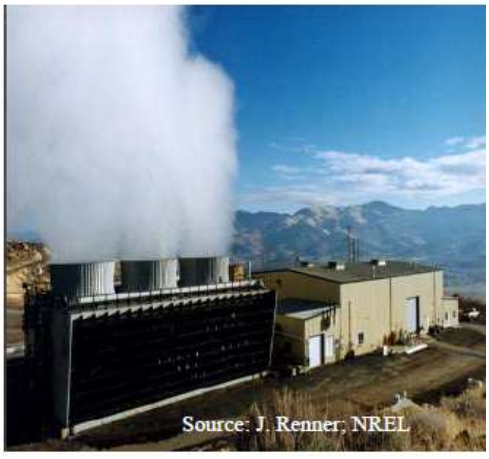
Energy Producing Systems: Geothermal Power

Geothermal energy systems use **thermal energy** from the interior of the Earth as a source of power. The word *geothermal* comes from Greek words *geo* (Earth) and *therme* (heat). The center of our planet is extremely hot, reaching temperatures of 7,000 to 12,000 degrees Fahrenheit. This heat is primarily the result of the slow radioactive decay of heavy elements at the Earth's core. Only the very surface of our planet has cooled enough to form the crust we live on. This crust is typically anywhere from three to 35 miles thick and below the crust exists the mantle, made of partially molten magma (melted rock) and reaching temperatures of 1,000-2,000 degrees Fahrenheit. This heat becomes available near the surface at areas where thermal conduction and intrusion of molten magna into unusually thin sections of the Earth's crust occurs. Such geothermal zones often give rise to naturally occurring surface features such as hot springs, geysers and volcanoes. High temperature geothermal zones offer a ready source of heat that can be used to generate **electrical power**. Lower temperature geothermal resources can be used for various applications such as heating buildings, drying crops, year-round greenhouses or heating water for fish-farming activities.

Geothermal heat pumps and Earth contact homes represent another type of geothermal energy system that does not rely on the location of nearby geothermally active zones. These systems take advantage of the stable temperatures found everywhere in the Earth's crust just 10-15 feet below the surface. At these shallow depths the ground has a temperature close to the average temperature of the region. In Missouri, this is 50 to 60 degrees Fahrenheit. Geothermal heat pumps and Earth contact homes take advantage of these stable temperatures in order to reduce the energy required to heat or cool buildings.

Types of Geothermal Systems

Hydrothermal Systems



Hydrothermal energy systems take advantage of groundwater that has been heated by geothermal activity. In some locations water comes directly to the surface as steam and can be routed to a **turbine** system used to generate electricity. These types of geothermal power plants are classified as *Dry Steam* power systems. The Geysers geothermal field in California uses dry steam and is currently the world's most developed field in the world supporting 15 plants.

In other geothermal locations the groundwater is located in deep underground reservoirs where it is heated to very high temperatures (400 degrees Fahrenheit) and is under immense pressure. At such sites a production well can be drilled and the high pressure water sprayed into an expansion tank where it turns to steam. The resulting steam is then used to drive turbine systems to generate electrical power. These types of hydrothermal systems are classified as *flash steam* power plants.

In some locations the available hydrothermal resources present more moderate temperatures. In these locations *binary cycle* systems can be used. A binary cycle plant passes the geothermal water through a loop called a heat exchanger and the thermal energy is transferred to a working fluid (usually isobutane) that boils at a low temperature. The vapor from the working fluid is then used to drive turbine systems and generate electrical power.

Source: W. Gretz, National Renewable Energy Laboratory

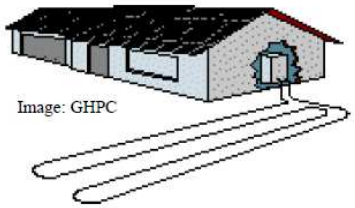
Direct Use

In many locations hot ground water is close to the surface, but not at temperatures sufficient for utility power production. Such water can still be used for so-called **geothermal direct use** applications such as providing heat to greenhouses and allowing the production of flowers, vegetables and other crops all year round. At one time, thermal water provides 80 percent of the energy used by vegetable farmers in Hungary.

Recently several fish-farming operations have begun to take advantage of geothermal water. The warm water is used to speed the growth of fish, shellfish and, in some cases, even reptiles. Utah, Oregon and California have geo-fish-farmers that produce catfish, trout, alligators and tilapia. Low temperature geothermal heat can also be used for industrial applications such as drying fish, fruits, vegetables and other products. Geothermally heated water has been piped under sidewalks and streets to prevent freezing in the winter and has been used to heat both commercial and residential buildings. It was once estimated that close to 300 communities in the United States are near geothermal reservoirs that could be developed to provide the majority of community heating needs.

Heat Pumps

Geothermal heat pump systems do not produce energy directly, however they greatly reduce the amount of energy required for commercial and residential heating and cooling. The approach takes advantage of the consistent temperatures found just ten to fifteen feet underground.



For heat pumps, plumbing for a ground heat exchanger is buried under or next to the structure to be heated and cooled. A carrier fluid is then pumped through the length of the exchanger and cycled through the main heating and cooling unit. This creates a thermal starting point from which to generate hot air in winter or cool air in summer. In the winter a ground source heat pump does not have to overcome the cold winter air to provide inside heating. Conversely, in summer the system uses the cooler ground temperature as a starting point for providing cooled air rather than attempting to cool the hot summer air, as would a conventional air conditioner. These systems are mechanically simpler and therefore more reliable, with lower maintenance costs than traditional heating and cooling systems. Ground source heat pumps can reduce energy consumption for heating and cooling by as much as 30 to 60 percent. This can amount to a significant saving as heating and cooling is often the largest energy cost associated with commercial or residential building use.

The Galt House East Hotel and Waterfront Office Building complex in Louisville, Kentucky uses one of the world's largest geothermal heat pump. The system was less expensive to install than a conventional heating and cooling system and saves the 750,000 square-foot hotel an estimated $25,000 a month in heating and cooling costs. Such systems can be applied to almost any location in the world. The U.S. Environmental Protection Agency has rated geothermal heat pumps the most efficient and least polluting heating and cooling system available.

Where are Geothermal Resources Available?

Geothermal heat pump systems and Earth contact homes are applicable anywhere in the United States. In areas with hard bedrock, vertical systems can be installed in drilled wells, etc. Large-scale utility level geothermal electrical plants do require the presence of specific geothermal features. These geological features are found predominantly throughout the western United States.

Earth Contact Homes

Image: McFadden, Pamm

A simple way to take advantage of the Earth's stable temperatures is to build an Earth contact home. In such cases one or more sides of the home and its foundation are built in contact with the Earth by digging in part of the building or pushing soil up to the side of the structure. A walk out basement is a simple form of Earth contact design. Earth contact homes take advantage of the Earth as a heat-sink and as a result such homes are easier to heat in winter and to cool in summer.

Characteristics of Geothermal Power

Geothermal electrical power is an extremely reliable source of energy. Power plants driven by geothermal power have historically much better service records than other electrical power sources. Geothermal energy systems represent a renewable, long-term source of power. These systems are **combustion**-free producing very low emission levels and avoiding the problems of acid rain, green house gas emissions and other pollutants associated with **fossil fuel** based systems.

Twenty-four countries use geothermal power systems. The development of geothermal power systems is growing by about five percent every year. Even in locations where hydrothermal activity is not available, geothermal heat pumps are still applicable.

Geothermal power is a proven energy system. The Geysers Geothermal Field in northern California has been in commercial operation now for more than 55 years. Geothermal power can be utilized 24-hours a day making it an ideal power source to complement other intermittent energy sources such as solar or wind power. Development of geothermal power systems promotes reductions in fossil fuel use and increases U.S. reliance on domestically produced sources of power.

The Future of Geothermal Energy in Missouri

In 2015 the U.S. produced 16.8 million megawatt hours of electricity using geothermal energy—roughly .4 percent of U.S. electricity production. Conversely, more than 40 percent of electrical power in El Salvador is planned to come from geothermal power by 2020, and Iceland heats 90 percent of its homes using geothermal power. Only a small fraction of the worldwide geothermal potential has been developed. While the state of Missouri does not possess geothermal resources applicable for use in generation of utility-grade electricity or for direct geothermal applications, Missouri is ideally suited for geothermal heat pump and Earth contact home applications. We experience several hot summer months and long cool winters. Geothermal heat pumps could save as much as 60 percent on utility bills associated with heating and cooling a typical Missouri home. The state of Missouri currently derives the overwhelming majority of its **electrical energy** from **coal**-fired plants. Ground source heat pumps could reduce the amount of energy currently required from coal and thereby reduce the environmental effects of coal use. The very earth below our feet has the potential to help provide the world with clean energy sources well into the future and to help significantly reduce the amount of energy we consume.

Glossary of Terms

Coal: A solid fossil fuel mined from the Earth's surface and underground which is often used to produce electricity through combustion. There are several different qualities of coal including anthracite, bituminous, and lignite

Combustion: A high-temperature chemical reaction resulting from the combination of a fuel with oxygen which releases carbon dioxide and water mixed with other substances (smoke) as well as thermal and light energy

Electrical energy: Kinetic energy as a result of moving electrons

Electrical power: Electrical energy used to conduct work; the measure of the rate of electrical energy used by a circuit. This is usually measured using a unit called a Watt (W)

Fossil fuels: Highly combustible substances generally found underground that were formed as the result of high levels of heat and pressure on decaying organic matter from millions of years ago. Fossil fuels include liquid oil, solid coal, and gaseous natural gas and are often burned to generate energy and power

Geothermal direct use systems: Geothermal energy systems which are located near geothermally heated water not hot enough for utility scale hydrothermal energy systems, but warm enough to heat small areas, provide hot water, and for agricultural uses. Not as available as geothermal heat pump systems, but more available than hydrothermal energy systems

Geothermal energy systems: The utilization of the constant temperature of the Earth's crust to heat water and air as well as warmer temperatures deeper underground which can be used to heat water to steam to operate **turbines** and general electrical power. Can be used in the form of hydrothermal, direct use, or heat pump systems

G**eothermal heat pump systems**: Geothermal systems which use the constant temperature of the Earth's crust to assist in heating and cooling water and even air in underground pumps. This type of geothermal system is available almost anywhere

Hydrothermal energy systems: The most effective geothermal systems which utilize water heated sometimes already to steam by very warm temperatures underground. The steam from these systems is used directly to drive turbines to generate electrical power or very warm water can be used heat a working fluid which then vaporizes and operate the turbine. Hydrothermal systems are only available in very geothermally active areas

Thermal energy: Kinetic energy associated with the movement of molecules; commonly produced from combustion. Heat is the transfer of thermal energy from bodies of higher kinetic energy to lower kinetic energy

Turbine: A device which harnesses the kinetic energy of an incoming force (often steam, water, or air) to spin rotors and create mechanical power. In electrical power generation the spinning motion of turbine rotors is used to turn generators which use rotating magnets inside copper wire to create an electrical current

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