

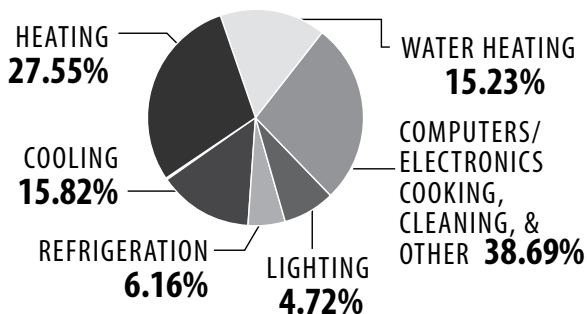


Energy Consumption

We use energy every day. We purchase food that was prepared and shipped to a store so we can cook, eat, and clean up after ourselves when finished. 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 a variety of building materials made at industrial facilities. We use energy to maintain a comfortable indoor temperature throughout the year, and we enjoy watching movies and TV shows and playing video games. The way humans have used energy over time has changed significantly, 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. All buildings or users within a sector share similar characteristics. The sectors of the economy are residential (homes); commercial (businesses, schools, hospitals, etc.); industrial (manufacturing complexes); transportation (vehicles); and electric power generation.

Home Energy Expenditures



Data: EIA 2020 RECS

*Total may not equal 100% due to independent rounding

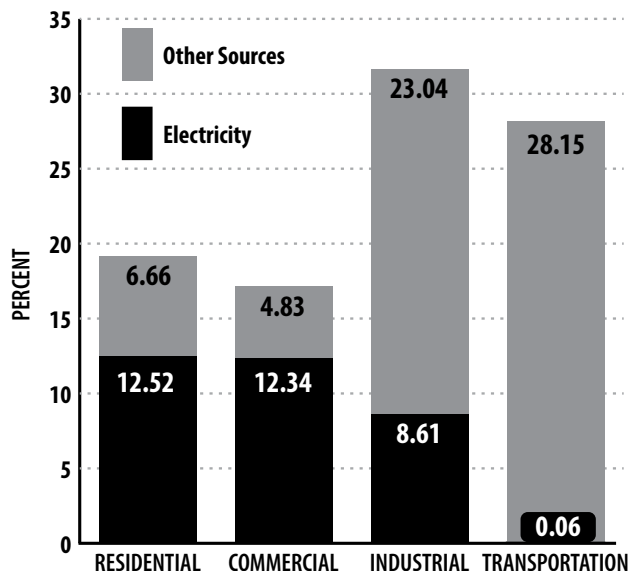
Residential and Commercial Sectors

The residential and commercial sectors are often grouped together because they both use energy similarly. 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, technology, and office machines. In the last 50 years, Americans have significantly reduced the amount of energy used to perform these tasks, mostly through technological improvements in the systems themselves, as well as in the manufacturing processes to make those systems.

■ Heating and Cooling

The biggest energy use in residential and commercial buildings is for keeping interiors 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.

U.S. Energy Consumption by Sector, 2025



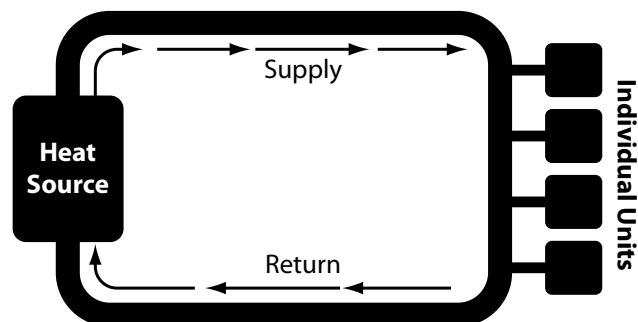
Data: EIA

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.

Heating can also be supplied by a district system. Good examples of district systems include college campuses or older cities with central steam systems. A building called a physical plant contains equipment that heats water that is pumped either as hot water or steam to the other buildings in the district. A heat exchanger, where air is circulated over specialized pipes containing the hot water, or a radiator, then heats the space. Cooling can also be provided in a similar manner, where enormous chillers cool water that is circulated.

Geexchange systems are those that use the Earth as a source of thermal energy. Also known as geothermal systems, or ground-source heat pumps, these systems rely on the consistent temperature that is maintained a few feet underground. A fluid circulates through pipes in the ground and can absorb thermal energy for heating, or release it for cooling.

District Heating System

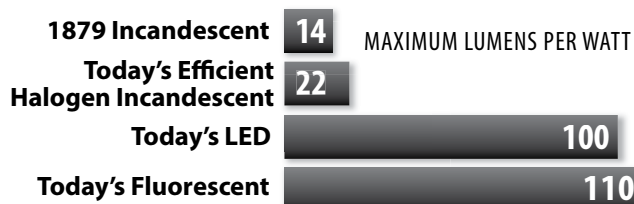


▪ Low-Temperature Lighting

The first lighting used in all buildings was incandescent lighting. This very inefficient style of bulb changes most of the electricity into heat rather than light. In the 1940s, commercial buildings were rapidly installing fluorescent lighting. These were very wide tube lights that had a flicker when they are turned on, and a continuous low-level hum. The **ballast** in early fluorescent lights was magnetic, and required a large surge of power to start. Electronic ballasts in commercial buildings and compact fluorescent lights in homes were much more efficient replacements.

Today, 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 equates to 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.

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. Generally speaking, the energy source used for heating in a home is also used for water heating. There are exceptions, of course, but most homes heat the interior space and water with the same fuel.

Refrigerators and freezers are the next-largest energy consumer. These appliances use a compressor and a chemical called a refrigerant to cool the interior. The refrigerant is put under pressure, condensed into a liquid, and then allowed to rapidly decompress and evaporate into a gas. The rapid evaporation makes the refrigerant get very, very cold. It can then absorb thermal energy and “carry” it outside the refrigerator or freezer compartment. Air conditioners work in a similar manner, but part of the cycle occurs indoors and part of it occurs outdoors.

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

▪ Smart Things

There is no question that the Internet has dramatically changed modern life. The early Internet was used mainly by universities, government agencies, and researchers. It was not widely available to the public and

required a land-based phone line and technical knowledge to use. As broadband Internet became more common in the late 1990s and early 2000s, manufacturers began developing products that could connect to home networks and be controlled remotely.

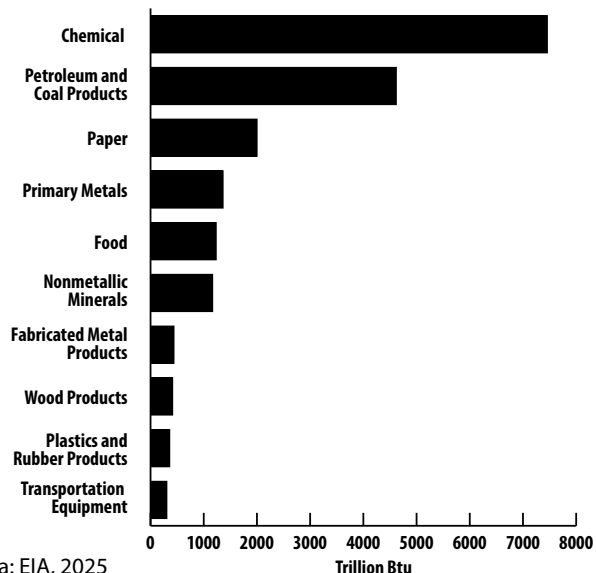
The modern smart-home era began when the Nest® smart thermostat was introduced. This Wi-Fi-connected control system allows the user to change settings with a smartphone. It also has the ability to recognize patterns in users’ behavior and make adjustments, saving energy. Smart light bulbs from Philips 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. Today 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 because surveys of home energy consumption 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. Energy managers of commercial buildings and campuses take advantage of 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

Until the start of the 20th century, the United States was primarily **agrarian**—most people worked in agriculture. The Industrial Revolution started bringing people into cities to work in factories, and by the early 1900s, more people worked in manufacturing than on farms. The facilities that make both raw and finished products—factories, foundries, and refineries to name a few—make up the industrial sector. In 2025, 32.89 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 are particularly energy intensive.

Top 10 U.S. Industries for Total Energy Consumption



Data: EIA, 2025



Energy Consumption

■ Petroleum Refining

Crude oil is a mixture of many compounds. To be useful, it must be separated into its respective products, and this takes place 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, primarily as small-sized hydrocarbons like methane and ethane. Petroleum refining is the second-largest energy consumer in the industrial sector.

PETROLEUM REFINERY



Image courtesy of BP

■ Steel Manufacturing

Steel is made from iron ore in a steel mill. Iron ore is an oxide of iron, such as hematite (Fe_2O_3) or magnetite (Fe_3O_4). 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 freight ships on the Great Lakes. At the mill, iron ore is heated in a blast furnace with coke, a fuel made from coal. The high temperature and chemical reactions remove oxygen from the iron ore, leaving molten iron. Elements such as carbon, manganese, and silicon are added to the iron to make steel, an alloy. Different types of steel contain different amounts and combinations of elements, giving them different properties.

The steel industry on its own is a major consumer of energy. However, when combined with the production of other metals such as aluminum, the energy consumption is even greater. The cost of energy is about 15 percent of the manufacturing cost of steel. Since 1990, the steel industry has reduced its energy consumption with improved technology, closing older plants, and the increased use of recycled steel. Recycling steel uses 75 percent less energy than making it from iron ore.

■ Aluminum Manufacturing

Aluminum begins as **bauxite**, a mineral rich in aluminum, oxygen, and hydrogen, which must be mined. Bauxite is then heavily processed to produce aluminum. Manufacturing aluminum is very energy-intensive. Just one step alone requires 6-7 kWh of electricity for each pound of aluminum produced.

The aluminum industry has significantly reduced the amount of energy needed to produce aluminum. A large part of the reduction in energy use has come from increased recycling of aluminum. Recycling aluminum uses 95 percent less energy than extracting 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 papermaking 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 its fossil fuel consumption per ton of paper by about 30 percent from 1990 to 2010, mostly through the use of better technology and cogeneration systems. Over 60 percent of the fuel the industry uses to power the cogeneration equipment comes from wood waste, a renewable energy source.

■ Chemical Manufacturing

Modern daily life is heavily influenced by the chemical industry. Chemicals are more than just detergents, cleaners, and solvents. Chemical manufacturing includes medicines, cleaning products, fertilizers, food containers and wrappers, and the raw materials used to make plastics. The additives, dyes, and flavorings added to processed foods are also part of the chemical industry. Because it produces such a wide variety of products, chemical manufacturing is the largest energy consumer in the industrial sector.

Chemical manufacturing uses large amounts of energy to operate equipment and generate the thermal energy for industrial processes. Petroleum and natural gas are also used as feedstocks, or raw materials used to make products rather than provide energy. Feedstocks are used to manufacture plastics, synthetic fibers, medical supplies, packaging materials, and many other products. The chemical manufacturing industry accounts for the largest share of nonfuel energy use in the manufacturing sector.

■ Cement Manufacturing

What is the largest concrete structure you have seen? A bridge? A power plant? Hoover Dam? Now imagine if modern concrete did not exist and all of those structures had to be built from stone. When cement is mixed with sand, gravel, and water, a fluid slurry called concrete is formed that can be molded into almost any shape. Like stone, concrete is strong and durable, but it can be formed into specific shapes much more easily and quickly.

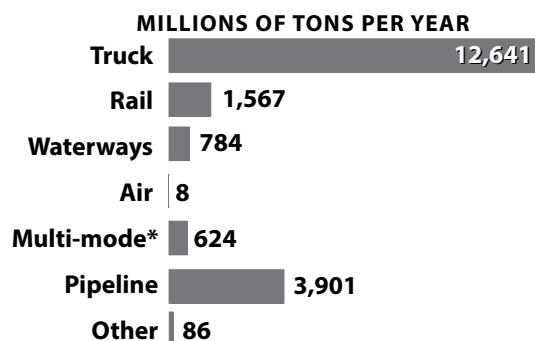
There are two major drawbacks to using concrete, and one feeds into the other. When cement is made from limestone, a byproduct is carbon dioxide—a lot of it. This does not include any CO_2 emitted from the energy used to make it. The second problem is the enormous amount of energy needed to manufacture, mix, and transport cement and concrete. In fact, manufacturing cement in the U.S. used more energy in 2024 than 134 countries! The United States manufactures an enormous amount of cement, and a large portion of it is shipped all over the world. New technologies in the last several decades have worked toward using less fossil fuels and reducing the amount of energy used to make cement, with the end goal of greatly reducing the carbon footprint of concrete.

Today, about 16 percent of the energy used to make cement comes from alternative energy sources, such as used tires. Pound-for-pound, used tires have about 25 percent more energy than coal. The American Cement Association is looking for ways to reduce the carbon emissions from cement manufacturing and concrete production. One possibility involves using fly ash, a waste product from coal-fired power plants, to replace some of the raw materials. Another solution proposes using renewable fuels in concrete production facilities. The cement industry has set an ambitious goal of decarbonizing cement manufacturing by 2050.

Transportation Sector

The United States is a nation on the move. We move ourselves from home to work, 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.

U.S. Freight, by Mode of Transportation



*Multi-mode includes any combination of truck, rail, air, waterway, and mail.

Data: Bureau of Transportation Statistics, 2023 report

■ The Automobile

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

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 than the vehicles of the 1970s. Furthermore, vehicle technology has improved to include alternative fuels, hybrid-electric vehicles, and fully electric vehicles, which reduce 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. Over land, 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 tug boats. A tug can move several barges at one time; the only limitation is the number of barges that will fit in a lock on a river. On the Great Lakes and across oceans, ships are used. They 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. That speed comes at a price—air freight is about 10 times more expensive than shipping by truck, and even more expensive compared to rail.

■ 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. 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 (CNG), 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 in all countries. In fact, from continent to continent and country to country, energy consumption depends greatly on the natural resources available, political stability, 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, though, 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, primarily biomass and hydropower. Where poverty, conflict, and political instability are present, access to energy is often limited. In some countries, unrest and violence have hampered the development and maintenance of energy infrastructure so severely that energy consumption has declined dramatically.

With just a little bit more than four percent of the world's population, Americans consume about 15 percent of the world's energy. The United States is not alone among industrialized nations; average world energy use per person continues to grow in many countries, while population also continues to increase. 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.