Geothermal Energy

Definition of Geothermal Energy

Geothermal energy is heat extracted from the Earth's interior.

The term originates from two Greek roots: the word *geo* which means "earth" and the word *thermos* which means "heat."

How is geothermal energy obtained?

The temperature increases with depth in the Earth, a value called the geothermal gradient. Beneath stable continents the gradient is ordinarily 30˚C/km, however, in active tectonic areas it can be as high as 100˚C/km. Ground water circulating underground through the hot rocks is heated. Very deep wells can be drilled to access the steam and water from these sources. In some places there is molten rock, called *magma*, which is extremely hot. Once brought to the surface, the energy can be used as heat or to generate electricity, or to heat buildings. Geothermal energy also can come from shallow ground, although the temperature is the lower.

What is geothermal energy used for?

Geothermal energy is used for electricity generation. It is also used as a form of direct heat.

Brief History of Geothermal Energy

Many centuries ago, people began using the naturally heated water from the Earth for bathing. Today, we convert the Earth's naturally heated water into electricity.

Bathing

Since Paleolithic times, geothermal energy has been used for bathing. People used natural hot springs for warmth and cleansing. Minerals in the water were considered a source of healing. Pictured above is the oldest known hot spring pool. It was built in China during the 3rd century BC.

Heating

During the first century AD, Romans started using hot spring water to feed public bath houses. During the 14th century, the commune of Chaudes-Aigues in France—known as a spa town—started using hot spring water not only to heat their spas but also to heat their houses.

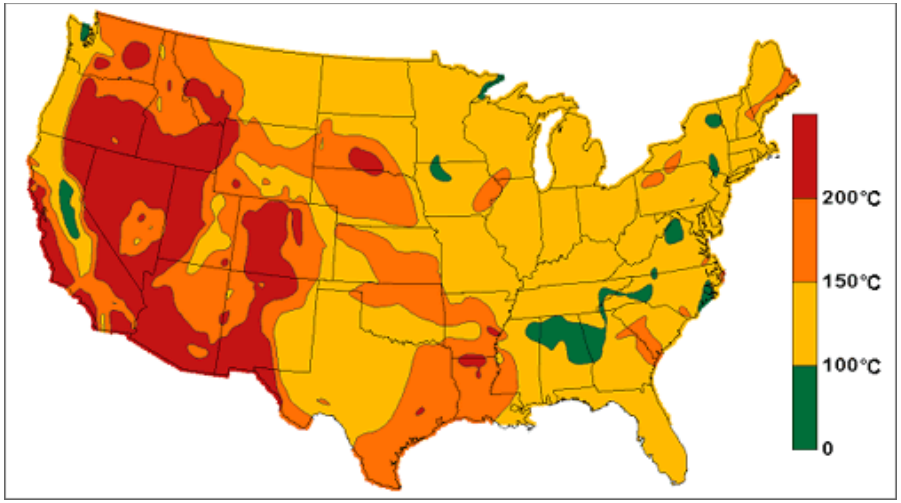
Electricity

At the beginning of the 20th century, people experimented with geothermal power of a source of electricity. In 1904, the first geothermal power demonstration was conducted at the Larderello dry steam field in Italy. By 1911, the world's first power geothermal power plant was built there. It would remain the only industrial plant until 1958 when New Zealand built their first plant.

A Global and Local Look at Geothermal Activity

The Earth's crust is made up of large surfaces called *tectonic plates*.
The most geothermal activity occurs where these plates comes together because this is where magma nears the surface, which also makes volcanoes in these areas.

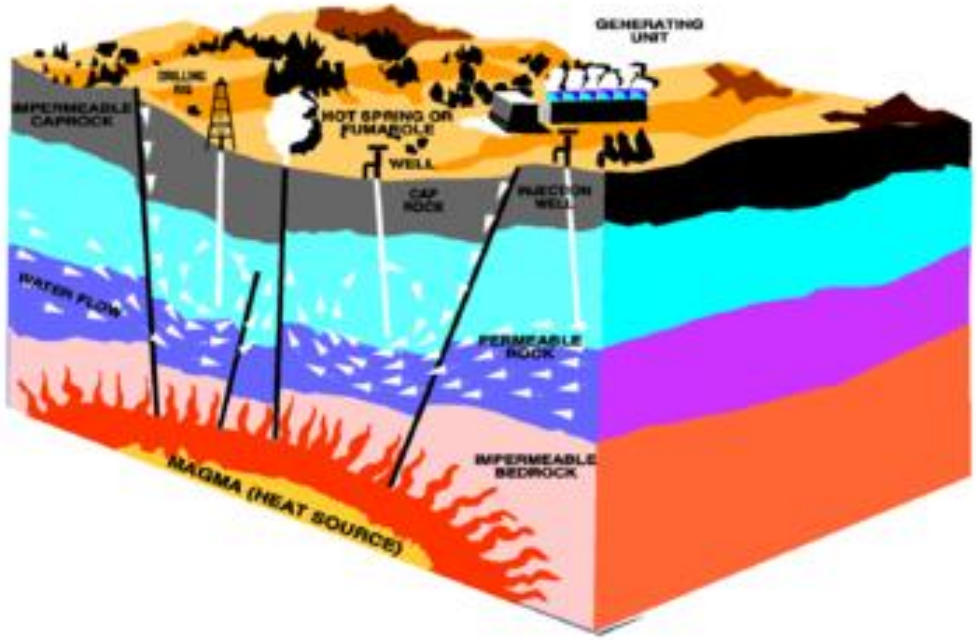
On the world map, most geothermal activity is located along the coasts of major continents. As of 2005, 24 countries were generating electricity using geothermal resources. The U.S. generates the most geothermal electricity.



In the U.S., most geothermal activity is located in the west, along with Alaska and Hawaii. Of states that have geothermal resources, California generates the most electricity with its 34 power plants. It's also home to the world's largest dry steam power plant, The Geysers.

Delving into Geothermal Activity

The Earth has an internal heat which is due mostly to the radioactive decay of minerals inside the Earth's core.



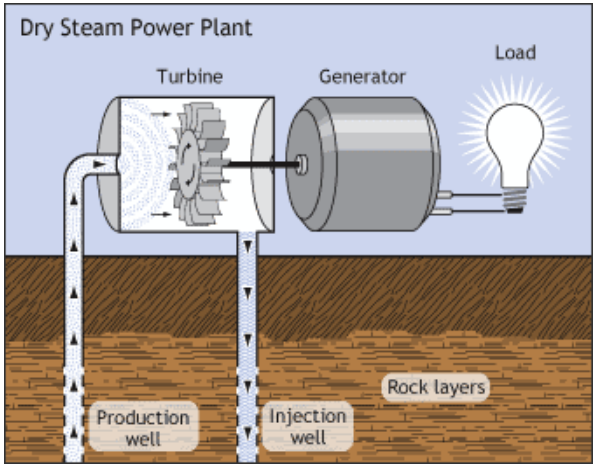
Under the earth's surface, scientists have found reservoirs that contain hot water or steam. The deeper the reservoir is, the hotter the water it contains. As water heats up, it can become hot enough to rise to the surface.

By drilling into these reservoirs, it allows the pressurized water to get to the surface. Geothermal power plants are built in these areas so they can utilize the hot water rising to the surface.

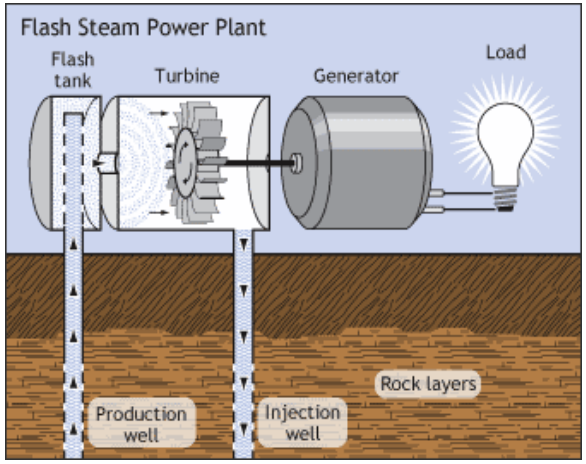
The rate at which the temperature increases with depth is the *geothermal gradient*. It quantifies how much heat is coming from the Earth's interior. Power plants are built in areas with high geothermal gradients.

Geothermal Power Plants

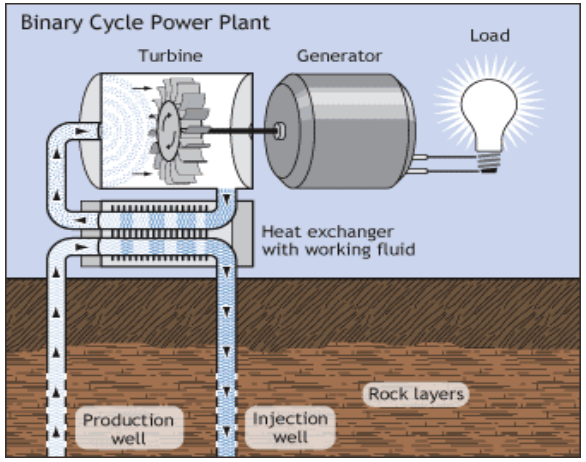
At a geothermal power plant, geothermal energy is used to turn a turbine which enables the generator to produce electricity. There are three types of geothermal power plants operating today.



The earliest design for a geothermal power plant is the dry steam power plant. Still used today, the dry steam power plant uses the steam directly from the underground geothermal reservoir, or *well*. The steam comes up from the well and turns the turbine.



The most common design for today's geothermal power plants is the flash steam power plant. They extract very hot water from underground wells and pump it to the surface under high pressure. The hot water is converted to steam which turns the turbine.



If the temperature of the underground water is less than 350°F, then a binary cycle power plant is used. Water is pumped to the surface so it can heat another fluid that has a lower boiling point, like a hydrocarbon. Steam from the second fluid is used to turn the turbine.

Direct Use of Geothermal Energy

Direct use of geothermal energy involves piping hot groundwater from near the Earth's surface directly into a place where it can be used.

Building Heating

In place of traditional heating systems, some individual buildings and even blocks of buildings use direct geothermal energy to heat up the buildings. Hot water is distributed through pipes in the building. This 800,000 square foot shopping center is heated with geothermal energy.

Greenhouses and Fish Farming

Vegetables, flowers and all kinds of plants are now being grown in greenhouses that are heated with direct geothermal energy. By using geothermal heat, greenhouse operators can save on fuel costs. Fish farmers have also found it effective to use geothermal heat to warm the waters for their fish.

Commercial and Industrial Uses

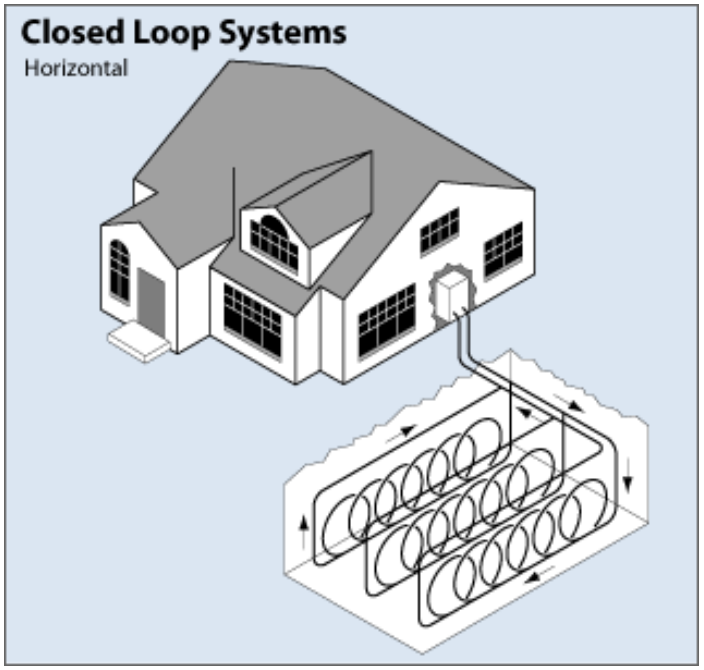
Spa resorts opted in for one of the earliest commercial uses of geothermal – to heat their pools. Many industries have also found effective ways to use direct geothermal energy. Today, geothermal heat is used to dehydrate food, to pasteurize milk, to do laundry, and more.

DID YOU KNOW?

- Some cities pipe hot groundwater under roads and sidewalks to melt snow.
- Energy intensive industries—such as aluminum procession—are built where geothermal power is available, e.g. Alcoa in Iceland.
- Iceland heats most of its homes with geothermal power and produces much of its electricity this way.

Geothermal Heat Pumps

Almost everywhere in the world, the 10 feet of earth just below the surface has a constant temperature around 50 to 60°F. Geothermal heat pumps utilize this shallow ground energy for heating and cooling buildings.

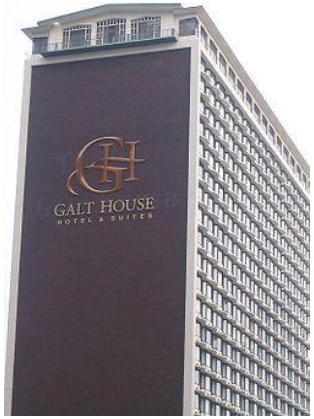


The geothermal heat pump system includes underground piping filled with liquid buried in shallow earth near the building. There is also a heat exchanger and the ductwork to connect it all together.

In the winter, when the air temperature is lower than the ground temperature, the system draws heat from the ground into the building.

In the summer, when the air temperature is higher than the ground temperature, the system uses the ground to help dissipate heat from the building. The system pulls the hot air from the building underground to a relatively cooler temperature. Some systems even use the extra heat to deliver hot water back to the building.

DID YOU KNOW?



The Galt House Hotel in Louisville, Kentucky has one of the largest geothermal heat pump systems in the world.

Benefits and Challenges of Geothermal Energy

BENEFITS

Geothermal energy offers significant benefits, which include:

- Building and using geothermal power plants has a very low impact on the environment. A few acres of land may be used, with some minor industrial looking buildings built on the area.
- Once produced, geothermal energy is nearly completely non-polluting. The energy is technically renewable and can be used as direct power source.
- Geothermal power plants are environmentally-friendly and leave few carbon footprints. The power plants generally do not expel pollutants into the air and they do not dump the extracted water somewhere on the surface.
- Geothermal power plants are relatively inexpensive to operate.
- Geothermal power plants are efficient and have a low environmental impact, making them good investments in the long run.
- Generally, the water drawn from the Earth is injected back down to resupply the source.

CHALLENGES

There are challenges to using geothermal energy, which include:

- Geothermal energy is available from only certain regions on the planet.
- Initial drilling costs are expensive and the process is complex. The plants cost around $100 million dollars to build.
- Hot rocks must be managed well or the water can cool the rocks.
- Open system plants expel hydrogen sulfide, trace amounts of arsenic and other minerals, but the amount is very little and is not a major concern.