

# Facts about Geothermal Energy Resources

## Introduction

Like the sun, Earth's interior provides heat energy from nature. This heat—geothermal energy—yields warmth and power that can be used without polluting the environment. Geothermal resources range from shallow ground sources (low temperature) to hot water, steam, and rock miles below Earth's surface (high temperature).

Geothermal heat originates from Earth's fiery consolidation of dust and gas over 4 billion years ago. At Earth's core—4,000 miles deep—temperatures may reach over 9,000 degrees F. Energy from Earth's core continuously flows outward, heating the surrounding layer of rock called the mantle. When temperatures and pressures become high enough, some mantle rock melts, becoming magma. Sometimes the hot magma reaches all the way to the surface, where it is called lava. But most often the magma remains below Earth's crust, heating nearby rock and water, sometimes to temperatures above 700 degrees F. There are some places in the world famous, such as Yellowstone National Park, for spectacular geothermal activities. Throughout the globe, Earth's crust receives heat generated from its core. The temperature of the ground just a few feet below Earth's surface is relatively stable, about 45 - 58 degrees F, throughout the year.



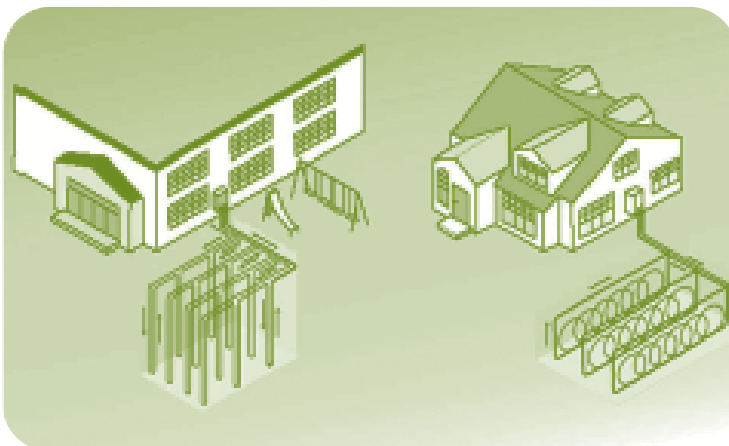
## Geothermal Heating and Cooling

There are locations in Wisconsin and other parts of the world taking advantage of the shallow ground sources of geothermal energy to help keep indoor temperatures comfortable. They use geothermal heat pumps to circulate water or other liquids through pipes buried in a continuous loop (either horizontally or vertically) next to a building. Depending on the weather, the system is used for heating or cooling. In heating, Earth's heat (the difference between Earth's temperature and the colder temperature of the air) is transferred through the buried pipes into the circulating liquid and then transferred again into the building. During hot weather, the continually circulating fluid in the pipes 'picks up' heat from the building—thus helping to cool it—and transfers it into the earth.

Geothermal heat pumps use very little electricity. In the U.S., the temperature inside over 400,000 homes, schools and offices is kept comfortable by these energy-saving systems, and hundreds of thousands more are used worldwide. The U.S. Environmental Protection Agency has rated geothermal heat pumps as among the most efficient heating and cooling technologies. In Wisconsin, Milwaukee's Washington Park Library and Fond du Lac High School are among the structures acclimated by geothermal energy. Many homebuilders are also starting to consider geothermal heat pumps as a means to reduce their home energy costs and impact on the environment.

## Electricity Production

High temperature geothermal resources are underground reservoirs of hot water or steam that can be tapped for electrical power production. Developers drill wells into the geothermal reservoirs to bring the hot water to the surface. Geologists, geochemists, drillers, and engineers do a lot of exploring and testing to locate underground areas that contain this geothermal water, so that they will know where to drill geothermal production wells. Then, once the hot water and/or steam travels up the wells to the surface, they can be used to generate electricity in geothermal power plants or for energy-saving non-electrical purposes.



In geothermal power plants, steam, heat, or hot water from geothermal reservoirs provides the force that spins the turbine generators and produces electricity. The used geothermal water is then returned down an injection well into the reservoir to be reheated, to maintain pressure, and to sustain the reservoir.

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## Credit:

Geothermal heat pump system  
graphic from Focus on Energy.  
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Publication REN2004-0602  
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## There are three kinds of geothermal power plants:

- A “dry” steam reservoir produces steam but very little water. The steam is piped directly into a “dry” steam power plant to provide the force to spin the turbine generator. The largest dry steam field in the world is The Geysers, about 90 miles north of San Francisco. Production of electricity started at The Geysers in 1960, at what has become one of the most successful alternative energy projects in history.
- A geothermal reservoir that produces mostly hot water is called a “hot water reservoir” and is used in a “flash” power plant. Water ranging in temperature from 300 - 700 degrees F is brought up to the surface through the production well where, upon being released from the pressure of the deep reservoir, some of the water flashes into steam in a separator. The steam then powers the turbines.
- A reservoir with temperatures between 250 - 360 degrees F is not hot enough to flash enough steam but can still be used to produce electricity in a “binary” power plant. In a binary system the geothermal water is passed through a heat exchanger, where its heat is transferred into a second (binary) liquid, such as isopentane, that boils at a lower temperature than water. When heated, the binary liquid flashes to vapor, which, like steam, expands across and spins the turbine blades. The vapor is then recondensed to a liquid and is reused repeatedly. In this closed loop cycle, there are no emissions to the air.

Since the first geothermally-generated electricity in the world was produced at Larderello, Italy, in 1904, the use of geothermal energy for electricity has grown worldwide to about 7,000 megawatts in twenty-one countries around the world. The United States alone produces 2700 megawatts of electricity from geothermal energy, electricity comparable to burning sixty million barrels of oil each year.

## Other Uses

Geothermal water is used around the world, even when it is not hot enough to generate electricity. Any time geothermal water or heat are used directly, less electricity is used. Using geothermal water directly conserves energy and replaces the use of polluting energy resources with clean ones. The main non-electric ways geothermal energy is used are direct uses and geothermal heat pumps.

Direct uses of geothermal waters ranging from 50 degrees F to over 300 degrees F include health spas, greenhouses, aquaculture, and milk pasteurization. These waters can also be used in the space heating of individual buildings and of entire districts. Geothermal district heating systems pump geothermal water through a heat exchanger, where it transfers its heat to clean city water that is piped to buildings in the district. There, a second heat exchanger transfers the heat to the building’s heating system. The geothermal water is injected down a well back into the reservoir to be heated and used again. The first modern district heating system was developed in Boise, Idaho. In the western U.S. there are 271 communities with geothermal resources available for this use. Modern district heating systems also serve homes in Russia, China, France, Sweden, Hungary, Romania, and Japan. The world’s largest district heating system is in Reykjavik, Iceland. Since it started using geothermal energy as its main source of heat Reykjavik, once very polluted, has become one of the cleanest cities in the world.

## Effects

The environmental impacts of direct uses of geothermal energy and geothermal heat pumps are minimal. The average home built in Wisconsin has sufficient yard space to accommodate the pipes needed for a geothermal system. However, geothermal energy is not available and/or feasible in all areas and there are some concerns about indoor air

quality. With open loop systems, there is the chance that geothermal systems can pollute groundwater resources in open systems. Finally, low temperature geothermal systems are more efficient in the cooling cycle.

Using geothermal energy to generate electricity has more negative environmental effects. Heat and fluid extraction from geothermal reservoirs can deplete the existence of geysers and surface hot springs, thereby hindering ecosystems that depend on the unique characteristics of these for survival. Subterranean extraction of heat and fluid can also cause land subsidence, much like the extraction of groundwater. Certain natural substances, such as arsenic, boron, and mercury, are sometimes present in the water released from geothermal cooling towers. Additionally, carbon dioxide, a greenhouse gas, is released from geothermal cooling towers. However, this release of carbon dioxide is less than one-tenth the amount that would be released from a fossil fuel electrical generation facility of similar capacity.

## Outlook

Thousands more megawatts of power than are currently being produced could be developed from already-identified geothermal resources. With improvements in technology, much more power will become available. The outlook for geothermal energy use depends on at least three factors: the demand for energy in general; the inventory of available geothermal resources; and the competitive position of geothermal among other energy sources. The inventory of accessible geothermal energy is sizable. Using current technology geothermal energy from already-identified reservoirs can contribute as much as 10% of the United States energy supply. And with more exploration, the inventory can become larger. The geothermal resource base becomes more available as methods and technologies for accessing it are improved through research and experience.

