

# GEOTHERMAL ENERGY



## **WHAT DOES THE WORD "GEOTHERMAL" MEAN?**

"Geothermal" comes from the Greek words *geo* (earth) and *thermal* (heat). So, geothermal means earth heat.

## **WHAT IS GEOTHERMAL ENERGY?**

Our earth's interior - like the sun - provides heat energy from nature. This heat - geothermal energy - yields warmth and power that we can use without polluting the environment.

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.

## **HOW DOES GEOTHERMAL HEAT GET UP TO EARTH'S SURFACE?**

The heat from the earth's core continuously flows outward. It transfers (conducts) to the surrounding layer of rock, the *mantle*. When temperatures and pressures become high enough, some mantle rock melts, becoming *magma*. Then, because it is lighter (less dense) than the surrounding rock, the *magma rises (convects), moving slowly up toward the earth's crust, carrying the heat from below.*

Sometimes the hot magma reaches all the way to the surface, where we know it as lava. But most often the magma remains below earth's crust, heating nearby rock and water (rainwater that has seeped deep into the earth) - sometimes as hot as 700 degrees F. Some of this hot geothermal water travels back up through faults and cracks and reaches the earth's surface as *hot springs* or *geysers*, but most of it stays deep underground, trapped in cracks and porous rock. This natural collection of hot water is called a *geothermal reservoir*.

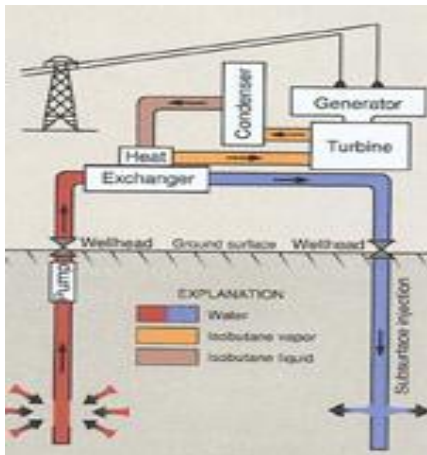
## HOW HAVE PEOPLE USED GEOTHERMAL ENERGY IN THE PAST?

From earliest times, people have used geothermal water that flowed freely from the earth's surface as hot springs. The oldest and most common use was, of course, just relaxing in the comforting warm waters. But eventually, this "magic water" was used (and still is) in other creative ways. The Romans, for example, used geothermal water to treat eye and skin disease and, at Pompeii, to heat buildings. As early as 10,000 years ago, Native Americans used hot springs water for cooking and medicine. For centuries the Maoris of New Zealand have cooked "geothermally," and, since the 1960s, France has been heating up to 200,000 homes using geothermal water.

## HOW DO WE USE GEOTHERMAL ENERGY TODAY?

Today we 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 we'll 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.*

## HOW IS ELECTRICITY GENERATED USING GEOTHERMAL ENERGY?



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. There are three kinds of *geothermal power plants*. The kind we build depends on the temperatures and pressures of a reservoir.

1) 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 the most successful alternative energy project in history.

2) 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.

3) 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.

### **WHAT ARE SOME OF THE ADVANTAGES OF USING GEOTHERMAL ENERGY TO GENERATE ELECTRICITY?**

- *Clean.* Geothermal power plants, like wind and solar power plants, do not have to burn fuels to manufacture steam to turn the turbines. Generating electricity with geothermal energy helps to conserve non-renewable fossil fuels, and by decreasing the use of these fuels, we reduce emissions that harm our atmosphere. There is no smoky air around geothermal power plants -- in fact some are built in the middle of farm crops and forests, and share land with cattle and local wildlife. For ten years, Lake County California, home to five geothermal electric power plants, has been the first and only county to meet the most stringent governmental air quality standards in the U.S.
- *Easy on the land.* The land area required for geothermal power plants is smaller per megawatt than for almost every other type of power plant. Geothermal installations don't require damming of rivers or harvesting of forests -- and there are no mine shafts, tunnels, open pits, waste heaps or oil spills.
- *Reliable.* Geothermal power plants are designed to run 24 hours a day, all year. A geothermal power plant sits right on top of its fuel source. It is resistant to interruptions of power generation due to weather, natural disasters or political rifts that can interrupt transportation of fuels.
- *Flexible.* Geothermal power plants can have modular designs, with additional units installed in increments when needed to fit growing demand for electricity.
- *Keeps Dollars at Home.* Money does not have to be exported to import fuel for geothermal power plants. Geothermal "fuel" - like the sun and the wind - is always where the power plant is; economic benefits remain in the region and there are no fuel price shocks.
- *Helps Developing Countries Grow.* Geothermal projects can offer all of the above benefits to help developing countries grow without pollution. And installations in remote locations can raise the standard of living and quality of life by bringing electricity to people far from "electrified" population centers.

## HOW MUCH ELECTRICITY IS FROM GEOTHERMAL ENERGY?

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.

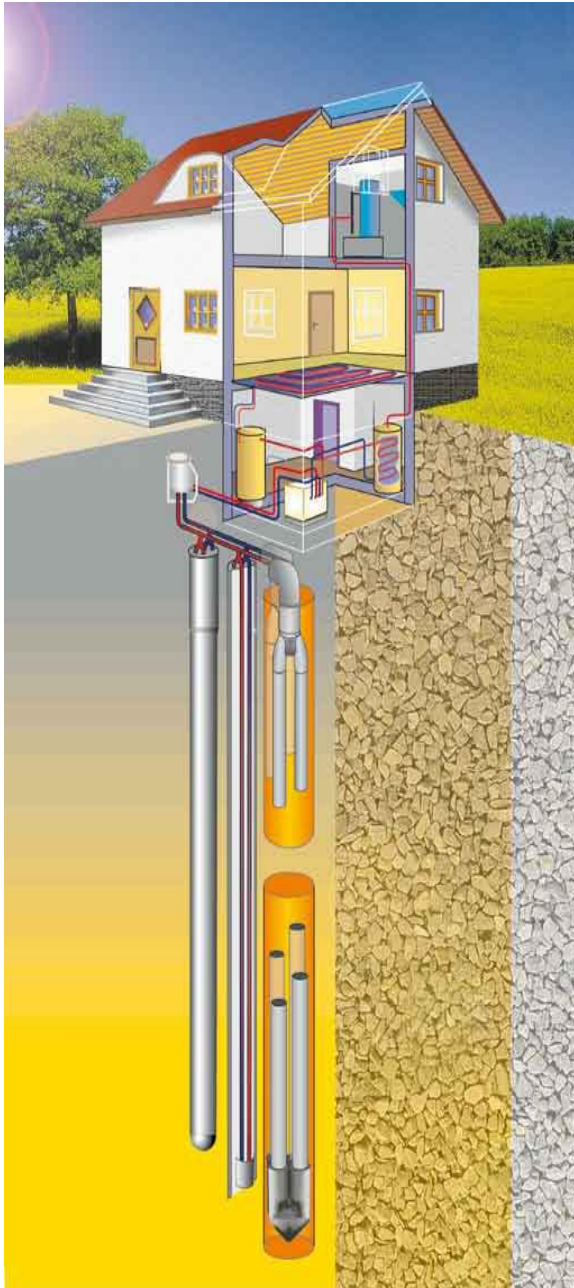
## WHAT ARE SOME NON-ELECTRIC WAYS WE CAN USE GEOTHERMAL ENERGY?

Geothermal water is used around the world, even when it is not hot enough to generate electricity. Anytime 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 we use geothermal energy are DIRECT USES and GEOTHERMAL HEAT PUMPS.

**DIRECT USES** Geothermal waters ranging from 50 degrees F to over 300 degrees F, are used directly from the earth:

- 'to soothe aching muscles in hot springs, and health spas (*balneology*);
- to help grow flowers, vegetables, and other crops in greenhouses while snow-drifts pile up outside (*agriculture*);
- to shorten the time needed for growing fish, shrimp, abalone and alligators to maturity (*aquaculture*);
- to pasteurize milk, to dry onions and lumber and to wash wool (*industrial uses*);
- *Space heating* of individual buildings and of entire districts, is - besides hot spring bathing - the most common and the oldest direct use of nature's hot water. 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. Geothermal heat is being used in some creative ways; its use is limited only by our ingenuity. For example, in Klamath Falls, Oregon, which has one of the largest district heating systems in the U.S., geothermal water is also piped under roads and sidewalks to keep them from icing over in freezing weather. The cost of using any other method to keep hot water running continuously through cold pipes would be prohibitive. And in New Mexico and other places rows of pipes carrying geothermal water have been installed under soil, where flowers or vegetables are growing. This ensures that the ground does not freeze, providing a longer growing season and overall faster growth of agricultural products that are not protected by the shelter and warmth of a greenhouse.

## GEOHERMAL HEAT PUMPS



Animals have always known to burrow into the earth, where the temperature is relatively stable compared to the air temperature, to get shelter from winter's cold and summer's heat. People, too, have sought relief from bad weather in earth's caves. Today, with geothermal heat pumps (GHP's), we take advantage of this stable earth temperature - about 45 - 58 degrees F just a few feet below the surface - to help keep our indoor temperatures comfortable. GHP's 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.

*Heating:* Earth's heat (the difference between the 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.

*Cooling:* 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.

GHP's use very little electricity and are very easy on the environment.

In the U.S., the temperature inside over 300,000 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 GHP's as among the most efficient of heating and cooling technologies