GEOTHERMAL POWER

Geothermal power is energy generated by the heat stored in Earth. The first geothermal generator was tested on July 4th, 1904, in Italy. The largest group of geothermal power plants in the world is located in The Geysers, a geothermal field in California. As of 2008, geothermal power supplies less than 1% of the world's energy.

The temperature within Earth increases with increasing depth. Partially molten rock at temperatures between 1,200 and 2,200° F is thought to exist everywhere beneath Earth's surface at depths of 50 to 60 miles. The temperature at Earth's center, nearly 4,000 miles deep, is estimated to be 5650 ± 600 kelvins.

Where does the heat come from? The heat within Earth is generated in a number of ways. Much of it is created by decay of naturally radioactive elements. An estimated 45 to 90 percent of the heat escaping from Earth originates this way. Heat may also be generated by tidal forces on Earth as it rotates. Heat might be released from the sinking of heavy metals as they descend to Earth's core, and some heat may be created by Earth's magnetic field.

Geothermal resources range from shallow ground to hot water and rock several miles below Earth's surface, and even further down to extremely hot magma. Wells over a mile deep can be drilled into underground reservoirs to tap steam and very hot water that can be brought to the surface for use in a variety of applications.

Geothermal technologies include:

- *Geothermal heat pump*: Almost everywhere, the upper 10 feet of Earth's surface has a nearly constant temperature between 50 and 60°F. A geothermal heat pump system consists of pipes buried in the shallow ground near a building, a heat exchanger, and ductwork into the building. In the winter, heat from the warmer ground goes through the heat exchanger into the house. In the summer, hot air from the house is pulled through the heat exchanger into the relatively cooler ground. Heat removed during the summer can be used to heat water.
- *Hot water* near Earth's surface can be piped directly into facilities and used to heat buildings, grow plants in greenhouses, and other uses. Some cities pipe the hot water under roads and sidewalks to melt snow. District heating applications use networks of piped hot water to heat buildings in whole communities.
- *Hot dry rock geothermal energy*: Using deep wells into hot rock, a fluid is heated and used to generate power. Dry steam plants directly use geothermal steam to turn turbines. Flash steam plants pull deep, high-pressure hot water into lower-pressure tanks and use the resulting flashed steam to drive turbines. Binary-cycle plants pass moderately hot geothermal water by a secondary fluid with a much lower boiling point than water. This causes the secondary fluid to flash to vapor, which then drives the turbines.

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GEOTHERMAL POWER

Geothermal energy has some advantages over traditional fossil fuels. First, the heat source requires no purchase of fuel. Few pollutants are emitted. It is nearly sustainable because the heat extraction is small compared to the size of the heat reservoir, which may also receive some heat replenishment from greater depths. Geothermal power plants are unaffected by changing weather conditions and work continuously, day and night. This is an advantage over intermittent renewable power sources such as solar or wind. Geothermal energy is extremely price competitive in some areas and reduces reliance on fossil fuels and their inherent price unpredictability.

There are several environmental concerns. Construction of the power plants can adversely affect land stability in the surrounding region. This is mainly a concern with hot dry rock geothermal energy, where water is injected into hot dry rock where no water was before. Dry steam and flash steam power plants also emit low levels of pollutants, although at roughly 5% of the levels emitted by fossil fuel power plants. However, geothermal plants can be built with emissions-controlling systems that can inject these substances back into Earth, thereby reducing carbon emissions to less than 0.1% of those from fossil fuel power plants. Hot water from geothermal sources will contain trace amounts of dangerous elements such as mercury, arsenic, and antimony, which if disposed of into rivers can make their water unsafe to drink.

Although geothermal sites can provide heat for many decades, eventually specific locations may cool down. Some interpret this as meaning a specific geothermal location can undergo depletion, and question whether geothermal energy is truly renewable. Along with biomass, geothermal energy is one of the only two renewable energy sources which require careful management in order to avoid depletion. If left alone, however, these places will recover some of their lost heat, as the mantle has vast heat reserves. An assessment of the total potential for electricity production from the high-temperature geothermal fields in Iceland gives a value of about 1500 TWh (total) or 15 TWh per year over a 100 year period. The electricity production capacity from geothermal fields is now only 1.3 TWh per year.

A 2006 report by MIT concluded that it would be affordable to generate 100 GWe (gigawatts of electricity) or more by 2050 in the United States alone, for a maximum investment of 1 billion US dollars in research and development over 15 years.

Enhanced geothermal systems (EGS) is an experimental technology that reaches at least 10 km down into hard rock. At a typical site, two holes would be bored and the deep rock between them fractured. Water would be pumped down one and steam would come up the other. The MIT report estimated that there was enough energy in hard rocks 10 km below the United States to supply all the world's current needs for 30,000 years.

Drilling at this depth is now possible in the petroleum industry, albeit expensive. It costs tens of millions of dollars to drill holes to depths greater than four thousand meters. The technological challenges are to reduce these costs. Apart from the energy used to make the bores, the process releases no greenhouse gases.

Besides the United States, other important countries considered high in potential for development are the People's Republic of China, Hungary, Mexico, Iceland, Australia and New Zealand.

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