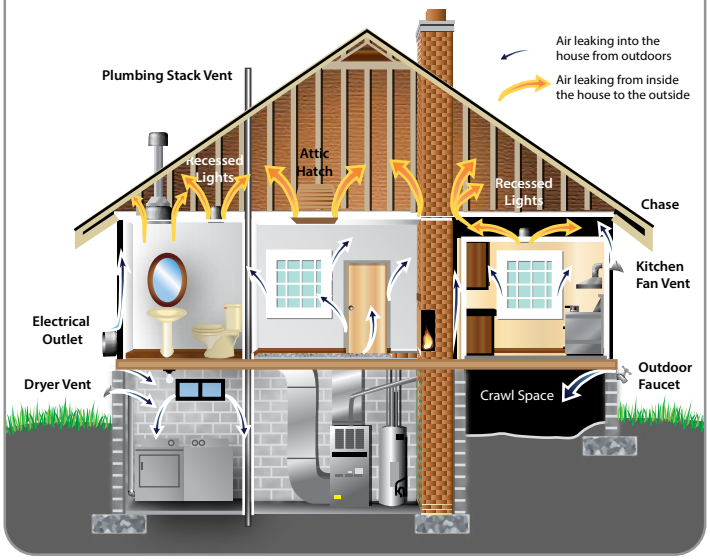
Replacing caulking and weatherstripping and adding gaskets to switch and outlet boxes are relatively simple actions that can save a lot of energy. Many utility companies offer weatherization services at no charge to residential customers. Programs and rebates for commercial customers may also be available.

Building Envelope Tips

Follow these tips to reduce energy consumption in buildings:

- Keep windows and doors closed when the heating or cooling system is turned on.
- Check around exterior doors—daylight means outdoor air is getting in.
- Make sure windows open and close without sticking, and are sealed well.
- Check the insulation in the attic space and add more where necessary.
- Install insulating gaskets behind outlet and switch covers.

House as a System



HVAC Systems

Heating, ventilation, and air conditioning systems use a machine to warm or cool air and send it out to different parts of a room or building. **Ventilation** is usually only used in commercial or industrial buildings. Commercial buildings have more people inside them than homes typically would have, and industrial buildings have a lot of machinery. Fresh air must be brought into these buildings to keep everyone healthy and alert.

The two biggest energy-wasting concerns with HVAC systems are **ducts** that have leaks and thermostats set too high. Ducts are metal tubes in the walls, ceiling, or floor that deliver warmed or cooled air. If the duct work is leaking, the system needs to work harder to push more air through it. Rooms farther from the furnace will be hot in summer and cold in winter. Sealing the leaks with the proper tape fixes this problem. Setting the thermostat to a very warm temperature in winter or a very cool temperature in summer uses a lot of energy. The U.S. Department of Energy suggests a winter heating temperature of 68° and a summer cooling temperature of 77° to save the most energy. Wearing a sweater in winter or using a fan in summer and not bumping the thermostat will help save energy.

HVAC System Tips

Follow these tips to reduce energy consumption when heating or cooling:

- In winter, set the thermostat to 68°F or lower. Wear a sweater if you are chilly.
- In summer, set the thermostat to 77°F or warmer. Use a fan if you are too warm.
- Regularly change the air filter.
- Use duct sealing tape to block any leaks in duct work.
- Make sure duct work running through attics or crawl spaces is insulated.
- Open blinds or curtains in winter to allow sunlight to warm the room. Close them in summer to prevent this.

THERMOSTAT



Image courtesy of Adobe Stock

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Lighting

Commercial buildings use much more lighting than residential or industrial buildings, but all three types of buildings have some kind of indoor lighting. The most efficient lights are LED lights, though many schools and other commercial buildings still rely on fluorescent lights.

The two biggest energy wasters when using lighting are lights that are too bright for the task, and lights that are left on unnecessarily. The Illuminating Engineering Society of North America has developed a list of recommended light levels, measured in **foot-candles**, for rooms based on the activities happening there. A foot-candle is the amount of light from one candle that reaches a surface located one foot away from the candle. Different tasks require different amounts of light. For example, school cafeterias should have about 20-30 foot-candles of illuminance, but a laboratory-style classroom needs 50-75.

Unlike school, we all tend to use many different kinds of light fixtures at home. Overhead lights help us see the entire room. Desk and table lamps give us light where we need it. Small lamps and other lit accessories give us soft lighting while watching TV or navigating at night. It would not make sense to have all of these turned on at once. Choose the light that best fits what you are going to do and leave the rest turned off.

Modern technology has given us lighting controls that automatically turn lights on and off, and even adjust how bright they are. Motion sensors turn lights on when someone enters the room. Occupancy sensors turn lights off when no movement is detected after a certain time period. Dimmer switches allow the user to make lights brighter or dimmer and only produce the amount of light they need. All of these help save energy. However, manually turning the lights off instead of waiting for an occupancy sensor to do it saves even more energy.

The least expensive, best energy-saving lighting is daylight. Opening blinds or curtains to take advantage of free daylight can save up to 100 percent of the energy used if you keep all of the lights turned off! However, it is important to balance using daylight against the cooling system's energy use. Opening the blinds or curtains to allow sunlight in can warm the room, which works against the room's cooling system. Consider all energy users, not just lighting, when deciding to open the blinds or curtains.

LIGHT SHELF



Image courtesy of Wikimedia Commons

The second floor of the Bronx Library in New York has a light shelf that redirects daylight further into the building.

DIMMER SWITCH



Image courtesy of Adobe Stock

Lighting Tips

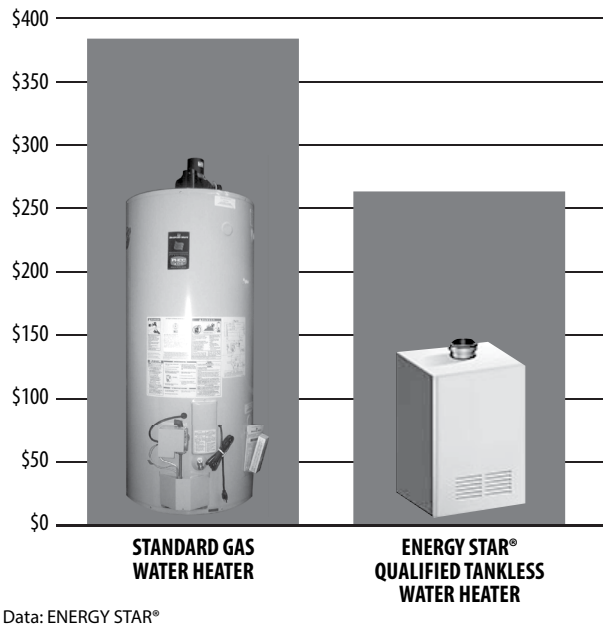
Follow these tips to reduce energy used for artificial lighting:

- Do not overlight spaces. At home, only turn on the lights you need. Use light bulbs or light fixtures that provide the right amount of light.
- Do not leave lights on when a room is empty. Turning them off saves 100 percent of the energy the lights were using.
- Install LED light bulbs or light fixtures to get the brightest light using the least amount of electricity (but don't overlight!).
- Use daylight through windows and skylights instead of turning lights on.

Water Heating

The energy to heat water is not something we think about until we do not have it. Heating water takes a lot of energy. Different energy-saving strategies are used in residential and commercial buildings because the way hot water is used in each environment is different.

Water Heater Comparison



Data: ENERGY STAR®

Any commercial building with a kitchen, like a school or restaurant, needs to provide very hot water for the kitchen—160°F! Dishes, cookware, and utensils must be cleaned and sanitized, which requires hotter water than most homes use. Industrial processes might need water at near-boiling, as high as 200°F or more. Industrial and commercial buildings have water heating equipment that is much larger and uses significantly more energy than residential equipment. When you are at school, you can help use less energy by not leaving hot water running unnecessarily.

Most homes have a water heater with a tank that keeps the water at a set temperature. Adding an insulating jacket to the water heater keeps thermal energy from being transferred to the area around the water heater, and insulating the pipe carrying the hot water to the fixtures using it helps, too.

Tankless water heaters are now available that only turn on when hot water is needed. When operating, they use a large amount of energy, but if no hot water is needed, they do not run at all. Most of the time, a tankless system uses less energy than a residential system with a tank.

Water should not be heated above 120°F, especially with young children in the home. Water that is hotter than necessary uses more energy and can cause serious burns.

Water Heating Tips

Follow these tips to reduce energy used for heating water:

- Take showers instead of baths. Showers use significantly less water.
- Set the water heater so it delivers water at 120°F. If you are going to be away from home for an extended period of time, turn it to its lowest setting—often "vacation" or "pilot." Remember to turn it up when you get back home.
- Wash clothes in cold water. Modern detergents are formulated for cold water washing.
- Fill a sink or wash basin with soapy water to wash dishes, then rinse them all at once or in batches. Do not let the hot water run while washing dishes.
- Install an insulating jacket around the water heater and make sure pipes delivering hot water are also insulated.

Plug Loads

A load is anything being powered by electricity. A plug load is anything that plugs into an outlet and uses electricity. Appliances, electronics, lamps, fans, and your gaming system are all plug loads. In short, if it plugs in, it's a plug load! The way these devices are used varies greatly, but there are some strategies that apply to all of them that we can use to save energy. The first is probably the most obvious: Don't allow something to run if it's not necessary. Another way to save energy is to purchase items that use less energy while operating.

Plug Load Tips

Follow these tips to reduce energy consumed by appliances and electronics:

REFRIGERATORS

- Make sure the gasket around the door seals completely. If a piece of paper or dollar bill can easily slide out from behind it, replace it.
- Do not allow the door to stay open longer than necessary. Help organize the groceries in groups to minimize the amount of time it takes to put them away. Close the door while you pour a beverage.
- Fill empty milk jugs or soda bottles with water and use them to fill empty spaces in the back of the refrigerator.
- Keep the area around and under the refrigerator clear and dust-free so the compressor operates at its best.
- Empty and unplug second refrigerators. Only plug in and operate when absolutely necessary.

WASHING MACHINES

- Set the washing machine appropriately for what you are washing. Aim for a full load of laundry when possible, as it will save water and energy.
- Use cold water for washing.

CLOTHES DRYERS

- Clean the lint filter after every load. Encourage or assist the adults in your home to make sure lint is cleaned from the interior of the dryer and dryer duct.
- Use the lowest heat setting possible.
- Hang clothes to dry outside when possible and use free solar energy.

DISHWASHERS

- Turn off the heated dry and allow dishes to air-dry. Opening the door when the cycle is complete will help.
- Run the dishwasher with the proper cycle or settings for the load size and dirt level of the dishes. Most modern dishwashers will use less water than hand-washing, even for smaller loads, if settings are chosen correctly.

TELEVISIONS, AUDIO AND GAMING SYSTEMS, AND RELATED DEVICES

- Plug devices into a smart strip surge protector that senses when the TV or primary device is off and cuts power to other items plugged into it. It also has the option for keeping some items, like a cable box, powered all the time.
- Use energy-saving settings and sleep timers to reduce electricity when possible.

OFFICE EQUIPMENT

- Power down devices when they are not being used for extended periods of time.
- Disable screen savers, as they use more electricity than sleep mode.
- Keep printers and scanners off until they are needed.
- Power down monitors when devices are off. Monitors that remain on will waste electricity.

EnergyGuide and ENERGY STAR®

Most appliances sold in the United States have a yellow-and-black EnergyGuide label. The label estimates how much energy an appliance uses and its approximate yearly operating cost. This information helps consumers compare similar products. Some products also qualify for the ENERGY STAR® label. ENERGY STAR® appliances and electronics use less energy than many similar products. Although energy-efficient products sometimes cost more to purchase, they often cost less to operate over time. Consumers sometimes compare the purchase price of an appliance to the money it may save on energy costs. The amount of time required for the savings to equal the additional purchase cost is called the payback period.

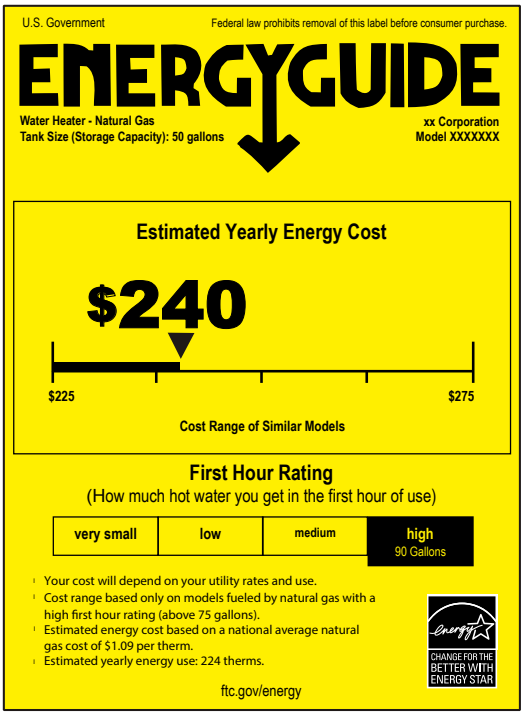
Purchasing energy-efficient appliances is one way to reduce energy use, but it is not the only way. Simple changes in how we use appliances and electronics can also save energy.

ENERGY STAR® Logo

Energy-efficient products are labeled with the ENERGY STAR® logo. Appliances include the EnergyGuide label allowing for easy energy comparisons between products.

CHANGE FOR THE BETTER WITH ENERGY STAR

EnergyGuide Label



Appliance Energy Consumption

Appliance	Average annual expenditure	kWh/yr
Electric stove, oven or range	$38	290
Ceiling fan	$29	226
Clothes dryer	$87	680
Clothes washer	$9	69
Dishwasher	$15	112
Microwaves	$15	107
Refrigerator	$87	617
Second freezer	$74	632
TV and related components	$87	760

Data: EIA 2020 RECS

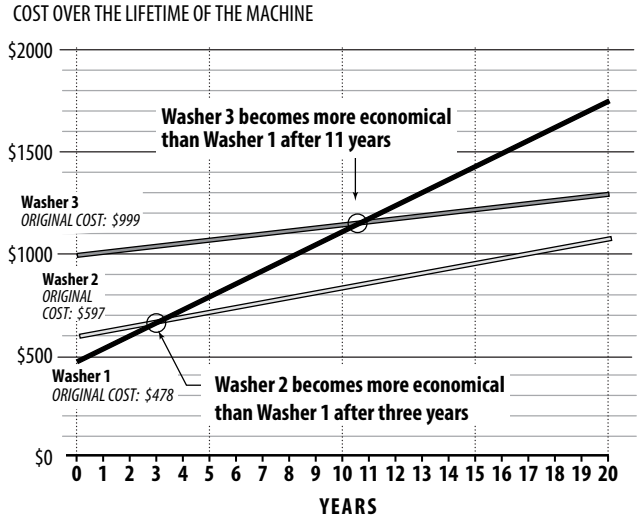
*Average yearly consumption data accounts for devices used in different modes, i.e., idle, charging, etc.

Washing Machine Payback Period

Spending a little bit more money on an energy-efficient appliance could save you several hundred dollars over the lifetime of the product. The payback period could be shorter than you think!



	WASHER 1	WASHER 2	WASHER 3
Original Cost	$478	$597	$999
Estimated Annual Electricity Use	427 kWh	160 kWh	102 kWh
Price of Electricity (per kWh)	$0.15	$0.15	$0.15
Operating Cost per Year	$64.05	$24.00	$15.30



Data: NEED analysis of washing machine EnergyGuide labels

Energy and Electricity

Electricity generation is the biggest energy consumer out of any other use. In 2025, three-fourths of electricity was generated with energy sources that heat water into steam. Thermal power plants are only about 30 percent efficient, meaning much of the energy is lost as waste heat and cannot be used to generate electricity. Saving electricity doesn't just make financial sense, it is environmentally smart, too. The cleanest and cheapest unit of energy is the one that never needs to be produced.

Phantom Loads

Some devices are always using power—even when they are turned off! This constant trickle of energy use is called a phantom load or a vampire load. How can you tell if something has a phantom load? Any device with a clock, LED, indicator light, or remote control, has a phantom load. There are plug-in meters that show phantom loads. Using a power strip or physically unplugging the device when not in use will stop the phantom load drain. Single-serving hot beverage machines can have some of the highest phantom loads because they are designed to keep water hot and ready for use.

MICROWAVE–A PHANTOM LOAD



Image courtesy of Adobe Stock

Transportation

Moving people and goods from one place to another uses a lot of energy. Passenger vehicles like cars and SUVs run on gasoline, and larger vehicles use diesel fuel. Ships and planes use fuels specifically made for those engines. Almost all of these fuels are petroleum products. Petroleum is expensive, and using it for energy produces carbon dioxide.

The transportation sector produces more carbon dioxide than any other sector—almost one-third of CO_2 emissions in 2025. When adults purchase vehicles, fuel efficiency is one factor they may consider. Keeping the vehicle maintained well and using good driving habits keep energy consumption down.

Even though, as a student, you cannot control the size, age, or fuel efficiency of the vehicles that move you and the products you use around, there are some things you can do to save energy with transportation.

Transportation Tips

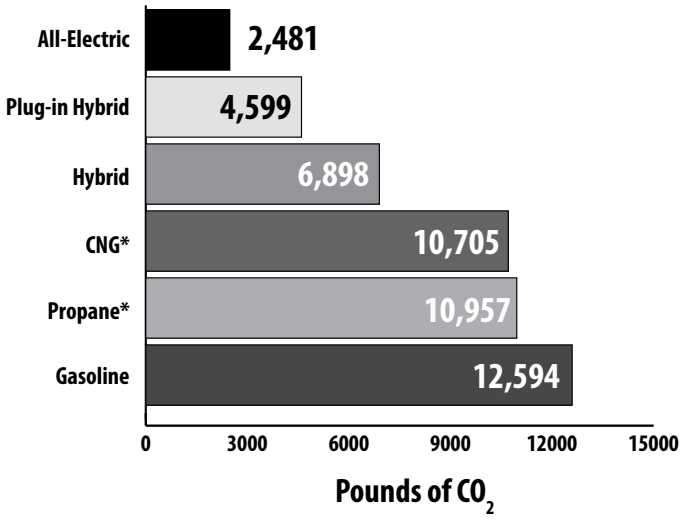
Follow these tips to reduce the amount of energy for transportation you use:

- Carpool with others going the same place as you.
- Take public transportation.
- Walk or ride your bike.
- Combine errands into one longer trip.
- When shopping online, choose shipping options that combine items into fewer deliveries.

Carbon Emissions

New technologies allow vehicles to use less fuel and produce less CO_2 emissions. Some vehicles use alternative fuels such as compressed natural gas (CNG) or propane. These vehicles are often owned by private companies or city governments. Hybrid vehicles combine a gasoline engine and an electric motor. Electric vehicles use batteries and electric motors instead of gasoline engines. These vehicles usually produce less CO_2 than gasoline-powered vehicles.

U.S. CO_2 Emissions per Vehicle, 2024



*Calculated based on estimate from Argonne National Laboratory
Data Source: Alternative Fuels Data Center

Materials and Manufacturing

Saving energy in industry is not achieved only at the manufacturing site. Consumers have the ability to greatly reduce the energy consumed for making materials and products. Beyond the energy consumed just to make materials like steel, aluminum, and paper is the energy needed to transport the products and dispose of the waste. Disposable, single-use items are one of the biggest consumers of energy in the realm of materials and manufacturing. Industry leaders are working on adopting improved technology and recovering waste heat from processes to reduce the energy their facilities consume.

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Saving energy for individuals and businesses is not limited to their own buildings and utility bills. It is also tied into the products they use and how they use those products. You've probably heard of the four Rs – Reduce, Reuse, Repair, and Recycle. Those practices are directly tied to energy saving in the industrial sector because a product that does not need to be re-made is the least expensive, best energy-saving option available.

▪ Reduce What You Buy

There is little question that we live in a consumer-based society. Purchased products have a limited lifespan and will one day be thrown away. By reducing the amount of stuff you buy and ultimately throw away, you save money and energy. Reducing your consumption does not necessarily mean going without. A large bag of potato chips and several small bags have the same number of chips, but the large bag has less packaging. A large, water-filtering pitcher eliminates the need for plastic bottles of water.

▪ Reuse What You Have

Which uses less energy, cleaning with paper towels every week, or using a cloth rag and washing it for reuse? If you said the cloth rag, you are correct. Over time, less energy is needed to wash a cleaning rag than to produce and transport paper towels. A refillable water bottle and reusable plastic containers and lunch bags save energy every time they are used in place of bottled water, zip-top plastic bags, or paper lunch sacks. Purchasing clothes from thrift shops, swapping sports equipment, and repurposing bottles and jars for other uses are other ways to reuse someone else's things.

▪ Repair What You Own

Jane had a laptop that worked well and did everything she wanted it to do. When Jane's laptop screen stopped working, she thought she needed a new computer. A repair shop was able to replace the screen for much less money than a new laptop would cost. Repairing the computer saved money and kept useful materials out of the trash.

Torn clothes can be sewn, parts of a bike can be replaced, and a new watch band can be attached to your smart watch. Repairing items and keeping them in service means a new item does not have to be made and transported to replace it.

▪ Recycle What You Can

All good things come to an end, and at some point, things are too worn to repair or reuse and they end up being thrown away. Before you put something in a trash bag destined for a landfill, consider whether it is recyclable. Steel and aluminum cans, plastic beverage bottles, milk jugs, cardboard boxes, and a lot of plastic containers and packaging can be recycled. Even textiles like jeans, towels, and fleece pullovers can be recycled into new thread for new fabric.

The availability of recycling programs varies from one community to another, so be sure you know what your recycling program will accept. That does not mean you cannot recycle items your local program does not take. There are some companies that, for a small fee, will send a bag or box to collect items, like snack food wrappers, that are typically not taken by community programs. Rechargeable batteries and electronics are often collected at home improvement stores, electronics repair shops, and other locations and sent to recycling centers. Some communities hold recycling drives for hard-to-recycle items like paint, plastic films, and chemicals. Recycling saves a lot of energy compared to using raw materials like iron ore, wood pulp, or bauxite.

▪ Recycling Is Not Always Simple



Manufacturers are always looking for ways to make their products more **sustainable**. Companies know that words like "recyclable" or "biodegradable" will appeal to some buyers. The unfortunate reality is that even if you put water bottles and milk jugs into a recycling bin, they may not be recycled. The problem is there aren't enough companies using recycled plastic and glass to keep up with the supply. People are recycling more than companies can use, and some ends up in a landfill anyway. People are innovative and inventive, though, and many are starting businesses to use the recycled glass and plastic to keep it out of a landfill.

Recycling Tips

There are a few things we as individuals and community members can do to improve recycling.

- Make sure you are following all of the guidelines for your community program.
- Put your trash in the trash can and your recyclables in the recycling bin.
- Make sure you clean containers of major food residues before recycling them.
- Write a letter to an elected official, especially your mayor or city council. Explain why recycling is important and how it saves energy. Ask them to improve recycling in your community.
- Purchase products made from recyclable materials to encourage businesses to keep making them.
- Think about starting a business that makes something needed in your community from materials recycled in your community. A local recycling stream saves energy when materials and products do not need to be transported great distances.

Looking to the Future

We will always need energy, and we are not going to just stop making, purchasing, and disposing of things. What we can do, though, is make sure the energy we use is necessary. If we treat energy like a limited resource the way we do money and time, and manage it well, there will be enough to meet all of our needs. A sustainable future is not out of reach. It might take a little extra effort, or a different way of thinking about things. When we work together, though, there is little we cannot achieve.



Energy sustainability focuses on long-term energy strategies and policies that ensure adequate energy to meet today's needs, as well as tomorrow's.

Glossary

a	**acid rain**	precipitation that has a low pH, usually caused by man-made emissions that react with water molecules in the atmosphere
	active solar home	a solar water or space-heating system that moves heated air or water using pumps or fans
	air infiltration	outside air leaking through a building envelope to the inside of a building
	alternating current (AC)	an electric current that reverses its direction at regular intervals or cycles; in the U.S. the standard is 120 reversals or 60 cycles per second; typically abbreviated as AC
	ampere (A)	a unit of measure for an electric current; the amount of current that flows in a circuit at an electromotive force of one volt and at a resistance of one ohm; abbreviated as amp
	anemometer	a device used to measure wind speed
	anthropogenic	originating with or created by humans
	appliance	a piece of equipment, commonly powered by electricity, used to perform a particular energy-driven function; examples of common appliances are refrigerators; clothes washers and dishwashers; conventional ranges/ovens; and microwave ovens, humidifiers and dehumidifiers; and toasters, radios, and televisions
	atmosphere	a layer of gases surrounding the Earth, or any planet
	atom	a tiny unit of matter made up of protons and neutrons in a small, dense core, or nucleus, with a cloud of electrons surrounding the core
b	**battery**	a device that stores chemical energy that can later be transformed into electrical energy
	bauxite	the ore that provides the principal source of aluminum
	biofuels	liquid fuels and blending components produced from biomass (plant) feedstock, used primarily for transportation
	biogas	a gas produced when organic material breaks down or decays
	biomass	any organic (plant or animal) material that is available on a renewable basis, including agricultural crops and agricultural wastes and residues, wood and wood wastes and residues, animal wastes, municipal wastes, and aquatic plants
	bulk plant	a filling station for propane dealers
c	**carbohydrates**	an energy-rich organic compound made of carbon, hydrogen, and oxygen
	carbon dioxide	a colorless, odorless noncombustible gas with the formula CO_2 that is present in the atmosphere; it is formed by combustion and by respiration
	caulking	material used to seal cracks and prevent infiltration or leaking of air or liquid
	chain reaction	a self-sustaining nuclear reaction that takes place during fission; uranium absorbs a neutron and divides, releasing additional neutrons that are absorbed by other fissionable nuclei, releasing still more neutrons

chemical energy	energy stored in the chemical bonds of a substance and released during a chemical reaction such as burning wood, coal, or oil
chemical reaction	a reaction occurring between elements or compounds when chemical bonds are broken or formed through digestion, or combustion, for example; items formed in a chemical reaction are transformed, thus gaining new properties
circuit(s)	a conductor or a system of conductors through which electric current flows
climate change	a term used to refer to all forms of climatic inconsistency, but especially to significant change from one prevailing climatic condition to another
coal	a fossil fuel formed by the breakdown of plant material hundreds of millions of years ago
coal bed methane	natural gas that forms within a coal deposit and can be extracted from the coal bed
cogeneration	when an industry facility or power plant generates electricity and produces another useful energy form such as heat
commercial sector (of the economy)	the part of the economy having to do with the buying and selling of goods and services; the commercial sector is made up of merchants, businesses, etc.
compact fluorescent light bulb (CFLs)	a light bulb consisting of a gas-filled tube and an electronic ballast; electricity flows from the ballast through the gas, causing it to give off ultraviolet light; the ultraviolet light causes a white phosphor coating inside of the tube to emit visible light; a compact fluorescent light bulb uses less energy and transforms a smaller fraction of that energy into thermal energy than a comparable incandescent bulb
concentrated solar power	technologies that focus the energy from the sun onto one smaller area creating high temperatures that can produce electricity
conversion	changing or transforming one material into another
cooling tower	a tower typically used to remove waste heat from fluids used in industry or generation
core	the innermost layer of the Earth composed of both solid and liquid contents under extreme heat and pressure
crude oil	see *petroleum*
crust	the uppermost, brittle, thin layer of the Earth that is divided into moving plates
current	the number of electrons moving past a point through a circuit, measured in amperes or amps

d

dam	structure or barrier built upon a waterway to retain water or prevent flooding
decarbonize	the process of reducing or removing carbon dioxide and other emissions from entering the atmosphere, typically involves a shift away from fossil fuel or combustible energy sources
derrick	a frame tower that supports the drill equipment used to find oil and natural gas in the Earth
diatomic	molecule made of two atoms
direct current (DC)	an electric current that flows in only one direction through a circuit, as from a battery; typically abbreviated as DC
distribution line	power lines that carry electricity at a safer voltage to consumers

distribution terminal	facility used by propane companies to store propane before shipping to retailers
drilling rig	equipment used for drilling and producing oil and natural gas from an onshore well
dry steam plant	power plant that relies on steam produced from a geothermal reservoir but uses very little water in liquid form
ducts	metal tubes that distribute heated or cooled air to the rest of a building

e

elastic energy	energy stored through the application of a force to stretch or compress an item
electric charge	either positive or negative, based on proton and electron interaction; electric charge determines the interaction of atoms with other atoms and produces electromagnetic fields
electric current	the flow of charged particles like electrons through a circuit, usually measured in amperes
electric grid	often referred to as "the grid," the system of equipment and wires that is used to transport and deliver electricity to consumers safely
electric power	see *power*; the part of the economy related to generation of electricity
electrical energy	the energy associated with electric charges and their movements
electricity	a form of energy characterized by the presence and motion of elementary charged particles generated by friction, induction, or chemical change; electricity is electrons in motion
electromagnetic	having to do with magnetism produced by an electric current
electrolysis	using electricity to break a chemical bond
electromagnetism	the interaction of forces occuring between electrically charged particles that can create an electric field or magnetic field
electron	a subatomic particle with a negative electric charge; electrons form part of an atom and move around its nucleus
element	the most pure form of matter; all matter is made of elements
energy	the ability to do work, produce change, or move an object; electrical energy is usually measured in kilowatt-hours (kWh), while heat energy is usually measured in British thermal units (Btu)
energy carrier	something produced from one energy source, transported, and used in a different location
energy conservation	changing a behavior or action with regards to energy use; riding a bike rather than driving a car
energy consumption	the use of energy as a source of heat or power or as a raw material input to a manufacturing process
energy efficiency	the ratio of energy input to output; energy transformations have varying levels of efficiency, depending on the forms of energy involved; efficiency can be increased with the incorporation or substitution of equipment
energy level	area where electrons can be found; describes the probable amount of energy in the atom
ENERGY STAR®	a program that tests and certifies products based on efficiency features; labels help consumers save money
EnergyGuide label	a label on an appliance that shows how much energy the appliance uses in comparison to similar appliances

	ethanol	a colorless liquid that burns to produce water and carbon dioxide; the vapor forms an explosive mixture with air and can be used as a fuel in internal combustion engines, usually blended with gasoline
	exploratory well	a well drilled by energy companies in an effort to locate a source of fuel, or geothermal activity
f	**F-gases**	synthetically sourced gases composed of bonded halogen and carbon atoms; these gases, also known as fluorinated gases, have a multitude of uses but can be harmful to the atmosphere
	feedstock	a raw material that can be used as a fuel or processed into a different fuel or product
	fermentation	changing of a sugar into an acid, gas, or alcohol with the presence of bacteria or yeast
	filament	the fine metal wire in a light bulb that glows when heated by an electric current
	fish ladder	installations at dams that allow fish to travel upstream, over the dam, to spawn
	fission	the splitting of atomic nuclei; this splitting releases large amounts of energy and one or more neutrons; nuclear power plants split the nuclei of uranium atoms
	foot-candles	amount of light emitted by one candle that illuminates a surface one foot away
	fossil fuels	fuels (coal, oil, etc.) that result from the compression of ancient plant and animal life formed over hundreds of millions of years
	fuel cell	a device used to generate electricity using hydrogen and oxygen, an electrolyte membrane, and catalysts
	fuel rods	sealed metal tubes consisting of ceramic fuel pellets; these rods are bundled into assemblies for use in nuclear reactors
	fusion	when the nuclei of atoms are combined or "fused" together; the sun combines the nuclei of hydrogen atoms into helium atoms in a process called fusion; energy from the nuclei of atoms, called "nuclear energy," is released from fusion
g	**generator**	a device that turns motion energy into electrical energy; the motion energy is sometimes provided by an engine or turbine
	geoexchange system	see *heat exchanger*
	geothermal energy	the heat energy that is produced by natural processes inside the Earth; it can be taken from hot springs, reservoirs of hot water deep below the ground, or by breaking open the rock itself
	global warming	an increase in the near surface temperature of the Earth; global warming has occurred in the distant past as the result of natural influences, but the term is most often used today to refer to the warming scientists agree is occurring as a result of increased man-made emissions of greenhouse gases
	gravitational potential energy	energy of position or place
	greenhouse effect	the trapping of heat from the sun by the atmosphere, due to the presence of certain gases; the atmosphere acts like a greenhouse
	greenhouse gases	gases that trap the heat of the sun in the Earth's atmosphere, producing the greenhouse effect; the two major greenhouse gases are water vapor and carbon dioxide; lesser greenhouse gases include methane, ozone, chlorofluorocarbons, and nitrogen oxides
	grid	the layout of an electrical distribution system
h	**halogen**	element that will glow in certain combinations, often used in light bulbs or lamps

	heat exchanger	any device that transfers heat from one fluid (liquid or gas) to another or to the environment
	hydrocarbon	a compound made up of only hydrogen and carbon; hydrocarbons are found in many fossil fuels
	hydrocarbon gas liquid (HGL)	hydrocarbon gases that can easily be liquefied under pressure or by cooling; ethane, propane (see LPG), butane, and propylene are examples
	hydroelectric power plant	a power plant that uses moving water to power a turbine generator to produce electricity
	hydrogen	a colorless, odorless, highly flammable gaseous element; it is the lightest of all gases and the most abundant element in the universe, occurring chiefly in combination with oxygen in water and also in acids, bases, alcohols, petroleum, and other hydrocarbons
	hydropower	energy that comes from moving water
	hydrothermal	referring to heated water, often used to describe steam generation
i	**incandescent light bulb**	a type of electric light in which light is produced by a filament heated by electric current
	industrial sector (of the economy)	the part of the economy having to do with the production of goods; the industrial sector is made up of factories, power plants, etc.
	infrastructure	buildings, pipelines, and other systems that support the use of something. For example, the system of highways, roads, parking lots, and fuel stations are the infrastructure for passenger vehicles.
	insulation	a material or substance used to separate surfaces to prevent the transfer of electricity, thermal energy, or sound
j	**jobbers**	companies that handle wholesale distribution of oil and refined products to merchants, industries, and utilities
k	**kilowatt**	a unit of power, usually used for electric power or energy consumption (use); a kilowatt equals 1,000 watts
	kilowatt-hour (kWh)	a measure of electricity defined as a unit of work or energy, measured as 1 kilowatt (1,000 watts) of power expended for 1 hour; one kWh is equivalent to 3,412 Btu
	kinetic energy	the energy of a body which results from its motion
l	**Law of Conservation of Energy**	the law governing energy transformations and thermodynamics; energy may not be created or destroyed, it simply changes form, and thus the sum of all energies in the system remains constant
	light-emitting diode (LED)	energy-saving light bulb that generates light through the use of a semiconductor
	liquefied petroleum gas (LPG)	mixture of hydrocarbon gases such as propane and butane; derived from the refining of petroleum and natural gas
	load	the power and energy requirements of users on the electric power system in a certain area or the amount of power delivered to a certain location or item
m	**magma**	molten rock within the Earth
	magnet	any piece of iron, steel, etc., that has the property of attracting iron or steel
	magnetic field	the area of force surrounding a magnet
	mantle	the largest, middle layer of the Earth, composed of rock and magma

	mercaptan	an organic chemical compound that has a sulfur like odor that is added to natural gas before distribution to the consumer, to give it a distinct, unpleasant odor (like rotten eggs); this serves as a safety device by allowing it to be detected in the atmosphere in cases where leaks occur
	methane	a colorless, flammable, odorless hydrocarbon gas (CH_4), which is the major component of natural gas; it is also an important source of hydrogen in various industrial processes; methane is a greenhouse gas
	molecule	particles that normally consist of two or more atoms joined together; an example is a water molecule that is made up of two hydrogen atoms and one oxygen atom
	motion energy	the displacement of objects and substances from one place to another
	motor	a mechanical device that converts electrical energy into motion energy
n	**natural gas**	an odorless, colorless, tasteless, non-toxic, clean-burning fossil fuel; it is usually found in fossil fuel deposits and used as a fuel
	neutron	neutrally charged particle within the nucleus of an atom
	Newton's Laws of Motion	three physical laws that govern the force and motion interaction of all bodies, for example, the Law of Inertia
	nonrenewable	fuels that cannot be easily made or replenished; we can exhaust nonrenewable fuels; uranium, propane, oil, natural gas, and coal are nonrenewable fuels
	nuclear energy	energy stored in the nucleus of an atom that is released by the joining or splitting of the nuclei
	nucleus	the core of the atom that houses positively charged protons and neutrally charged neutrons
o	**offshore**	the geographic area that lies seaward of the coastline; in general, the coastline is the line of ordinary low water along with that portion of the coast that is in direct contact with the open sea or the line marking the seaward limit of inland water
	oil	a black, liquid fossil fuel found deep in the ground; the raw material that petroleum products are made from; gasoline and most plastics are made from oil
	organic	material that is living or came from a once-living organism
	ozone	also known as trioxygen, this unstable gas is created when chemicals from human activities in the atmosphere react with sunlight; an ozone layer, however, in the atmosphere protects plants and animals from ultraviolet light (UV) exposure
p	**passive solar home**	a means of capturing, storing, and using heat from the sun, without using specialized equipment
	payback period	the length of time a person must use a more expensive, energy-efficient appliance before it begins to save money in excess of the initial cost difference
	peak demand	a period when many consumers want electricity at the same time; peak demand often takes place during the day, and may require additional generation by utilities to satisfy demand
	penstock	a large pipe that carries moving water from the reservoir to a turbine generator in a hydropower plant
	permafrost	soil that remains frozen for two consecutive years or longer
	petroleum	generally refers to crude oil or the refined products obtained from the processing of crude oil (gasoline, diesel fuel, heating oil, etc.); petroleum also includes lease condensate, unfinished oils, and natural gas plant liquids

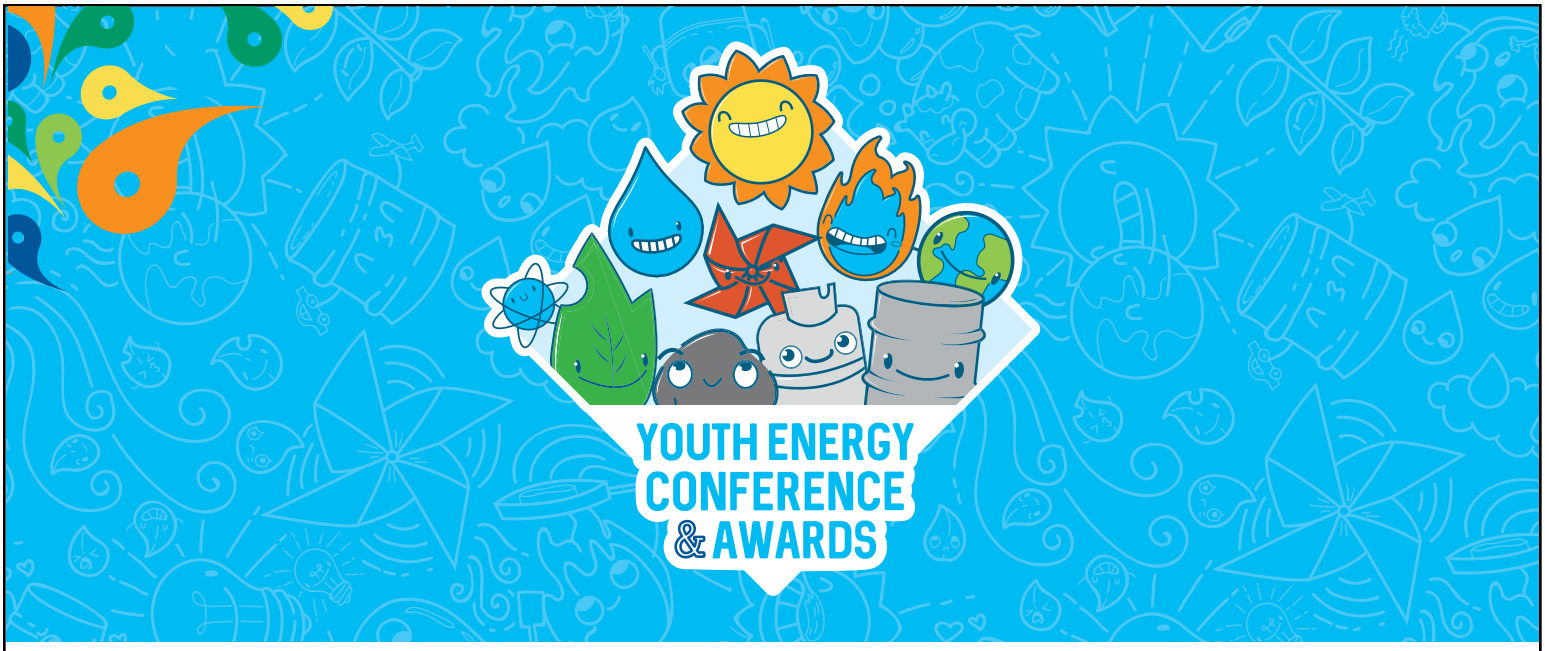
photosynthesis	the process by which green plants make food (carbohydrates) from water and carbon dioxide, using the energy in sunlight
photovoltaic cell	a device, usually made from silicon, which converts some of the energy from light (radiant energy) into electrical energy; another name for a solar cell
pipeline	a length of pipe that carries petroleum and natural gas from a refinery to the consumer
plates	pieces of the Earth's crust that shift and move slowly over time
porous	property of materials, including rocks, that describes the amount of pores or tiny spaces within the material
positive feedback loop	cyclical process in which the results add to the original cause, making the effects larger
potential energy	the energy stored within a body
power	the rate at which energy is transferred; electrical energy is usually measured in watts; also used for a measurement of capacity
power plant	a facility where power, especially electricity, is generated
prevailing wind	wind that blows from one direction at a particular point on the Earth at most times
propane	a normally gaseous, straight-chain hydrocarbon; a colorless, paraffinic gas that boils at a temperature of -43.67 degrees Fahrenheit; it is extracted from natural gas or refinery gas streams
proton	positively charged particle within the nucleus of the atom
pumped storage facility	a method of storing and producing electricity to supply high peak demands by moving water between reservoirs at different elevations

r

R-value	a measurement of how well a material resists transferring thermal energy
radiant energy	any form of energy radiating from a source in electromagnetic waves
radiation	any high-speed transmission of energy in the form of particles or electromagnetic waves
radioactive (decay)	a natural process during which atoms give up energy and particles to become stable; radioactive waste from a power plant has not yet become stable and, thus, can be harmful
reactor	part of a nuclear power station—the structure inside which fission occurs in millions of atomic nuclei, producing huge amounts of heat energy
reclaimed	land that was once used by industry (mining, drilling) and has been restored to original conditions/habitats, or as close to original condition as possible
recycling	the process of converting materials that are no longer useful as designed or intended into a new product
refinery	an industrial plant that heats crude oil (petroleum) so that it is separated into chemical components, which are then made into more useful substances
renewable	fuels that can be easily made or replenished; we can never use up renewable fuels; types of renewable fuels are hydropower (water), solar, wind, geothermal, and biomass
repository	a housing for spent nuclear fuel
reserves	natural resources that are technically and economically recoverable

	reservoir	natural or artificial storage facility
	residential sector (of the economy)	the part of the economy having to do with the places people stay or live; the residential sector is made up of homes, apartments, condominiums, etc.
	Ring of Fire	a region of high geothermal activity in the Pacific Ocean, located along several plate boundaries
S	**scrubber**	air pollution control device that power plants use to remove particulate matter and gases from their emissions
	secondary source of energy	also known as energy carriers, these sources require another source of energy to be created; electricity is an example of a secondary source of energy
	sedimentary	a type of rock formed by deposits of earth materials, or within bodies of water; oil and gas formations, as well as fossils are found within sedimentary rock formations; coal is a sedimentary rock
	silicon	element commonly used for semiconductors and in electric components
	siting	the multi-step process of determining the best location for wind turbines
	smelting	producing a metal from its ore, separating the metallic parts of an ore
	solar cell	an electric cell that changes radiant energy from the sun into electrical energy by the photovoltaic process
	solar collector	an item, like a car or greenhouse, that absorbs radiant energy from the sun and traps the energy within it as thermal energy
	solar energy	the radiant energy of the sun, which can be converted into other forms of energy, such as thermal energy or electricity
	sound energy	energy that travels in longitudinal waves
	space heating	heating the interior of a building or home
	spent fuel	irradiated fuel that is permanently discharged from a nuclear reactor
	spillway gate	a gate or apparatus at a dam that helps to control the water level of a reservoir; gates release excess water following heavy rainfall
	substation	equipment located along transmission lines that lowers voltage
	surface mining	takes place within a few hundred feet of the surface; earth above or around the coal (overburden) is removed to expose the coal bed, which is then mined with surface excavation equipment
	sustainable	describing a behavior or practice that is capable of being continued with minimal effects on the environment
t	**thermal energy**	the total potential and kinetic energy associated with the random motions of the atoms and molecules of a material; the more the molecules move and vibrate the more energy they possess
	thermostat	a device that adjusts the amount of heating and cooling produced and/or distributed by automatically responding to the temperature in the environment
	transformer	a device that converts the generator's low-voltage electricity to higher-voltage levels for transmission to the load center, such as a city or factory

	transmission line	a set of conductors, insulators, supporting structures, and associated equipment used to move large quantities of power at high voltage, usually over long distances between a generating or receiving point and major substations or delivery points
	transportation sector (of the economy)	the part of the economy having to do with how people and goods are transported (moved) from place to place; the transportation sector is made up of automobiles, airplanes, trucks, ships, trains, etc.
	turbine	a device with blades, which is turned by a force, e.g., that of wind, water, or high pressure steam; the motion energy of the spinning turbine is converted into electricity by a generator
U	**underground (deep) mining**	coal mining that takes place several hundred feet below the surface of the earth; workers and coal enter and exit through a vertical shaft
	uranium	a heavy, naturally-occurring, radioactive element
V	**ventilation**	bringing fresh, outside air inside
	volt (V)	the International System of Units (SI) measure of electric potential or electric force
	voltage	the difference in electric potential between any two conductors or between a conductor and the ground; it is a measure of the electrical energy per electron that electrons can acquire and/or give up as they move between the two conductors
W	**waste-to-energy plant**	a power plant that generates electricity by burning garbage
	watt (W)	a metric unit of power, usually used in electric measurements, which gives the rate at which work is done or energy used
	watt-hours (Wh)	a measure of electrical energy consumed
	weatherstripping	flexible material attached to windows and doors that fills spaces around them, preventing air flow
	well	a hole drilled in the Earth for the purpose of finding or producing crude oil or natural gas, or producing services related to the production of crude oil or natural gas
	wind	the term given to any natural movement of air in the atmosphere; a renewable source of energy used to turn turbines to generate electricity
	wind farm	a series or group of wind turbines in one location
	wind turbine	device powered by the wind that produces motion or electric power



YOUTH AWARDS PROGRAM FOR ENERGY ACHIEVEMENT

NEED's annual Youth Awards Program for Energy Achievement rewards students for their efforts in energy outreach and student leadership.

The Youth Awards Program is great for all schools—new to energy education, or veteran. Projects and outreach completed for the program provide opportunity for enrichment and engagement, as well as an opportunity for your students, classroom, and school to shine. Youth Awards projects can be completed by afterschool/out-of-school time programs, community groups, and even families!

What's involved?

Students and teachers set goals and objectives and keep a record of their activities. Students create a digital project to submit for judging. In April, digital projects are uploaded to the online submission site.

Check out:

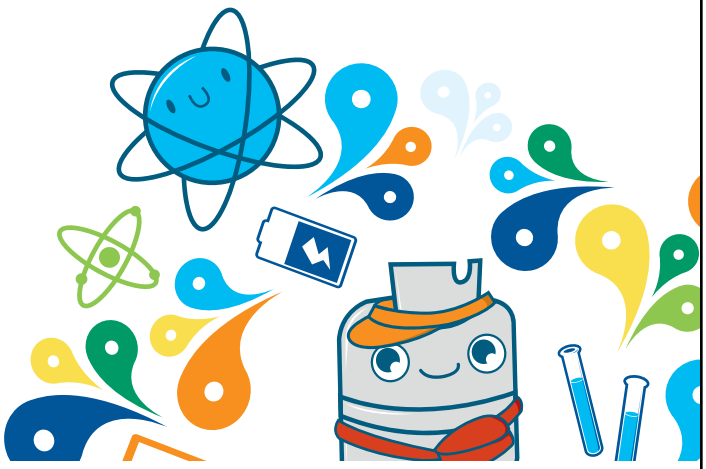
For more information and project submission details, we invite you to visit **https://youthawards.NEED.org**. Be sure to explore the site to view past winning projects and garner inspiration!

YOUTH ENERGY CONFERENCE & AWARDS

The NEED Youth Energy Conference and Awards gives students more opportunities to learn about energy and to explore energy in STEM (science, technology, engineering, and math).

The annual June conference has students from across the country working in groups on an Energy Challenge designed to stretch their minds and energy knowledge. The conference culminates with the Youth Awards Ceremony recognizing student work throughout the year and during the conference.

For More Info:
www.NEED.org/youthenergyconference



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