Energy Primer

Where Does Energy Come From?

You can't see it, touch it, smell it, or taste it, and yet it powers everything in nature as well as everything people do. What is it? Energy, of course. Energy is the ability to do work or create change.

Energy is important because nothing happens without it! We use energy when we read, run, or have fun. Energy lets us grow our food, process and package it, deliver it to stores, cook it, eat it, and digest it. We need energy for our TVs and cell phones. We also need energy for our houses, clothes, and other needs.

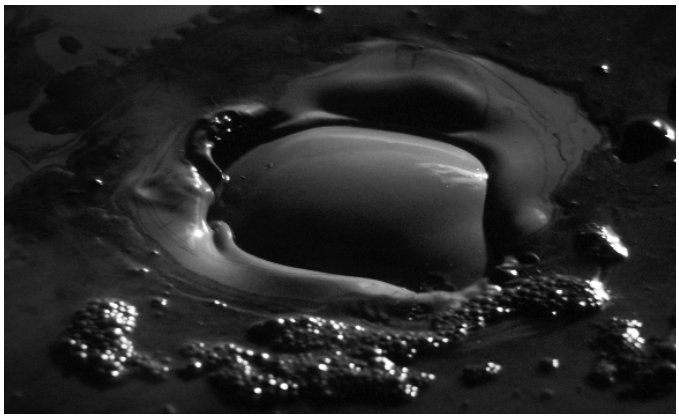
We get energy from many different sources, which can be either nonrenewable or renewable. If an energy source is nonrenewable, there is a limited amount of it; once you deplete the supply, it's gone. If an energy source is renewable, it can be either replenished or used over and over. Regardless of the source, all energy resources need to be used responsibly.

A. Nonrenewable Energy Sources

1. Fossil Fuels

Most of the energy sources we use today—oil, natural gas, and coal—are what we call fossil fuels. These fuels were formed millions of years ago, some of them before the age of the dinosaurs. Coal was created from plants that decayed in swamps and bogs, and oil and natural gas were formed from the remains of marine organisms in shallow ocean areas. Over time, these plants and animals were buried deeper and deeper under layers of sand and silt. Intense heat and pressure squeezed the buried organisms so much that they slowly changed into fossil fuel.

Fossil fuels are concentrated energy sources, storing all the energy from the ancient organisms that formed them. We burn these fuels to release the energy.



Unfortunately, when we burn fossil fuels to get energy, carbon dioxide and other gases are also released. While carbon dioxide is a natural part of the Earth's atmosphere, too much of it may raise the temperature of the Earth's atmosphere. Many scientists believe that the Earth's atmosphere is getting warmer because of all the fossil fuels we are using. This "global warming" is believed to be causing polar ice caps to melt, sea levels to rise, and climates to change.

a. Oil

Oil, or petroleum, is a fossil fuel that is found in layers deep below the Earth's surface. It is pumped up to the surface and then sent through pipelines or shipped on tankers to oil refineries. At a refinery, the oil is turned into different kinds of fuel.

Petroleum is the fuel for almost all cars, trucks, and other vehicles. In some areas it is used to heat homes and to generate electricity. It is also used to make plastic and other products; even some of your favorite clothes may be made from it.

The United States consumes 25 percent of all the oil produced in the world, using it for transportation and industry. Oil accounts for 40 percent of all the energy consumed in the United States.

The major oil-producing states in the United States are Texas, Alaska, Louisiana, California, and Oklahoma. These states produce about half the petroleum consumed by Americans. The rest must be imported from other areas of the world, including Russia and the Middle East.

Oil is the most widely used fossil fuel throughout the world. It is relatively inexpensive, easy to store and move, and packs a lot of energy in a small volume. Unfortunately, it also has downsides. Oil production and consumption raise a number of concerns. The process of drilling for oil can affect wildlife and the people who live in the area. Transporting the oil poses a risk of accidental oil spills, which can kill wildlife and endanger people. At current rates of consumption, some experts predict we may soon run out of affordable, easy-to-reach deposits. In addition, the burning of fossil fuels releases carbon monoxide and carbon dioxide into the atmosphere.

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b. Natural Gas
Natural gas is a fossil fuel that was formed millions of years ago when the remains of plants and marine organisms were buried under sand and rock. It is usually found underground near oil. Lighter than air and almost invisible, natural gas burns easily and has no odor. After it is pumped out of the ground, it is mixed with a chemical to give it a strong smell so people can detect any gas leaks. The gas is sent through underground pipes to homes, schools, or businesses where it is used to cook food or provide heat. It is also sent to power plants to generate electricity.

About one-fifth of all energy used in the United States comes from natural gas. Almost half of the nation's homes use it, and industry and electric utilities also are major consumers.

Much of the natural gas produced in America comes from Texas, Oklahoma, New Mexico, Louisiana, Wyoming, and Kansas. Worldwide, Russia, Canada, and the United States have the largest amounts of natural gas.

Propane is a by-product of natural gas or of petroleum. Because it can be turned into a liquid, propane is easily portable. It is used mostly in rural or suburban areas that are not served by a natural gas pipeline.

Natural gas burns cleaner than any other fossil fuel, causing relatively small amounts of air pollution. It can be used for a number of different energy purposes, and is relatively inexpensive. Vehicle engines fueled with natural gas emit cleaner exhaust than gasoline engines.

However, natural gas and propane also raise a number of concerns. Some natural gas deposits are found in sensitive ecological regions and the production of natural gas can have a negative impact on wildlife and habitat. At current rates of consumption, some experts predict that there is only enough natural gas to last until the latter half of this century. Further, the burning of natural gas produces carbon dioxide, which may contribute to global climate change.

c. Coal
Coal is a black, rock-like mineral. Like gas and oil, it is a fossil fuel. Coal is classified by hardness. The harder the coal, the less moisture it contains and the more efficient it is as fuel.

Coal is removed from the earth in two ways—surface mining and underground mining. Surface mining (or strip mining) is the most common method. When coal is mined from the surface of the earth, the plants, trees, and soil are removed to reach the coal 100 to 200 feet below. Underground mining is used to extract coal lying deep beneath the surface or in seams exposed on hillsides.

Burning coal generates more than half of the electricity we use in the United States. The United States has the world's largest share of known coal deposits. At current rates of consumption, there is thought to be a 200- to 300-year supply left in the United States alone. Major coal producing states include Wyoming, Montana, Kentucky, West Virginia, Pennsylvania, Texas, and Illinois. Globally, other large producers include Australia, China, and Russia.

Coal is relatively inexpensive, abundant, and easy to transport. But, like other fossil fuels, burning coal releases carbon dioxide and creates air pollution. It also adds to acid rain, rain that is polluted by acid in the atmosphere. Coal also can be difficult or dangerous to mine, and surface and underground mining of coal can impact the environment. Of all the fossil fuels, coal produces the largest amount of carbon dioxide per unit of energy.

2. Uranium (Nuclear Energy)

Everything in our world is made of matter. What makes up matter? Atoms! Atoms are tiny, invisible-to-the-eye particles. Each and every atom has a center, or a nucleus, and little particles or electrons that spin around the center.

An atom's nucleus can be split apart to release an enormous amount of energy. This process is called nuclear fission. When this energy is released all at once, it makes a tremendous explosion. If it is released slowly, it can be used to provide heat, which can then be used to generate electricity in a power plant.

Nuclear power plants use uranium, an element found in rocks, as a fuel. Uranium is used because the nuclei of uranium atoms can be more easily split apart than the nuclei of other atoms. Inside the power plant, uranium atoms are slowly and carefully split apart to release heat

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energy. This heat energy is used to boil water in the core of the reactor to produce steam. The steam then powers a turbine that, in turn, generates electricity.

Uranium is found in rocks all over the world; however, the largest uranium deposits so far have been found in New Mexico and Wyoming. Uranium is used to run nuclear power plants that currently provide about 20 percent of all the electricity generated in the United States and about 17 percent of the world's electricity.

The positive things about nuclear energy are that there is a lot of uranium to use and nuclear power plants produce very little air pollution. But, nuclear energy creates radioactive waste material. Radioactive means that the material sends out rays such as gamma rays and X-rays that are harmful to living things. Safely storing this radioactive waste requires that it be placed in secure container systems. At present, there is no permanent disposal site for these wastes, although for several years the government has been trying to find and prepare a good, underground site where these wastes can be safely placed. Nuclear power plants also are relatively expensive to build, operate, and close.

Some experts hope that another nuclear process—nuclear fusion—will someday provide an endless supply of energy for generating electricity. Nuclear fusion involves joining uranium nuclei in a reaction that also gives off heat and light. With nuclear fusion, there would be less radioactive waste than with nuclear fission. However, scientists have not yet found a way to control the nuclear fusion reaction.

B. Renewable Energy Sources

1. Biomass Energy

Biomass energy is fuel from plant or animal material. During photosynthesis, plants use the sun's energy to form carbohydrates. Those carbohydrates, in turn, can be burned to release energy.

The most common form of biomass energy is wood. Throughout the world, people burn wood for cooking and heating. Burning waste such as yard clippings, raked leaves, recycled paper, and kitchen scraps can also produce biomass energy. In some places, biomass is used to create steam for power plants to generate electricity.

Biomass can also be used to make other fuels. In some rural parts of the world, people compost plant and animal waste to produce a kind of gas (called biogas, which is similar to natural gas) to cook and provide light. Sugar, corn, and other crops can be used to produce ethanol, which is a liquid biomass fuel used to power some automobiles. Blending ethanol in gasoline reduces carbon monoxide tailpipe emissions, however, it can be very expensive to produce these liquid fuels.

Biomass is a very flexible source of energy. It can be used as it is or converted to a gaseous or liquid fuel. Because biomass energy relies on plant and animal materials, it can be considered environmentally "friendly." However, some experts say that it would be better if these wastes were used for compost to grow more food because burning wood and many other kinds of biomass materials produces air pollution.

2. Hydropower

The flow of water is one of Earth's natural forms of energy and has been used for centuries. "Hydro" means water and "hydropower" means generating energy through the movement of water.

A dam is used to capture the energy of moving or falling water. Water from the reservoir behind the dam is sent through a pipe in the dam. The rushing water pushes against the giant blades of a turbine, turning it and generating electricity.

The United States has used hydropower to generate electricity for many years. Early in the 20th century, hydropower supplied 40 percent of the nation's electricity; today it produces about 10 percent.

Hydropower is a cheap way to generate electrical energy and does not create air pollution. But it is very expensive to build large hydropower plants, and they need a great deal of open land. Also, when a dam is constructed, plants and animals that live in the flooded area are harmed and migrating fish (such as trout and salmon) are blocked. Historical and cultural sites also can be damaged. Because of this, it is very hard to find and develop new hydropower sites.

3. Solar Energy

Solar energy is created in the sun's hot core. All the energy in fossil fuels, wood, food, wind, and most waterpower originally comes from the sun.

Solar energy can be used directly to heat buildings and water, and to provide light. These uses are usually inexpensive, efficient, and non-polluting.
Solar energy also can be used to produce electricity. In a

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solar power plant, large mirrors focus the sun's energy onto water pipes. The water boils and produces steam, and then the steam turns a turbine to generate electricity.

Solar energy is also used to power solar cells, or photovoltaic cells. When light from the sun hits the special materials in a photovoltaic cell, electrical energy is produced. Small appliances, such as calculators, can be powered this way. When panels of photovoltaic cells are arranged together, they can produce enough energy to power homes, businesses, cars, satellites, and spacecraft. The problem with this kind of power plant is that it cannot make electricity at night or when it is cloudy. However, electricity made from solar energy can be stored in batteries for use when the sun is not shining.

The sunny American Southwest is a prime area for generating solar electricity. Currently, solar energy provides about one percent of the electricity consumed in the United States. Projects are also underway to produce solar electricity in other parts of the world.

Solar energy is very clean. In most cases a solar power plant produces little pollution, and using the sun's energy to generate electricity does little to harm the environment. Solar energy systems can be used anywhere the sun shines and are best in areas with a large number of sunny days per year. However, solar energy can be a very expensive way to produce energy in large quantities because of the cost of solar collection systems. Also, solar power plants require a large amount of open land.

4. Wind Energy

Wind is created by the sun's uneven heating of the Earth's surface. The sun's energy heats the air, causing it to rise. Heavier, colder air rushes in to take the place of the lighter, warmer air and creates wind.

Wind was one of the earliest forms of energy that people learned to use, moving sailboats through the water, and powering mills and to grind grain. Farmers have been using wind energy for many years to pump water from wells. Today, wind is also used to generate electricity.

Large numbers of wind turbines are grouped together in "wind farms." They are designed to catch the high-speed winds that blow throughout the year. These wind turbines look like enormous airplane propellers. When the blades spin, they turn a generator that makes electricity.

California has the largest number of wind farms in the United States. Other countries also are advancing in this field, including Germany, India, Denmark, and Spain.

Because the wind does not blow all the time, wind turbines are not able to continuously generate electricity. When they are turning, the wind turbines generate a lot of electricity—just three of California's wind farms can power the entire city of San Francisco.

Wind turbines do not pollute, and can be placed near residences, workplaces, agriculture, and ranches. However, wind farms are expensive to install, noisy, hazardous to some birds, and take up a lot of land. Also, they can only be built in the few places that have the right wind conditions.

5. Geothermal Energy

Geothermal energy—from "geo," meaning Earth, and "thermal," meaning heat—comes from the heat deep within the Earth. When water touches very hot rocks in the Earth's crust, steam is produced. These steam deposits create hot springs and geysers. When they are close enough to the Earth's surface, they can be used to heat buildings or to generate electricity.

At lower temperatures, geothermal resources can be used directly for bathing (their oldest use), warming buildings, growing plants, processing food, and even

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fish farming. Geothermal power plants use higher temperature water or steam directly from underground to drive turbines to generate electricity. They operate without having to burn a fuel.

Geothermal resources at varying temperatures are found all over the United States. The hottest geothermal sites are found in the western states. California generates the most geothermal electricity in the world. Globally, geothermal resources are found in Iceland, Indonesia, Mexico, Italy, New Zealand, and countries in Central and South America.

Geothermal energy is reliable, efficient, and produces less carbon dioxide, nitrogen oxide, and sulfur dioxide emissions than burning fossil fuels. But, it can only be used where it is found. The steam or hot water cannot be transported the way other fuels can, and there are only a few good geothermal sites.

6. Hydrogen

Hydrogen is never found alone in nature—it is always combined with other elements such as oxygen and carbon. People have found that if they separate it from the other elements, it becomes a gas that can be used for fuel. Hydrogen fuel is most commonly produced by running an electric current through water to separate out the hydrogen, or by heating hydrocarbon molecules.

It takes energy to produce hydrogen fuel, and that energy can be either from fossil fuels or from renewable energies like solar. Hydrogen fuel is only renewable if it is made using a renewable energy source.

Hydrogen is a transportable, versatile fuel—both in its gas form and also in compressed liquid or solid forms. Burning hydrogen fuel emits few or no air pollutants. But producing it is expensive and takes a lot of energy. Hydrogen can also be explosive, so it must be carefully handled and stored.

Hydrogen is currently used in industrial processes, rocket fuel, and spacecraft propulsion. People believe that it could one day serve as an alternative source of energy for heating and lighting homes, generating electricity, and fueling motor vehicles. In fact, automobile manufacturers have already developed some hydrogen-powered cars. But there is a long way to go before hydrogen can be used as a substitute for gasoline. A major barrier is the huge expense of developing systems to produce, store, and distribute the hydrogen fuel.

Another way to make electricity from hydrogen is with fuel cells. Like batteries, fuel cells use a chemical reaction to create electricity. Unlike batteries, they require a steady flow of hydrogen fuel to work, and as long as they have fuel, they don't run down.

The automobile industry is currently testing out fuel cells to power cars and trucks. These fuel cells are different from hydrogen-based ones. They use natural gas, methanol, and even gasoline, and so aren't really a renewable energy source. But, since these fuel cells work on chemical reactions rather than combustion (burning), they are less polluting than combustion engines.

7. Ocean Energy

A vast amount of solar energy is held in the ocean, and scientists are currently working on possible ways to harness that energy. One possibility is an ocean thermal energy conversion (OTEC) system, which uses temperature differences in ocean water to turn a turbine for producing electricity. Another possibility is to capture the energy from waves and tides by channeling the moving water through turbines to produce electricity.

The challenges facing these technologies include the cost of equipment, the fact that seawater is very corrosive, and the need to overcome powerful ocean forces.

C. Energy Conservation

Have you ever heard the expression, "A penny saved is a penny earned?" Well, the same is true with energy. The easiest and least expensive way to get more energy is to save energy.

One way to save energy is to cut energy waste. At home this means doing things like turning off lights and appliances when you are not using them, or taking the bus or walking instead of driving. For businesses, industry, and transportation systems this means continuing to develop machinery, vehicles, and processes that use less energy than the ones being used today. Each choice we make about energy can involve tradeoffs in terms of money or quality of life.

By using energy resources wisely, we can ensure that reliable and affordable energy supplies will be available now and for future generations.