# Geothermal Is the Answer

It is no secret that energy is an irreplaceable element of a successful economy and society. The diminishing supply of fossil fuels and the emerging effects of global warming create the need to find alternatives that allow us to maintain our high standard of living while protecting the environment. Geothermal energy is one viable, but often overlooked option. Geothermal energy is clean, renewable, flexible, and more affordable than many people may assume. The whole idea behind geothermal energy is to harness the stable, renewable energy trapped in the earth. This energy can then be used for a variety of tasks including heating and cooling buildings and driving a turbine to generate electricity. Increased utilization of geothermal energy is necessary to maintain our standard of living in an increasingly energy-hungry world. Through the exploration of the history, applications, benefits, drawbacks, environmental impact, and impact on fossil fuels, it will become evident that geothermal technology is the way of the future.

While it may come as a surprise, the use of geothermal energy is really not a recent development. Since the beginning of civilization, people have taken advantage of geothermal energy in the form of hot springs. Many civilizations regarded these natural wonders as sacred and communities often developed around them. The first use of geothermal energy in the home occurred in 1892, when people in Boise, Idaho, made a piping system to route water from a hot spring into a home. Before long, a system was constructed that served 200 homes and 40 businesses (U.S. Department of Energy, 2008). The first electricity-generating geothermal power plant was developed in 1921 by John D. Grant. The plant was successful and generated enough electricity to support a small resort community. Shortly later in 1926, Charlie Lieb developed the first downhole heat exchanger, which was used in conjunction with a 1000-foot-deep well to heat his home (U.S. Department of Energy, 2008). This advancement was followed by a dry spell for geothermal technology.

As oil emerged as a flexible and readily available fuel, geothermal technology took a back seat because of its cost and the lack of concern for the environment. The next advancement came in 1960 when the first large-scale geothermal power plant began operation. The turbine produced 11 megawatts of power and remained in operation for over 30 years. In the 1970s, geothermal energy started to regain attention as a source of residential climate control, but it took until the later 1990s for the technology to become efficient and affordable enough for mainstream use (U.S. Department of Energy, 2008). Throughout history, a variety of uses for geothermal energy have been developed, and in the future it is likely that several more will be found.

One of the several uses of geothermal energy is the generation of electricity. Right now, most of the electricity in the U.S. is produced by pollutant-emitting coal-burning power plants. Geothermal power plants produce little to no emissions since they use steam from the ground as an energy source. To access the hot water trapped in the earth, wells are drilled up to 16,000 feet deep. Several wells must be drilled and half of them are used to return the cooled water to the earth. The return wells prevent depletion of the aquifers. In other systems, a closed loop is utilized. Chemicals such as isopentane or isobutene are pumped through sealed pipes deep in the earth. The fluids in the pipe are heated by the hot water in the earth, but no water is actually removed. Since isobutene and isopentane vaporize easily, they can be used to drive a turbine and generate electricity ("Geothermal Well to Wheels," 2008).

Recent advances in turbine technology have decreased the necessary fluid temperature for operation from 400 degrees Fahrenheit to 200 degrees Fahrenheit (Fahey, 2008). This technological advance greatly increases the number of feasible sites for geothermal power plants. Recent estimates state that by 2050, geothermal power plants could provide 100 gigawatts of electricity (Fahey, 2008). To put this into perspective, one gigawatt is roughly the output of a large nuclear plant. Estimates put the cost of geothermal generated electricity at five cents per kilowatt-hour over the long term. Compare this to eight cents for natural gas, six cents for wind, and 31 cents per kilowatt-hour for solar energy (Fahey, 2008). The future definitely looks bright for geothermal electricity.

Another productive use of geothermal heat is for climate control of large buildings. Geothermal technology can provide many benefits for larger structures, such as schools or office buildings. The common configuration of these properties is well suited to geothermal systems because they typically have a large amount of space available for the borefield. The borefield is the area in which the heat exchange loops are drilled. The loops do not need to be nearly as deep as the loops found in electricity generating power plants. For climate control systems, the loops are typically about 300 feet deep, rather than 16,000 feet for geothermal power plants. The size of the borefield varies based on the heating and cooling demands of the structure it is servicing. The borefield can be split up into several smaller borefields if the situation requires (MacMillan, 2007). After installation of the borefield is complete, no visual evidence is left to show that a geothermal system is at work.

The borefield is then linked to heat pumps within the building. These pumps circulate fluid through the loops in the borefield with heat being exchanged between the ground and the fluid. In the winter, the fluid absorbs heat from the ground. The heat pump then transfers this heat to the air by using a heat exchanger, allowing the warm air to circulate throughout the building just like hot air from a furnace. In the summer, heat is transferred from the warm air to the ground. By the flip of a switch, the heat pump can function as a condenser. The cool fluid enters the pump from the ground loop and is pumped through the heat exchanger. When the warm air passes over the cool coil, the fluid absorbs the heat and the cool air is circulated throughout the building. The refrigerant passes back into the ground loop and the heat is released into the ground (Alliant Energy, 2008). The speed of the heat pump is automatically controlled to maintain a stable temperature and maximize efficiency.

Efficiency is only one of the many benefits of geothermal technology, although it is a rather convincing one. Schools that have invested in geothermal systems have reported a reduction in energy consumption by 25% to 50% compared to traditional systems (MacMillan, 2007). Geothermal systems can also supply hot water, which is an additional cost-reducing feature. Another benefit is the relatively compact size of the geothermal equipment. The necessary equipment takes up much less space than the boiler, circulating fans, air conditioning units, and other equipment associated with a typical climate control system. Along with taking up less space, the geothermal equipment is significantly quieter while in operation.

Geothermal systems are also designed to be highly modular. The benefits of using several smaller heat pumps are numerous. First of all, if one pump fails, only a small portion of the building will be affected and the non-functioning pump can be easily exchanged. If a furnace fails in a traditional system, often the entire building is affected and the repair is typically very expensive. Overall, geothermal technology is more reliable than conventional heating and cooling equipment (Wisconsin Geothermal Association, 2008). Very little maintenance is required, as most of the system is sealed. The piping system carries a warranty of up to 50 years. The same types of pipe and pipe joining methods have been safely used in the natural gas industry for over 30 years (Alliant Energy, 2008). Another benefit of the modular system is the capability of individual control. The heat pumps can be individually controlled to provide different levels of heating and cooling to different parts of the building. If only one part of the building is being utilized, the geothermal system has the capability to heat or cool only that specific part of the building (MacMillan, 2007). This feature is especially valuable for buildings such as schools or offices that may have occupancy in only certain parts of the building on weekends. While geothermal technology provides many benefits for large buildings, private homes can also benefit from a geothermal system.

Every year it seems that the cost to heat and cool the average home becomes a bigger part of the family budget. With energy prices constantly fluctuating, many people are looking for ways to cut their utility bills, and a geothermal system is a great way to accomplish this. Geothermal technology can provide many of the same benefits for homes as it provides for larger structures. When installing a geothermal system, consumers have a couple of options. The first possibility is an open loop system. This system consists of a deep well that is used to pump ground water directly into the interior heat pump. Water is then discharged into a pound or a return well. The open loop system is generally cheaper to install, but it is also less reliable and poses some environmental issues such as aquifer pollution. A more popular choice is a closed loop system similar to one typically used in larger buildings. Depending on the size of the lot and the geological conditions, either a horizontal loop or a vertical loop can be installed.

The horizontal loop involves trenching the piping parallel to the surface at a depth of about four feet. This option tends to be the cheapest, but a larger amount of space is required (Alliant Energy, 2008). Homes can also take advantage of a vertical loop system. This system is very similar to what is typically used in larger buildings. Homes generally only require one heat pump.

Many of the benefits of a residential geothermal system are similar to those of a commercial system. Energy bills are typically reduced by anywhere from 25% to 50%. The system also supplies the home with hot water. Safety is another positive aspect of residential geothermal systems. Furnaces and other gas-burning appliances always have the possibility of leaking deadly carbon monoxide. This is not possible with a geothermal system. Also, geothermal systems are also much quieter than a furnace or air-conditioning unit.

Along with the many great benefits that geothermal systems have to offer, there are also a couple of drawbacks. The most common issue that deters people from geothermal technology is the cost. The initial startup cost of a geothermal system is somewhat of a hurdle, but with the savings on utility bills, this cost can generally be regained in a couple of years. According to Jim MacMillan (2007), geothermal systems result in “a typical payback period of two to eight years” (p. 34). This amount of time is just a very small fraction of the life of the system (Fell, 2003). Geothermal systems are almost always a positive investment in the long run. It should be noted that geothermal systems do require electricity to operate. However, thanks to technology like variable speed pumps, energy requirements are minimal.

Placement of the borefield is another drawback to geothermal systems. The horizontal loop is the cheapest borefield to install. However, this requires a significant amount of space and favorable geological conditions. If sufficient space is not available or if the soil is too rocky, then a vertical loop or open loop system must be used instead. The open loop system is the cheaper of the two options. As explained above, it consists of a source well and a return well. Ground water is used as the refrigerant fluid. This system also poses several issues. Minerals from the ground water can accumulate and clog the pipes and heat pump. The open loop system also increases the possibility of depletion or pollution of the aquifer. For these reasons, closed loop systems are most commonly installed today. These systems solve the reliability and environmental issues, but they do require more holes and therefore a larger borefield. After the borefield installation is complete, it remains hidden under the soil. However, the space the borefield occupies cannot be used for the construction of buildings or roadways, as the pressure would damage the pipes. Another concern associated with the borefield is that whenever piping is run under the ground, there is always the possibility of a leak. Geothermal systems use high-durability pipes and joining methods perfected in natural gas distribution, so the system is generally very reliable. Non-toxic refrigerant is used in closed loop systems to prevent an environmental disaster if a leak were to occur (Alliant Energy, 2008). Despite these drawbacks, geothermal systems remain a cost-effective and environmentally friendly tool.

Global warming is a serious threat to our society. New evidence is continually uncovered to confirm that human behavior is causing irreversible changes to the environment. Carbon dioxide emissions must be reduced in order to diminish this threat. According to Jim MacMillan (2007), a journalist for *ASHRAE Journal*, "More than 40% of carbon dioxide emissions in the U.S. are due to energy use for buildings" (p. 35). Through the use of geothermal systems and geothermal power, the U.S. could greatly reduce carbon dioxide emissions (Livingston, 1998). Geothermal systems currently in use help to eliminate more than 1.5 million tons of carbon emissions every year, and as more systems are installed this number will continue to grow. Geothermal climate control systems are 40 percent more efficient than air source heat pumps, 48 percent more efficient than natural gas furnaces, and an impressive 75 percent more efficient than oil furnaces (Alliant Energy, 2008). Through increased utilization of geothermal technology, the U.S. can reduce its carbon footprint and slow global warming while cutting down on the consumption of fossil fuels.

American society has grown very dependent on fossil fuels, a finite resource that will eventually run out. Fluctuating fuel prices play a large role in the U.S. economy and they affect the average American in many ways. One significant way is heating fuel for the home. Geothermal systems are an ideal alternative fuel. Heat from the earth is stable, reliable, and, best of all, free. Through the widespread use of geothermal systems, consumption of heating oil and natural gas could be greatly reduced. This would help to ease the strain on our economy and increase security by cutting imports. Geothermal systems are a great tool in reducing fossil-fuel consumption.

Since ancient times, people have regarded the heat that comes from the earth as a great sacred power. Through technological developments, we are now able to harness this renewable source of energy. The generation of electricity is one promising application. Geothermal power plants have the potential to produce large amounts of energy with little to no emissions. Another important application is the heating and cooling of buildings. Both large buildings, such as schools, and smaller buildings, such as homes, can benefit immensely from a geothermal system. Reduced costs, lowered emissions, and reliability are just a few benefits of geothermal systems. Because of concerns about the environment and the dwindling supply of fossil fuels, alternative sources of energy are needed. The demand will only continue to grow in the future. Despite the cost, geothermal technology is a worthwhile and necessary investment.

References


Alliant Energy. (2008). Geothermal. Retrieved November 13, 2008, from Alliant Energy Web site: http://www.alliantenergygeothermal.com/stellent2/groups/public/documents/pub/geo_001407.hcsp

Fahey, J. (2008). Journey to the center of the earth. *Forbes, 182*(4), 48-52.

Fell, N. (2003). Deep heat. *New Scientist, 177*, 40-42.

Geothermal well to wheels.(2008). *Mechanical Engineering, 130*(8), 20-21.

Livingston, B. (1998). Burying high energy costs. *American City & County, 113*(9), 22.

MacMillan, J. (2007). Ground source heat pumps in schools. *ASHRAE Journal, 49*(9), 34-38.

U.S. Department of Energy, (2008). Geothermal Technologies Program. Retrieved November 11, 2008, from Energy Efficiency and Renewable Energy Web site: http://www1.eere.energy.gov/geothermal/

Wisconsin Geothermal Association, (2008). What is geothermal. Retrieved November 13, 2008, from Wisconsin Geothermal Association Web site: http://www.wisgeo.org/index.php?option=com_content&view=article&id=44&Itemid=53