GEOTHERMAL

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What is Geothermal Energy?

The word *geothermal* comes from the Greek words *geo* (earth) and *therme* (heat). So, geothermal energy is heat from within the earth. In the simplest terms we can recover this heat as steam or hot water and use it to heat buildings or generate electricity.

Geothermal energy is a renewable energy source because the heat is continuously produced inside the earth.

Geothermal activity is constantly and naturally occurring around the world. Large areas of hydrothermal resources are called geothermal reservoirs. Most geothermal reservoirs are deep underground with no visible clues showing above ground. But geothermal energy sometimes finds its way to the surface in the form of:

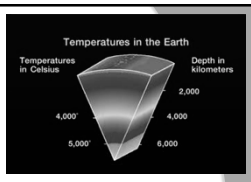
1. Volcanoes and fumaroles (holes where volcanic gases are released)
2. Hot springs
3. Geysers

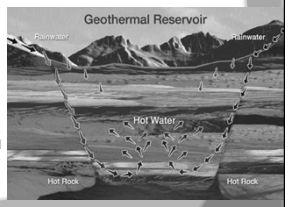
Brief History and Uses

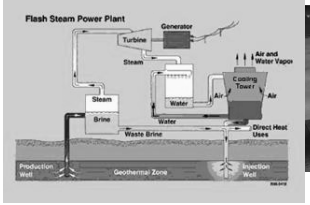
- The Romans used geothermal water to treat eye and skin disease and, at Pompeii, to heat buildings. Medieval wars were even fought over lands with hot springs. The first known "health spa" was established in 1326 in Belgium at natural hot springs. And for hundreds of years, Tuscany in Central Italy has produced vegetables in the winter from fields heated by natural steam

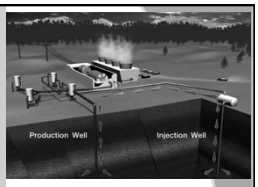
How it works

- A geothermal system requires heat, permeability, and water
- Natural collection of hot water is called a geothermal reservoir
- Wells are drilled into a geothermal reservoir. The wells bring the geothermal water to the surface, where its heat energy is converted into electricity at a geothermal power plant
- Geothermal Heat Pumps (GHPs) take advantage of the Earth's relatively constant temperature at depths of about 10-300 ft. GHPs can be used almost everywhere in the world. GHPs circulate water or other liquids through pipes buried in a continuous loop, either horizontally or vertically, under a landscaped area, parking lot, or any number of areas around the building. The EPA considers them to be one of the most efficient heating and cooling systems available.

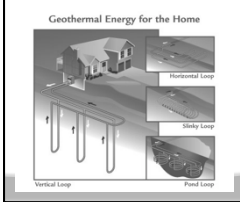


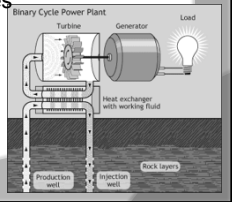




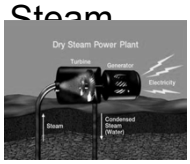


Examples

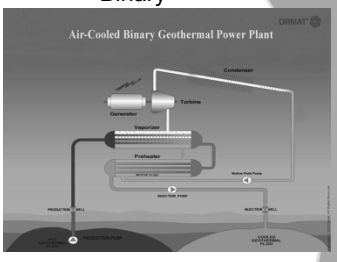




Dry Steam

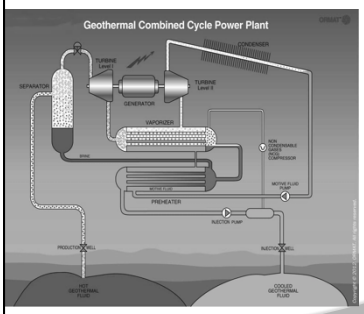


Binary



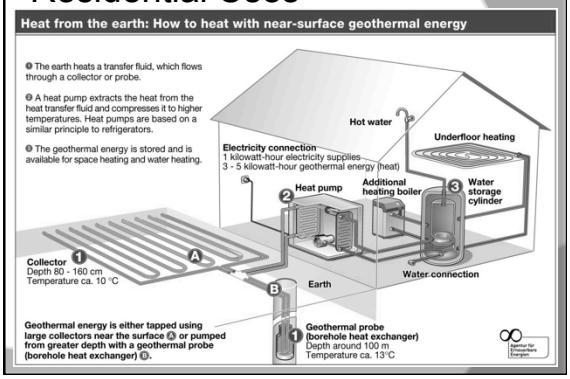
Geothermal fluid heats another liquid, such as isobutane or other organic fluids such as pentafluoropropane, which boils at a lower temperature than water. The two liquids are kept completely separate through the use of a heat exchanger, which transfers the heat energy from the geothermal water to the working fluid. The secondary fluid expands into gaseous vapor. The force of the expanding vapor, like steam, turns the turbines that power the generators. All of the produced geothermal water is injected back into the reservoir.

Flash/Binary Combined



Uses a combination of flash and binary technology, has been used effectively to take advantage of the benefits of both technologies. In this type of plant, the portion of the geothermal water which "flashes" to steam under reduced pressure is first converted to electricity with a backpressure steam turbine and the low-pressure steam exiting the backpressure turbine is condensed in a binary system.

Residential Uses



In the United States

- As of August 2008, almost 4,000 MW of new geothermal power plant capacity was under development in the U.S. (this includes projects in the initial development phases). Those states with projects currently under consideration or development are: Alaska, Arizona, California, Colorado, Florida, Hawaii, Idaho, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. Combined, these states have approximately 103 projects in development ranging from initial to advanced stages.
- Direct uses applications of geothermal energy occur today in 26 states—almost as many states as produce coal. New direct use projects are encouraged by the provisions of the Geothermal Steam Act Amendments passed by Congress in 2005. There is interest in new direct use projects in numerous states and on various Indian reservations within several states.
- Geothermal heat pump installations have been growing at an annual rate of 15 percent, with more than 600,000 units installed in the U.S. by the end of 2005. Every year in the U.S., 50,000 to 60,000 new units are installed—the largest growth in the world for geothermal heat pumps.

World Wide

- Geothermal energy supplies more than 10,000 MW to 24 countries worldwide and now produces enough electricity to meet the needs of 60 million people. The Philippines, which generates 23% of its electricity from geothermal energy, is the world's second biggest producer behind the U.S. Geothermal energy has helped developing countries such as Indonesia, the Philippines, Guatemala, Costa Rica, and Mexico.
- Iceland, a country of just over 300,000 people is now fully powered by renewable forms of energy, with 17% of electricity and 87% of heating needs provided by geothermal energy. In 2004, Iceland was reported to have generated 1465 gigawatt-hours (GWh) from geothermal resources; geothermal production is expected to reach 3000 GWh this year (2009).
- 21 Countries Generating Geothermal Power in 2000: Australia, China, Costa Rica, El Salvador, Ethiopia, France (Guadeloupe), Guatemala, Iceland, Indonesia, Italy, Japan, Kenya, Mexico, New Zealand, Nicaragua, Philippines, Portugal (Azores), Russia, Thailand, Turkey, United States
- 22 Potential New Countries by 2010 (for potential total of 46): Armenia, Canada, Chile, Djibouti, Dominica, Greece, Honduras, Hungary, India, Iran, Korea, Nevis, Rwanda, Slovakia, Solomon Islands, St. Lucia, Switzerland, Taiwan, Tanzania, Uganda, Vietnam, Yemen
- Geothermal electricity generation is likely to expand. According to the International Geothermal Association (IGA) in IGA News 72 (April–June 2008), total global geothermal capacity is expected to rise to 11 GW by 2010.
- In 2005, 72 countries reported using geothermal energy for direct heating, providing more than 16,000 MW of geothermal energy. Geothermal energy is used directly for a variety of purposes, including space heating, snow melting, aquaculture, greenhouse production, and more.

Future Potential In the US

- the Earth is considered limitless; its use is only limited by technology and the associated costs. Technology development and further studies are expected to show even greater potential, but here we have cited the first part of a new assessment released in September 2008 by the U.S. Geological Survey (USGS). The report focuses on 13 western states and breaks the geothermal estimate into three categories:
- In 2006, Massachusetts Institute of Technology prepared an analysis of the future geothermal potential in the U.S. The report estimated that geothermal systems could produce 100 GWe in the next 50 years with a reasonable investment in R&D.
- In 2006 the National Renewable Energy Laboratory released a report, Geothermal—The Energy Under Our Feet, which estimates domestic geothermal resources. The report estimates that 26,000 MW of geothermal power could be developed by 2015, with direct use and heat pumps contributing another 20,000 MW of thermal energy. The report suggests that by 2025 more than 100,000 MW of geothermal power could be in production, with direct use and heat pumps adding another 70,000 MW of thermal energy.

Future Potential Around the World

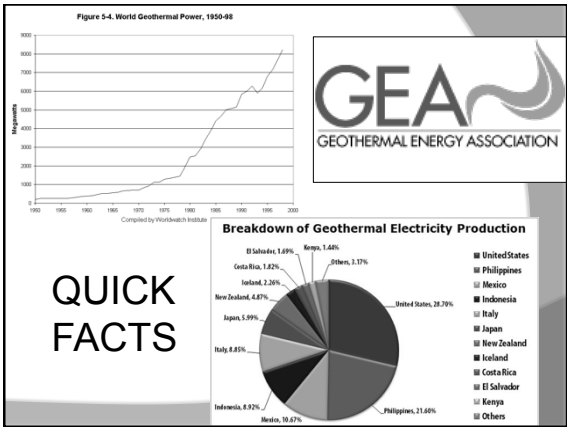
- There has not been a significant new analysis of international geothermal potential comparable to either the USGS report or the NREL report discussed above. A 1999 study that used fairly conservative assumptions about the resource base and technology concluded that geothermal resources using existing technology have the potential to support between 35,448 and 72,392 MW of worldwide electrical generation capacity. Using enhanced technology (defined as the technology expected to be available by 2009), the geothermal resources could support between 65,576 and 138,131 MW of electrical generation capacity. Assuming a 90% availability factor, which is well within the range experienced by geothermal power plants, this electric capacity could produce as much as 1,089 billion kWh of electricity annually. The estimates produced for world energy potential by this study did not assess the limits of geothermal resource base, nor the potential for new development with significantly different technologies, such as engineered geothermal systems.
- Another Estimate claims capacity will reach 28.6 gigawatts in 62 markets by 2030, compared with 11.4 GW in 25 markets in 2012.

Environmental Impacts

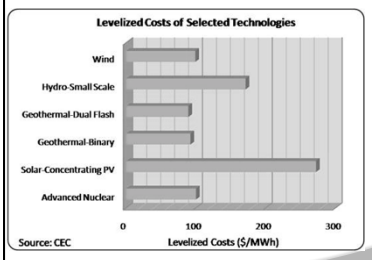
- Unlike fossil fuel power plants, no smoke is emitted from geothermal power plants, because no burning takes place; only steam is emitted from geothermal facilities. Emissions of nitrous oxide, hydrogen sulfide, sulfur dioxide, particulate matter, and carbon dioxide are extremely low, especially when compared to fossil fuel emissions. The binary geothermal plant, which currently represents around 15% of all geothermal plant capacity, along with the flash/binary plant, produce nearly zero air emissions. Even dry steam plants, which are considered to have the highest levels of air emissions, are considered environmentally benign compared with fossil fuels. At The Geysers, air quality has even improved as a result of geothermal development because hydrogen sulfide, which would ordinarily be released naturally into the atmosphere by hot springs and fumaroles, instead now passes through an abatement system that reduces hydrogen sulfide emissions by 99.9%
- a geothermal facility uses 404 m2 of land per gigawatt hour, while a coal facility uses 3632 m2 per gigawatt hour.
- Air cooled geothermal power plants do not consume any water. Geothermal plants that use water for cooling typically use geothermal water or steam condensate and not fresh water. Geothermal power plants could also produce potable water from geothermal condensate, and at least one such plant was designed recently for use in East Africa

Reducing power plant nitrogen emissions by one million tons and sulfur emissions by four million tons as of 2010 would mean:

- The number of related deaths would be reduced by 8714, with an associated healthcare savings of almost 53 million
- The number of related cases of chronic bronchitis would be reduced by 5997, with an associated healthcare savings of almost 2 million
- The number of related heart attacks would be reduced by 13,924, with an associated healthcare savings of almost 2 million because geothermal use



- On average the cost for new geothermal projects ranged from 6 tp 8 cents per kilowatt hour according to a 2006 report, including the production tax credit



Does the price of geothermal power fluctuate like the price of oil and gas?
No. Geothermal energy acts as a price stabilizer that offsets U.S. dependence upon highly volatile fossil fuel power markets. This is because geothermal power does not need outside fuel to operate—geothermal relies on a constant source of free fuel