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## The Role of Water in the Generation of Electricity

Electricity in the United States is generated using a number of different energy resources. Much of our electricity is generated using fossil fuels such as coal, oil, and natural gas. Electricity is also generated from nuclear power plants, hydroelectric power plants, and other renewable energy resources, including solar energy, wind energy, geothermal energy, and biomass. Each of these resources requires the use of water in some way to generate electricity.

### The Role of Water in Fossil Fuel Extraction

Fossil fuels are nonrenewable resources that formed from plants that lived hundreds of millions of years ago. To be used for generating electricity, these resources first have to be extracted from the ground. Extracting each of these resources requires the use of water.

*Coal:* Water is used in coal mining to cool equipment. It is also sprayed to keep dust levels down at the mines. It is estimated that coal mining consumes up to 260 million gallons of water per day. Water is also used in the transportation of coal when it is piped from the mines. Coal is mixed with water to create a coal slurry that can be more easily moved through the pipe system. Finally, significant quantities of water are used to clean impurities from coal before burning it.

*Oil and Natural Gas:* At first, little water is used in extracting oil and natural gas from wells. However, as wells age, water is pumped in to keep the pressure up and the oil and gas flowing. Most of this water is not freshwater. When oil and gas are pumped out of the earth, water is often pumped out with them. An estimated 49 million gallons of water are extracted along with oil and natural gas each day. Only about 70 percent of this water can be recycled and reused.

Another method of extracting natural gas is called hydraulic fracturing or hydrofracking. This method injects a fracking liquid into the ground to create fractures that allow natural gas to be extracted more easily. This fracking liquid can include up to 99 percent water with chemicals added to it. Hydrofracking can use up to an estimated 5 million gallons of water per well. Estimates of how much of this water is recovered and not consumed vary from 15 to 80 percent, depending on the area.

*Water Quality and Environmental Concerns:* The extraction processes for fossil fuels raise a number of water quality concerns. One concern is contamination of groundwater and surface water through the chemicals used in extraction. Elements naturally found in rock can also be released in quantities that can contaminate freshwater.

Runoff from coal mining operations can also contaminate ground and surface water. In addition, the water used in coal slurries is contaminated in the process. This water must be disposed of carefully to avoid contaminating the freshwater supply.

# The Role of Water in the Generation of Electricity, continued

## The Role of Water in Thermoelectric Plants

Thermoelectric power plants operate by using an energy resource to heat water to produce steam. The steam is then used to turn a turbine and generate electricity. A number of energy resources are used in this way to generate electricity. Coal, oil, and natural gas can each be burned to heat water into steam. Nuclear power relies on nuclear fission using radioactive uranium to heat water into steam.

Biomass is a renewable energy resource that can come from a variety of sources. These sources include municipal and industrial waste, manure and crop waste from farming, wood, and specially-grown crops. Depending on the source, biomass can be burned directly in the same way as coal. Gas from some kinds of biomass can be captured and burned in the same way as natural gas. Other forms of renewable energy, such as solar energy and geothermal energy, can also be used to heat water into steam.

*Water Use and Consumption:* Thermoelectric power plants require water for cooling and condensing the steam. Water is also used to cool and clean equipment. Older open-loop systems withdraw large quantities of water from a nearby water source such as a lake or reservoir. They pump that water back into the lake or reservoir after it has been used for cooling. Though large quantities of water are used in this process, less than one percent of that water is actually consumed through evaporation.

New power plants use a closed-loop system. These systems use less than 5 percent of the water used by older models. However, most of this water is consumed through evaporation. Thus newer systems consume as much or more water than older systems, though they withdraw and use less.

The use and consumption of water in a thermoelectric power plant can vary based on the resource being used and the type of power plant. On average, though, thermoelectric power plants in the United States withdraw and use about 136 billion gallons of water per day and consume about 3.3 billion gallons per day.

*Water Quality and Environmental Concerns:* Though most of the water withdrawn for use in a thermoelectric power plant is returned to the source, there are still some negative effects on water quality and the environment. When water levels are low in an area, the large withdrawals needed for generating electricity can put a strain on the local aquatic life. When water is replaced after it is used for cooling, it is warmer than normal. This can stress the aquatic life, particularly in the summer months when the water temperature in the lake or reservoir is already at its peak.

## The Role of Water in Hydroelectric Power

Hydroelectric power uses the flow of water to turn turbines and generate electricity. Most hydroelectric power plants are located on rivers, where they can take advantage of the flow of water. Large-scale hydroelectric plants rely on human-made dams to control the flow of water. These dams create reservoirs holding vast amounts of water. The amount of water released over

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the dam to turn the turbines can be controlled. This allows plants to generate more electricity during times of peak demand.

*Water Use and Consumption:* Hydroelectric power plants use large amounts of water to turn turbines. On average, about 3,160 billion gallons of water are used per day to generate electricity in hydroelectric power plants in the United States. Almost all of this water is returned to the rivers where it originated. However, hydroelectric plants that use large reservoirs can consume a significant amount of water through evaporation from the surface of the reservoir. An average of 3.8 billion gallons of water are consumed per day from hydroelectric reservoirs in the United States.

*Water Quality and Environmental Concerns:* Though most of the water used in hydroelectric power plants remains in the rivers where the plants are located, the plants do impact aquatic life in the rivers. Damming a river and creating a reservoir can change the flow of water downstream. When cooler water is released from a reservoir into a river, it can lower the water temperature and oxygen levels in the river. These changes can kill some aquatic species.

## The Role of Water in Generating Electricity from Other Renewable Resources

Energy resources are renewable when they are used at a rate at which they can naturally be resupplied. Solar, wind, and geothermal energy resources are examples of renewable energy resources. As is the case when fossil fuels are used to generate electricity, water is also needed when generating electricity from renewable resources.

*Solar:* Solar photovoltaics convert sunlight directly into electricity. Photovoltaics require very little water to operate. Water is mainly used to clean the photovoltaic panels so they will work efficiently. However, solar thermal plants require water use similar to other thermoelectric power plants. These plants use solar troughs to concentrate the sun's heat on tubes filled with liquid. This creates steam. These plants require water for cooling and condensing the steam and for cooling equipment.

*Wind:* In general, wind turbines do not require the use of water to generate electricity. However, small amounts of water are used to clean the wind turbines. Keeping the turbines clean helps them to work at top efficiency.

*Geothermal:* Geothermal power takes advantage of the heat found naturally under Earth's surface. Geothermal power plants use wells drilled into the ground to access water that has been naturally heated underground. Depending on the temperature of this water, steam can be used directly from the geothermal source to turn turbines. Water from the source can also be used to heat liquids with a lower boiling point, creating steam. In both cases, hot water is removed from the geothermal source and replaced after use as warm water. In water-cooled geothermal systems, the amount of water use for cooling is similar to the amount used in other types of thermoelectric power plants.

Geothermal power can affect water quality in the area as well. Some chemicals are used in the process of drilling and keeping equipment clean. These chemicals can potentially leak into the groundwater, affecting water quality.