Geothermal Power

Introduction

Geothermal power is an alternative source of energy that harnesses the heat from within the Earth in order the generate electricity and space heating. Currently the worldwide capacity for geothermal energy is estimated at 9,704 thermal megawatts. Almost each and every country in the world has areas which are underlain with at least low to moderate temperature geothermal waters, making all of these countries candidates for the technology. With the expansion of the direct usage of this geothermal water, this could be another step in meeting the energy needs of developing countries. The Earth itself is continuously heated through radiation from within itself and with the gathered rainfall and snowmelt which is supplied each year new geothermal reservoirs are created. The production from these individual reservoirs can be sustained for many decades and perhaps even centuries. With essentially zero emissions during the capturing process, geothermal energy is classified as a renewable resource.

Types of Geothermal Plants

There are three types of geothermal energy generation plants in use today. First, there are dry steam plants which harvest steam from fractures in the ground. The steam is directly used to drive a turbine that spins a generator, an example of this is shown below:

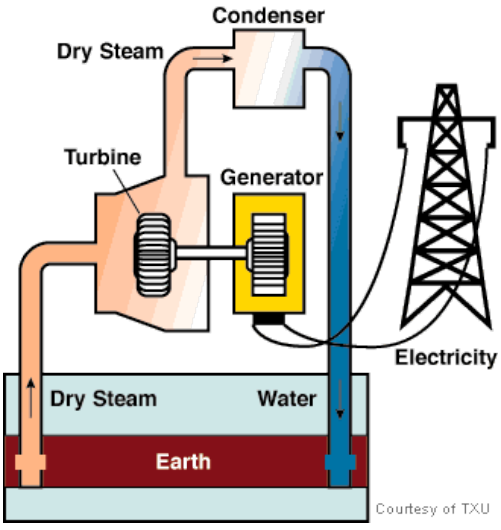

Figure 1: Geothermal Energy Used for Dry Steam Plant

Since steam is used directly, the cost of boilers and boiler fuel eliminated, providing energy at a very low cost. However, the technology is bounded by the extremely rare resources of dry-steam. The geysers in California are the only existing source in the United States. Flash plants are used to collect ground water with temperatures of over 360 degrees Fahrenheit. The water boils in its ascent and is sprayed into a tank held at much lower pressure than the fluid. This causes the fluid to vaporize rapidly, or "flash." The vapor then drives a turbine to run the generator. Some plants utilize a second tank in order to flash any remaining fluid for more energy. A diagram of how a flash plant works can be seen below:

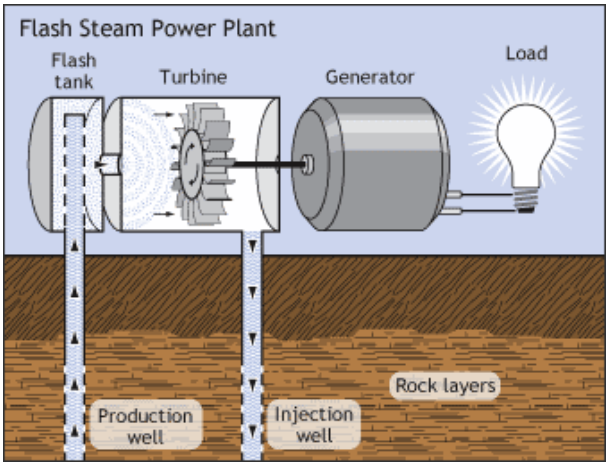

Figure 2: Diagram of Geothermal Flash Plant

In binary plants, water under 400 degrees Fahrenheit is extracted from the Earth. Hot geothermal fluid and a second organic fluid, consisting of a much lower boiling point, are passed through a heat exchanger. The geothermal fluid produces heat that flashes the organic fluid to vapor, which in turn, drives the turbines. This is the most common source of geothermal energy production due to its abundance of moderate-temperature water found in the Earth. An example of one of these binary plants is shown below:

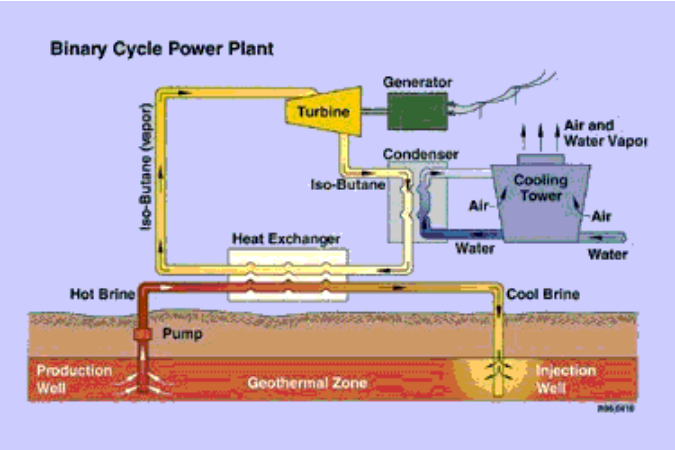

Figure 3: Diagram of Geothermal Binary Plant

With all three of these methods, the left over condensed steam and geothermal fluids are returned to the Earth in order to generate more heat.

Case Study

A study of the simple payback period of a residential geothermal heating system when compared to the replacement of a standard efficiency air source heat pump was completed. The initial cost of a smaller system was found to be around $9.60 per square foot of the house. For this specific case the area of the house used was 2500 ft^2 resulting in a cost of $24,000 for the system. This initial cost can be reduced using the New Jersey Smart Start Program[1] which provides an equipment incentive of $370 per ton for ground source heat pumps, which would provide a total discount of $3,700 for the approximately 10 tons of the system size. This would result in an initial cost of the system being $20,300. The annual savings was found using the WaterFurnace Savings Calculator[2] and assumed an electricity cost of $0.13 per kWh and a four resident household. The annual savings was estimated at $1,402 per year using this calculator. The simple payback was then found as the initial cost divided by the annual savings or $20,300/$1,402, resulting in a simple payback period of 14.5 years. Geothermal systems are more dependent on localized factors than many other energy systems, so it may be worth it to use the savings calculator for your specific site and determine a more accurate payback.

Future of Geothermal Technology

The Earth's heat is so immense that harnessing it to power the entire world would only utilize a small fraction. The Earth's magma and dry rock will provide cheap, clean and nearly unlimited energy as soon as the technology for extraction is developed. Before geothermal electricity can be regarded as a key component of the U.S. source of energy, it must become economically competitive with the forms of generation in place today. The Department of Energy is working with the geothermal industry in order to attain a price level of $0.03 to $0.05 per kilowatt-hour, which is projected to occur within the next decade.

References

Figures and Tables

Figure 1: Geothermal Energy Used for Dry Steam Plant
From U.S. Department of Energy (2006)
Figure 2: Diagram of Geothermal Flash Plant
From U.S. Department of Energy (2006)
Figure 3: Diagram of Geothermal Binary Plant
From U.S. Department of Energy (2006)

End Notes

[1] New Jersey Clean Energy Program, "New Jersey Smart Start -Equipment Incentives" [Online Document]. 2002 [cited 2007 March 26]. Available HTTP: http://www.njsmartstartbuildings.com/main/equip_inc.html

[2] WaterFurnace , "Your WaterFurnace Savings Calculator" [Online Document] 2007 [cited 2007 March 26]. Available HTTP: http://www.waterfurnace.com/forms/form_savingscalculator.aspx?section=residential&page=calculator

Additional Information

Geothermal Education Office, "Geothermal Energy Facts" [Online Document]. 2000 [cited 2007 March 26]. Available HTTP: http://geothermal.marin.org/pwrheat.html

U.S. Department of Energy, “Geothermal Power Plants” [Online Document]. 2006 [cited 2007 March 26]. Available HTTP: http://www1.eere.energy.gov/geothermal/powerplants.html