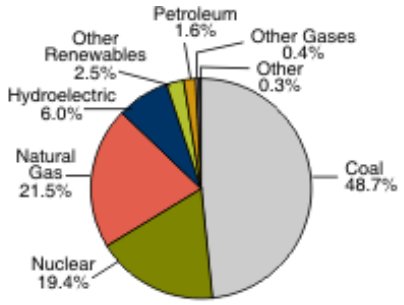
Where Does Electricity Come From?

(Excerpt from *NGS Environmental Literacy Teachers Guide Series, Energy Potential: A Guide for Teaching Energy in Grades 3 to 8*)

It is possible to use energy every day, but never think about how it is becomes available to us. Everyday, people charge their cell phones, turn on televisions and computers, or play video games. In buildings, we use lights and heating and cooling systems that utilize electricity. Electrical energy is working in our world day and night. Occasionally, people may mistake electricity and energy to be the same thing. Electrical energy is just one form of energy, albeit an important one in this modern world.

Electricity is the most common form of energy used in many human communities. Electricity can come from multiple sources and is distributed through a vast energy grid, which consists of a large network of wires that transmits the energy from power plants to our communities. Power plants, or power stations, are facilities responsible for transforming one form of energy into the electricity we can use. They send this electricity across power lines for domestic, commercial, and industrial use.



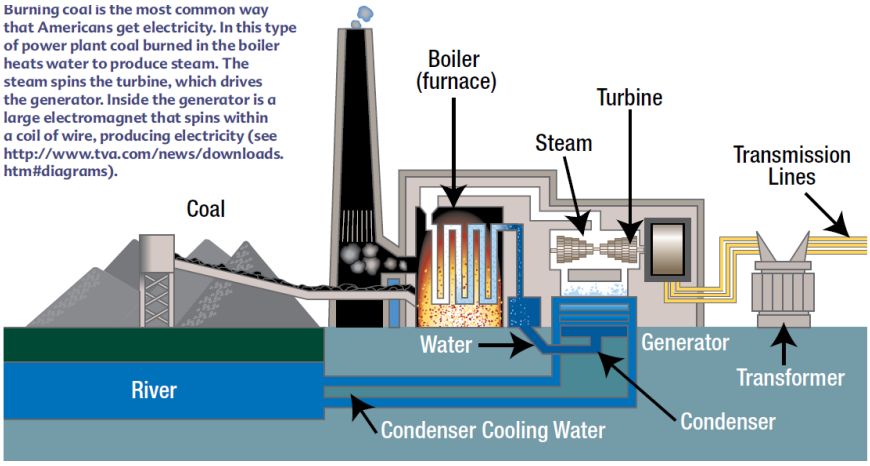
Source: Energy Information Administration, Form EIA-906, "Power Plant Report;" and Form EIA-920, "Combined Heat and Power Plant Report."

While power plants may not have a visible presence in your community, power lines likely do. You may wonder where these power lines start, how far they extend, and how they bring electricity into our homes.

The electricity we use every day is generated by lots of different energy sources. In the United States, about half of our electricity production comes from burning coal. Other types of power plants include nuclear, natural gas and hydroelectric. Each type of power plant transforms a different type of energy into electricity.

Even though the original source of energy varies, every power plant has common components. Describing how these parts work will help you understand how different types of energy are used in different power plants. A power plant typically includes the following parts: **Turbine**: A turbine is a blade arrangement, common to all types of power plants that may look like a fan but in this case it is the air that moves the blades, not the blades moving the air. **Generator**: A generator is the part of a power station in which motion energy from the turbine's movement is transformed into electrical energy. **Transformer**: A transformer changes the voltage of an electrical current so the electricity is at the proper voltage for being used in homes. Most differences in power plants are related to the source of energy turning the turbine.

Fuel Power Plant. Fuel power stations take energy-rich materials, like coal or natural gas, and transform their chemical energy into electrical energy. The chemical energy found in fuels is burned (combusted), which yields heat energy and a rearrangement of the matter in the fuels. As part of this rearrangement, CO_2 and water are released into the atmosphere. The heat energy is then transformed into motion energy, which powers turbines and rotors that then change the motion energy into electrical energy. Finally, the electrical energy leaves the power plant via power lines.



Burning coal is the most common way that Americans get electricity. In this type of power plant coal burned in the boiler heats water to produce steam. The steam spins the turbine, which drives the generator. Inside the generator is a large electromagnet that spins within a coil of wire, producing electricity (see http://www.tva.com/news/downloads.htm#diagrams).

There are many types of fuel-based power plants: coal-powered, gasoline-powered, natural gas-powered, or **biofuel**-powered (the burning of **biomass**—or living matter, such as manure or wood—to make fuel such as ethanol or biodiesel). In the United States, most fuel-based power plants use either coal or natural gas. Combustion of fuels produces emissions of carbon dioxide (and other gases, some of which are potentially toxic) into our atmosphere. Carbon dioxide is called a greenhouse gas because of its ability to trap heat energy within the atmosphere.

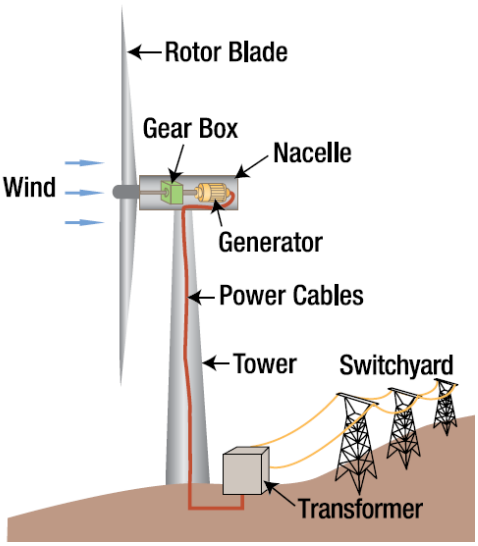
Nuclear Power Plant. Nuclear power plants use nuclear reactions (in particular, fission) to yield heat energy, which is then transferred to a fluid, mostly water. (Note that a tiny bit of matter is actually converted to energy in the nuclear reaction. MATTER TO ENERGY CONVERSIONS ONLY HAPPEN IN NUCLEAR REACTIONS, NOT CHEMICAL REACTIONS!) The heat resulting from the nuclear reaction causes the water to vaporize and the heated vapor flows through a turbine, which makes the rotor of a generator spin. After that, the water vapor is condensed and cooled, and then reused in a cycle. The changes in energy follow this sequence: nuclear reaction yields heat energy, heat energy is transformed to motion energy in a fluid, motion energy in the turbine and rotor is transformed to electrical energy as a product.

Nuclear power makes up a relatively small, but important, portion of our energy resources. Nuclear power does not emit greenhouse gases, whereas fossil fuel-based power plants do produce carbon emissions. However, when using nuclear power plants people must be careful about other potential impacts, such as the disposal of nuclear wastes and the discharge of heated wastewater into waterways and oceans. Some aquatic and marine ecosystems are affected when heated water is released into the system, also the infrastructure can alter habitats along the shore.

Geothermal Power Plant. Geothermal energy utilizes heat energy, mostly coming from Earth's internal heat (under the Earth's crust). This heat is transported to the Earth's surface in the form of geysers, hot springs, or other sources of heated fluid such as lava. These phenomena occur mainly near boundaries of tectonic plates, oftentimes in earthquake and volcanic zones. As a result, most of the geothermal power plants in the United States are located on the West Coast or Hawaii. In geothermal power plants, the stages of energy transformation are similar to other power plants. Hot water or steam coming from geysers is directed towards a turbine where the heat energy is converted to motion energy. The spinning turbine makes the rotor of the generator spin, and the motion energy is transformed into electrical energy in the generator.

Hydropower Plants. Hydropower is a relatively clean source of energy because no waste products are produced from power generation. Furthermore, dams also control the flow of water throughout a region and across time, so they serve multiple purposes beyond power generation. Like all power plants,

hydropower is not without fault. Dams break up the natural flow of a river, create reservoirs that can destroy terrestrial ecosystems, and can disrupt migration patterns of aquatic life. Dams also have relatively short life spans and many older dams are now being dismantled in order to restore natural flows to rivers.

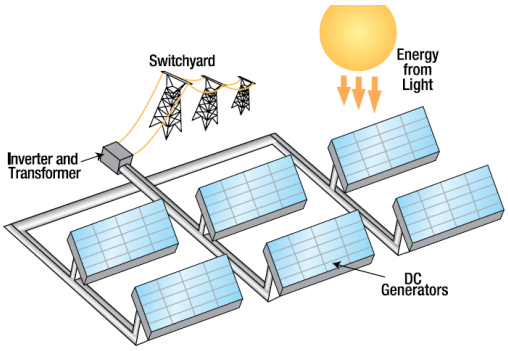


Wind turbines generate electricity inside their hub, or nacelle. A turbine and gear box are mounted in the casing called the nacelle, and rotor blades are attached to the turbine. The turbine localizes the energy of the turning rotor blades in a single rotating shaft that generates electricity (see http://www.tva.com/news/downloads.htm#diagrams).

Wind Power Plants. Wind power plants use motion energy in airflow to move a turbine. Before the technology of electricity production was developed, motion energy of wind was used for grinding grain, for pumping or draining water (used extensively in low-lying terrains seen in Holland), and to propel ships using sails. Most people refer to air motion energy as wind energy. In a zone of high-energy winds, wind farms may be built to generate electric energy. Wind farms are arrangements of many wind turbines, which are high towers that usually have three rotating blades.

Several wind farms are already generating electrical energy in the American West, especially in Texas and California. These farms harvest wind energy in locations where wind flow is strong and reliable, such as gaps between mountains, which create natural wind tunnels, and open prairies. While wind farms are a clean source of energy they face the challenge of dealing with bird and bat fatalities that occur as birds and bats migrate using the same wind currents that our wind farms seek to harvest.

Solar Power Plants. People have been taking advantage of solar heating for many years. For example, sunrooms are designed to maximize passive solar heat that can be captured just from utilizing incoming sunlight. With technological advancement, we have been able to better harvest the Sun's energy. There are two types of solar power plants including solar thermal power plants, which are relatively new technology and solar photovoltaic power plants. In solar thermal power plants, sunlight can be used in one of several different ways: sunlight can be directed by using mirrors or lenses to a focal point in which a fluid is boiled and used to spin a turbine, or sunlight can be used to warm up massive amounts of air, which are directed through a turbine. Most solar thermal technology is relatively new, so there is some technological advancement still to be made in this area.



Photovoltaic (PV) systems use semiconductor cells that convert sunlight directly into electricity. Direct current from the PV cells, which are arrayed in flat panels, flows to inverters that change it to alternating current (see http://www.tva.com/news/downloads.htm#diagrams).

You may be familiar with solar photovoltaic power if you have ever seen solar panels on a house. Solar photovoltaic power plants use the same sort of panels but on a large scale. Photovoltaic solar cells use the properties of some materials (semiconductors) that react to solar light by activating electrons

and creating a charged electrical field. This movement of charges provokes an electrical flow, which is harnessed as electrical energy. Solar panels are expensive to build and some metals and materials used to build them are rare or costly. In some communities, homeowners can receive help in purchasing solar panels.