

Energy Producing Systems: Fossil Fuels

Introduction

Fossil fuels have played a critical role in the development of our modern society. Prior to the start of the industrial age (200 to 300 years ago) we met the vast majority of our **energy** needs with **renewable energy resources** such as wood for heat, watermills for grinding crops or wind to propel sailing vessels. With the advent of fossil fuels such as **oil, natural gas, and coal** we found new sources of energy that have been pivotal in the establishment of industrialized economies. Our modern transportation systems are almost entirely dependent on the use of petroleum (oil). Modern society has been fundamentally shaped by the use of fossil fuels and we are still very much dependent on these fuels for our energy needs.

Fossil fuels are essentially the remains of ancient organisms; predominately plants and bacteria. This organic matter resulted from ancient forests and swamps that existed on Earth from 100 million to 400 million years ago. Following changes in the Earth's climate and geology a portion of this material was trapped (*sequestered*) below the Earth's surface under multiple layers of sediment and rock. This sequestered organic matter was exposed to immense heat and pressure from the Earth's interior for millions of years. This process physically changed the original decaying **biomass** and created the fossil fuels we use today. Oil, gas and coal deposits can be found in specific geological sediments throughout the world.

When we burn gasoline in our cars or use oil for heating needs we are in essence burning ancient plants. The chemical process is called **combustion** and burning fossil fuels is the equivalent of burning a piece of firewood from a tree that existed several million years ago. However, the deposits of fossil fuels such as oil, gas and coal are not infinite—they are **nonrenewable energy resources**. Some sources of fossil fuels are already becoming more difficult to obtain and we will eventually deplete the available reserves of these fuels. In addition to simply running out, there are increasing environmental problems associated with our current use of fossil fuels. Finding other forms of energy to replace our disappearing fossil fuels is becoming increasingly critical.



Categories of Fossil Fuels

Coal

Coal has been used to power steamships and railroad engines, heat homes and provide heat for steel production since the 1800s. Coal is the most abundant of the fossil fuels. Coal can be found in several forms. For example some is hard, black, shiny and rock-like with a high-energy content (**anthracite**), while other deposits are soft and crumbly with a reduced energy content (**lignite**) and **bituminous** in between. Currently, 30 percent of the world's energy needs are met with coal. The primary use for coal is in the generation of electrical power. Coal is also used for industrial applications such as steel production. Coal represents an increasingly dominant energy source for developing countries such as China and India. One third of the **electrical power** generated in the United States comes from combusting coal and about 80 percent of electricity generated in Missouri is achieved using coal-fired plants.

Coal is mined in 25 states. Currently, the leading coal producing states are Wyoming, West Virginia, Kentucky, Pennsylvania, and Illinois. Almost all the coal mined in the United States is combusted to generate electrical power. A major factor in the mining of coal is the sulfur content of the coal. High sulfur content in coal can significantly increase air pollutants associated with its combustion. Missouri does have coal reserves; however, the high sulfur content of Missouri coal limits its use as an energy source. Worldwide the percentage of coal used for energy is expected to decline as coal-fired systems are being replaced by cleaner burning natural gas systems and rapidly growing renewables. By 2040 roughly equal shares of global electricity generation are expected to come from renewables (29 percent), natural gas (28 percent), and coal (28 percent).

Coal has more environmental impact than any other energy source. When coal is combusted large amounts of air pollutants are produced. The main emissions from coal are sulfur dioxide, nitrogen oxides, particulate matter, carbon dioxide and mercury. Together these pollutants can combine to form **smog**. Sulfur dioxide and nitrogen oxide emissions have been linked to acid rain. Mercury is a toxic heavy metal that has been linked to various neurological and reproductive impairments. Recent regulations from the federal government would reduce Mercury emissions from power plants by 90%. Combustion of coal also produces large quantities of carbon dioxide, a greenhouse gas. The Midwest relies heavily on coal for power production. With its higher population, Missouri produces more carbon dioxide than the surrounding states of Iowa, Kansas, Nebraska, North Dakota, South Dakota and Arkansas.

Petroleum

Petroleum is a thick, viscous and flammable black liquid that has been used for lighting since ancient times. Petroleum can be refined and separated into different components (fractions) and are used to generate products such as gasoline, propane gas, various lubricating oils and asphalt. Petroleum is also a key ingredient in plastics and many other common household products. Petroleum is the leading source of energy worldwide. Over thirty percent of total energy consumed is derived from petroleum products such as gasoline, diesel fuel, propane gas, and domestic cooking and heating fuels.



The majority of the petroleum used goes towards transportation needs. The first automobile was produced in 1892 and by 1920 there were 9 million cars in the United States. Today there are more than 250 million vehicles on the road. Although the United States is the leading producer of petroleum, we imported about half of our petroleum in 2015. This makes the United States dependent on other major petroleum exporting countries like Canada, Saudi Arabia, Venezuela, Mexico, and Colombia. Petroleum is refined into gasoline for cars, jet fuel for planes and diesel fuel for trucks. Transportation systems are a significant source of air pollution producing sulfur dioxide, nitrogen oxides and carbon dioxide emissions. Nitrogen oxides contribute to the formation of ozone and the subsequent formation of smog. Automobiles are a major contributor to urban air quality issues. Petroleum products also present environmental concerns during extraction, transportation and use. Used motor oil lost from automobiles onto paved surfaces or following improper disposal represents a major source of surface water pollution. Just one gallon of improperly disposed oil can pollute 1 million gallons of water—the supply of 50 people for an entire year.

Natural Gas

Natural gas can often be found in locations where petroleum is extracted. Natural gas is primarily composed of methane with varying amounts of other hydrocarbons such as ethane, propane, and butane. The United States is the world's largest producer and consumer of natural gas. Over 20 percent of U.S. energy needs are met using natural gas systems. More than half the homes in America use natural gas for residential heating needs.

Natural gas is one of the fastest growing sources of energy worldwide. It is expected to surpass coal in global energy production and electricity production within the next 20 years. Natural gas produces less air pollution than coal or petroleum. Most combustion engines can be modified to use natural gas. In an attempt to reduce air pollution many large U.S. cities have initiated programs to promote the use of natural gas for large car fleets, city trash trucks and municipal transportation buses. Natural gas operated vehicles can reduce the production of carbon monoxide and other air pollutants by as much as 60 to 80 percent.

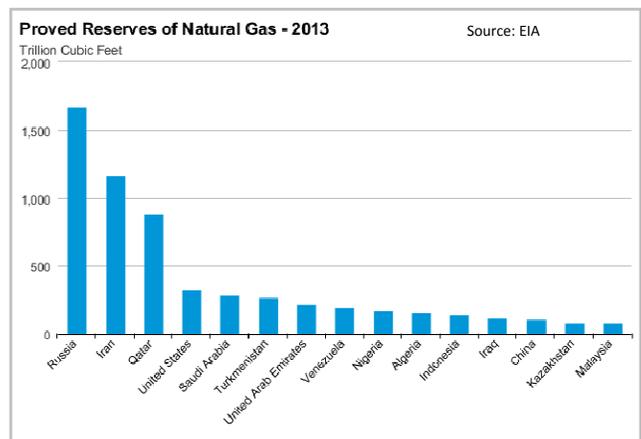
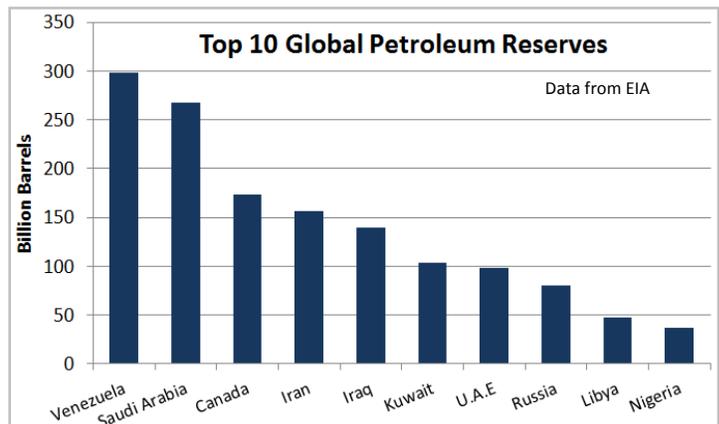
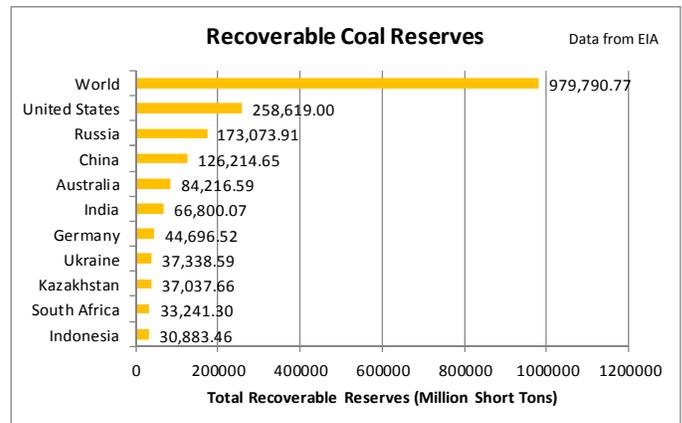
Reserves of Fossil Fuels

Coal is the most abundant fossil fuel. Coal reserves worldwide vary significantly in quality and accessibility. Bituminous and anthracite coal beds produce much higher energy fuels than subbituminous and lignite coal reserves. The table to the right indicates the reserves of these coal types worldwide. Only a few countries control almost 75% of world coal reserves: the U.S., China, Russia, Australia, and India.

North American coal beds are widely distributed (see map right). Not all of these coal beds are currently mined due to the high sulfur content in some locations. Missouri coal is not used to any significant degree due to sulfur content of the local coal beds. Efforts to research methods for removing sulfur from coal are being pursued. It is estimated that with the current rate of consumption, assuming no net growth in overall coal use, that the United States has enough coal to last more than 250 years.

Petroleum reserves have a different distribution than coal. The largest oil fields are located in the Middle East with almost 50% of the known world petroleum reserves. The largest petroleum reserves are found in Venezuela, Saudi Arabia, Canada, Iraq, Iran, Kuwait, and the United Arab Emirates.

Texas is the largest producer of domestic petroleum followed by off-shore drilling in the Gulf of Mexico, North Dakota, California, and Alaska. The two largest oil fields in the U.S. are located in Texas. Producing a combined 337 million barrels of oil in 2013. While the state of Missouri does produce some petroleum, the amount is about .0001% of the output of Texas and less than .00005% of the output of the U.S..

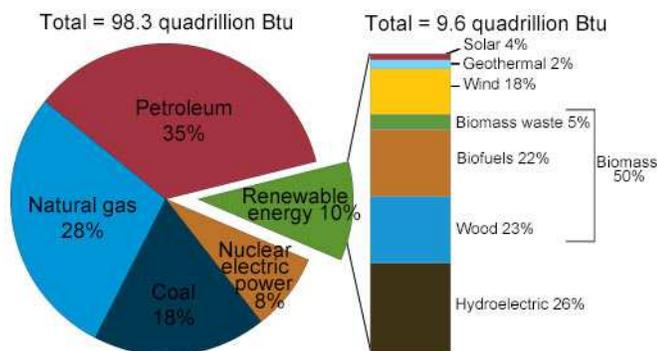


Known natural gas reserves have grown in the last 30 years with the discovery of major resources in Russia, the Middle East, the U.S., and South and Central America. World natural gas reserves are more widely distributed than petroleum fields. The largest natural gas reserves are found in Eastern Europe and the former Soviet Union.

Specific Characteristics of Fossil Fuels

The majority of the world's energy needs are currently being met by the use of fossil fuels. Fossil fuels have proven to be an abundant source of energy and have been critical in the development of our modern world. However fossil fuel use also raises serious environmental issues. Acid rain is caused by sulfur oxides and nitrogen oxides released into the air predominately by coal fired power plants. Acid rain has been shown to have significant impacts on aquatic and forest ecosystems. Nitrogen oxides contribute to ozone pollution and have been linked to serious health issues and long term health problems. Mercury emissions from coal have long been a serious health concern. Fossil fuel use has contributed to a rise in atmospheric levels of carbon dioxide raising climate variability concerns. The mining, extraction and transportation of fossil fuels can cause various types of environmental damage ranging from habitat loss to pollution and contamination of ecosystems. Used motor oil from automobiles has become a significant surface water pollutant in the United States.

U.S. energy consumption by energy source, 2014

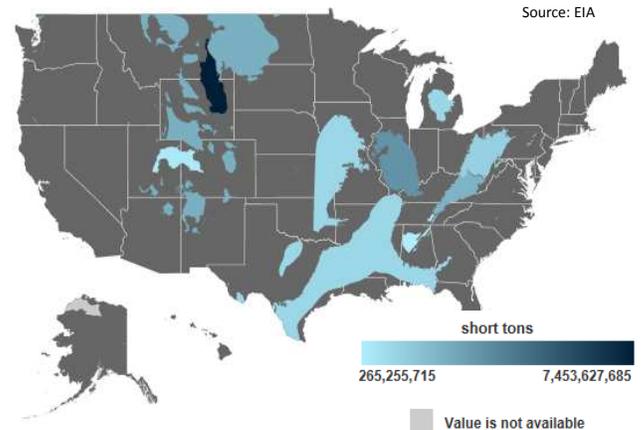


Note: Sum of components may not equal 100% as a result of independent rounding.

Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3 and 10.1 (March 2015), preliminary data



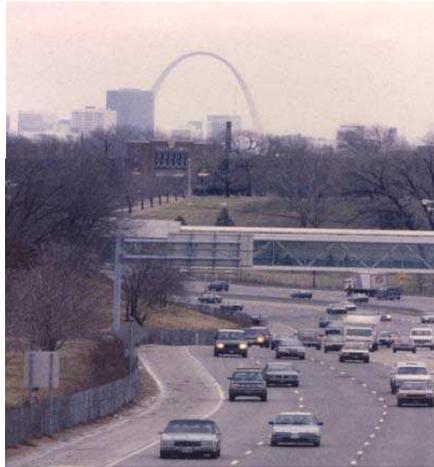
Recoverable Coal Reserves at Producing U.S. Mines 2012



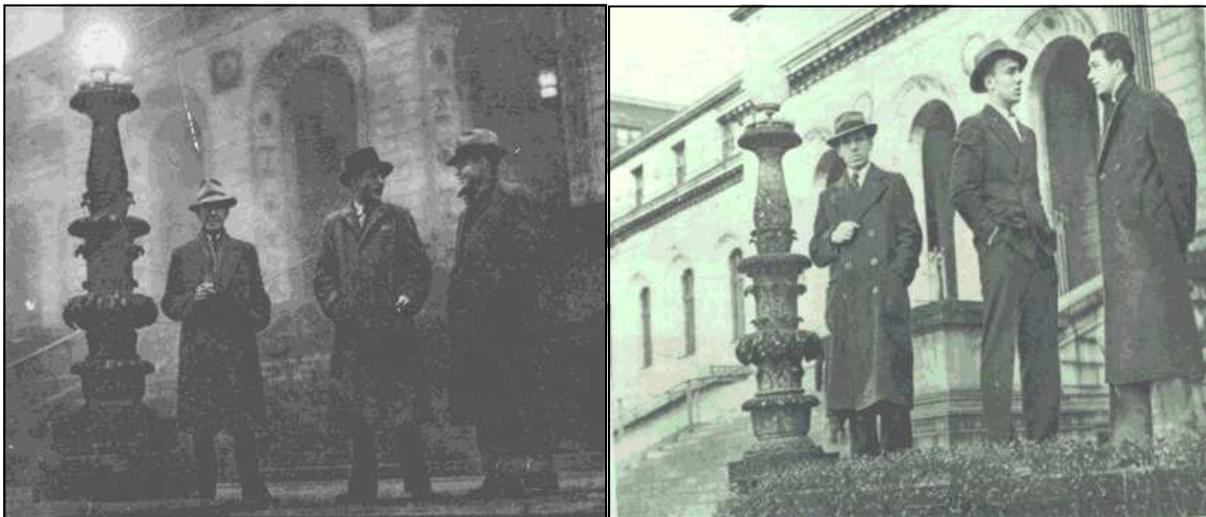
Fossil fuels are a limited resource. The supplies of fossil fuels will not last forever. The world will not only require energy in the future, but those energy needs are destined to grow. Development of renewable energy systems such as hydroelectric, geothermal, wind, biomass and solar will become more critical. We will have to find other sources of power, as we will eventually run out of fossil fuels.

The Future of Fossil Fuels in Missouri

Almost 90 percent of Missouri energy needs are met using fossil fuels. We import the petroleum we use to propel our transportation systems and the coal and natural gas used to generate our electricity. While the fossil fuels we use for power may be brought into the state, the pollution produced from these energy sources affects people right here. Both Kansas City and St. Louis have had serious problems with air quality as a result of automobile traffic, industry and utility emissions. Coal-fired electric plants produce significant amounts of mercury (a highly toxic heavy metal). At one time Missouri ranked 11th in the country in total power plant emissions of mercury. Statewide fish consumption advisories had to be issued as a result of mercury contamination. With the exception of Illinois, Missouri generates double the amount of CO₂ and N₂O (greenhouse gases) from electric power generation than the bordering states of Nebraska, Iowa, Arkansas, Oklahoma, and Kansas.



Missouri does not produce the fossil fuels it uses to any significant degree. Missouri has fairly large coal deposits, but the sulfur content of the coal currently prevents any significant resource development. Missouri was the fifth-highest ranked coal receiver in 2014, getting 42.49 million short tons of coal. In 2013 Missouri spent \$1.6 billion on coal, the second largest per capita expenditure in the U.S. If even a small fraction of this money could be spent on locally produced renewable energy sources, such as solar power, biomass systems, hydropower or wind power, the benefit to Missouri's economy and environment could be significant.



The gentleman in St. Louis posed during the day for the picture on the left, when coal use in the city was unregulated and again on the right following a ban limiting residential and commercial coal use. The street lights were on during daylight hours as a result of coal smoke.

Glossary of Terms

Anthracite Coal: The highest quality of coal with the highest carbon content and heat production capabilities. Constitutes a very small amount of the coal mined in the U.S. and is primarily used for industrial purposes

Bituminous Coal: The second highest quality of coal following anthracite and also the most abundant

Biomass: Any plant or animal matter; can be used as fuel especially as crop waste, wood, grasses, paper waste, and other plant material

Coal: A solid fossil fuel mined from the Earth's surface and underground which is often used to produce electricity through combustion. There are several different qualities of coal including anthracite, bituminous, and lignite

Combustion: A high-temperature chemical reaction resulting from the combination of a fuel with oxygen which releases carbon dioxide and water mixed with other substances (smoke) as well as thermal and light energy

Electrical power: Electrical energy used to conduct work; the measure of the rate of electrical energy used by a circuit. This is usually measured using a unit called a Watt (W)

Energy: The ability to do work

Fossil fuels: Highly combustible substances generally found underground that were formed as the result of high levels of heat and pressure on decaying organic matter from millions of years ago. Fossil fuels include liquid oil, solid coal, and gaseous natural gas and are often burned to generate energy and power

Lignite coal: The lowest quality of coal, and the youngest. Has a high moisture content, low heat value, and is much softer than bituminous and anthracite coal

Natural gas: A fossil fuel gas which can be recovered from underground and combusted as a fuel source. Increasingly used to generate electricity

Nonrenewable energy source/fuel: Primary energy source that cannot be replenished at an equal or greater rate to its consumption; unsustainable energy source

Oil: Also known as petroleum; a viscous and combustible fossil fuel liquid found underground which can be refined into different products including fuels which are often burned for transportation or other energy needs

Renewable energy source/fuel: Primary energy source that can be replenished at an equal or greater rate to its consumption; sustainable energy source

Smog: Combination of smoke and fog; a type of air pollution in which particulate matter and other pollutants coalesce to form an often toxic visible cloud. Common sources include emissions from the combustion of coal and transportation emissions

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