U.S. Geothermal Electricity Fact Sheet

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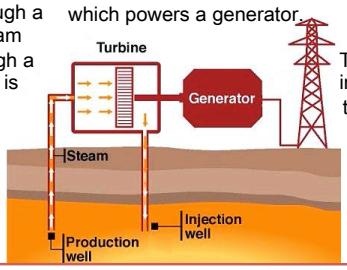
Main Types of Geothermal Systems

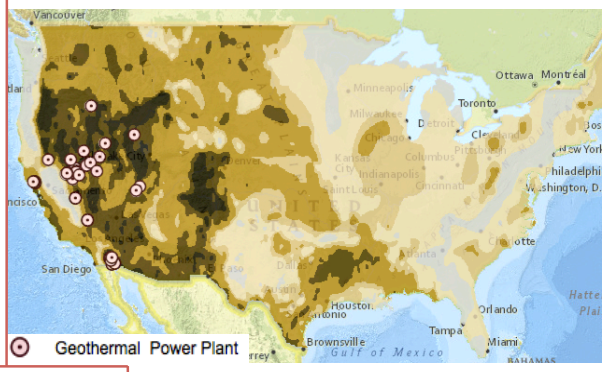
Flash Power Plants: Water is heated by geothermal heat. Under pressure, This separates into steam and hot water through a steam separator. The steam powers a generator through a turbine, and the hot water is injected back into the reservoir.

Dry Steam Power Plants: Water is heated by geothermal heat. This turns purely into steam that goes to the turbine which powers a generator.

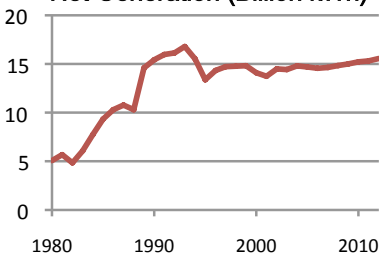


Binary Power Plants: Binary cycle power plants operate on water at lower temperatures. The heat from the hot water boils a working fluid with a low boiling point. The working fluid is vaporized in a heat exchanger and used to power a turbine. The water is then injected back into the ground to be reheated.

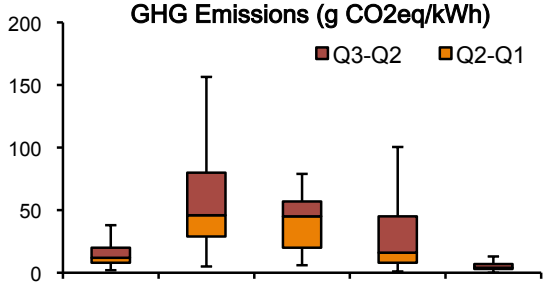
U.S. Geothermal Potential



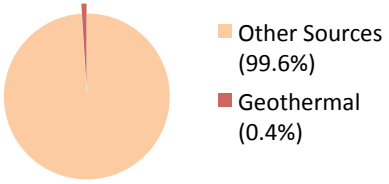
U.S. Geothermal Electricity Net Generation (Billion kWh)



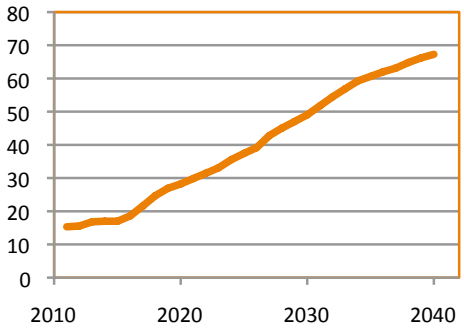
GHG Emissions (g CO2eq/kWh)



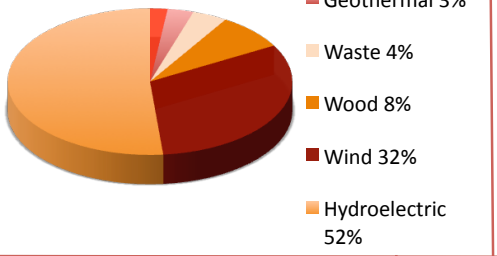
Geothermal Percent of Total Electricity Generation



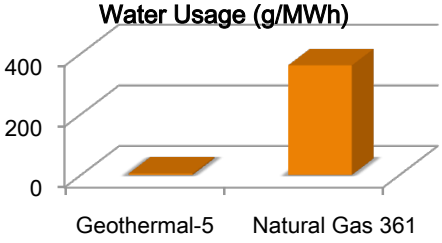
U.S. Geothermal Electricity Net Generation Projection (Billion kWh)



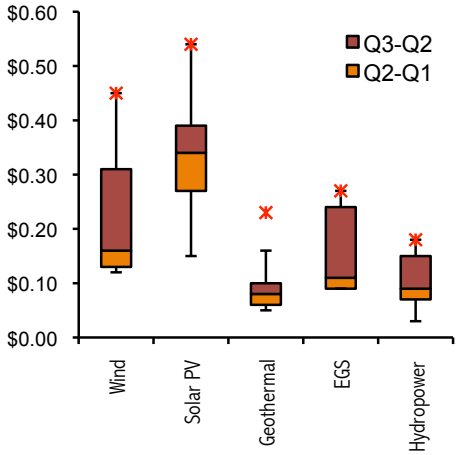
Renewable Electricity Generation, 2013



Water Usage (g/MWh)



Levelized Cost of Energy ($/kWh)



Key Terms

Geothermal energy- Steam and hot water that is extracted from geothermal reservoirs. This can be used for geothermal heat pumps, water heating, and electricity generation.

Geothermal plant- A plant with the main driver being a steam turbine. The turbine can be driven either by steam from hot water, or by steam from natural sources such as geysers.

Geothermal heat pump- A heat pump that uses the constant temperature of the earth as the heat source in the winter, and a heat sink in the summer instead of the outside air temperature.

Enhanced Geothermal System (EGS)- An engineered reservoir created where there is geothermal energy but a lack of permeability. Fluid is injected into the earth's surface which causes pre-existing fractures to open again, creating permeability.

Closed-loop system-A geothermal system where gases that rise from the well are injected back into the earth and are not exposed to the atmosphere.

Issues & Environmental Concerns

- Many geothermal resources are often located in national parks and are protected by laws and regulations, making them non-usable.
- Geothermal Electricity is not 100% emission free
- Enhanced Geothermal Systems can increase the risk of seismic activity. This can be avoided by placing plants far away from fault lines.
- Geothermal facilities require approximately 0.0627 mi^2 per MW of electricity produced.
- Geothermal power plants produce noise pollution during drilling and operation

Key Numbers

Current land space occupied by geothermal power plants: **~63.3 mi^2**

Land space required to produce all U.S. electricity with geothermal energy: **~9,873.1 mi^2**
With wind energy: **~224,191 mi^2**

Total U.S. Capacity (2012) **~3187 MW**

Geothermal Capacity Factor (2010) ~ **87.4%**

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U.S. Geothermal Energy Fact Sheet References

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Energy Technology

Main Types of Geothermal Systems

For more definitions, see
"Geothermal Electricity Production." *NREL: Learning -. N.p., n.d. Web. 13 Apr. 2014.*
"Geothermal Basics - Basics." *Geothermal Basics - Basics. N.p., n.d. Web. 13 Apr. 2014.*

Image from http://www.reuk.co.uk/Eden-Project-Geothermal-Power-Plant.htm

U.S. Geothermal Potential

Graph created using EIA U.S. Energy Mapping System

Note: Geothermal potential for the U.S. based on Levelized Cost of Electricity, with class 1 having the most favorable geothermal potential, and class 5 having the least favorable geothermal potential.
Data period: 2009
For more assumptions, see
"U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." *U.S. Energy Mapping System (EIA). N.p., n.d. Web. 12 Apr. 2014.*

U.S. Geothermal Electricity Net Generation

Data from EIA
For assumptions and methods, see:
"International Energy Statistics." *U.S. Energy Information Administration (EIA). N.p., n.d. Web. <http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=2&pid=35&aid=12&cid=regions&syid=1980&eyid=2012&unit=BKWH>.*

GHG Emissions

Data from Moomaw, W., P. Burgherr, G. Heath, M. Lenzen, J. Nyboer, A. Verbruggen, 2011 (2011): Annex II: Methodology, IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation

Geothermal Percent of U.S. Total Energy Production/Consumption

Source: Energy Information Administration, Monthly Energy Review (April 2013)
"Geothermal." *Institute for Energy Research. N.p., n.d. Web. 12 Apr. 2014.*

U.S. Geothermal Electricity Net Generation Projection

Data from Table 16 from AEO2014 Early Release Overview
Source: "AEO2014 Early Release Overview." U.S. Energy Information Administration. N.p., n.d. Web. 15 Apr. 2014. <http://www.eia.gov/forecasts/aeo/er/tables_ref.cfm>.

Renewable Electricity Generation

Data from EIA Electricity Power Monthly (Released February 2014)
For more information, see
http://www.eia.gov/energy_in_brief/article/renewable_electricity.cfm

Water Usage

Source: "Geothermal Energy Association Fact Sheets." *Geothermal Energy Association Fact Sheets. N.p., n.d. Web. 13 Apr. 2014.*
This figure does not include geothermal fluid, because this is injected back into the reservoir and therefore is not withdrawn from freshwater sources.

Levelized Cost of Energy

Chart generated by
"Transparent Cost Database." *Energy Information, Data, and Other Resources. N.p., n.d. Web. 14 Apr. 2014.*
Note: Data from 2010-2012. Other renewable sources shown for reference.

Key Terms

Definitions from:

"U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." *Glossary. N.p., n.d. Web. 13 Apr. 2014*

"Energy.gov." *Enhanced Geothermal Systems. N.p., n.d. Web. 14 Apr. 2014. <http://www.energy.gov/eere/geothermal/enhanced-geothermal-systems-0>*

"Geothermal Heat Pumps." *Energy.gov. N.p., n.d. Web. 14 Apr. 2014. <http://energy.gov/energysaver/articles/geothermal-heat-pumps>.*

Issues and Environmental Concerns

For more information see Kagel, A. (2007) *A Guide to Geothermal Energy and the Environment, Washington, DC: Geothermal Energy Association*
Though this is from 2007- it is mostly discussing the major issues associated with geothermal energy, which I doubt have changed drastically since.

Key Numbers

Calculation assuming Geothermal plant area per MW =0.0627 mi^2 per MW, and total U.S. electricity consumption to be $4.36*10^9$ MWh/year.
Data from Rogers, Mike. "The Geysers: Renewable, Geothermal Energy." *Calpine. N.p., 18 Oct. 2012. Web. <http://www.geysers.com/media/Calpine-10-18-2012-Impact-Sonoma-Presentation.PDF>.*
Total US capacity calculation
2012 US Geothermal Power Production and Development Report
"Geothermal Plants." *Geothermal Plants. N.p., n.d. Web. 14 Apr. 2014. <http://geo-energy.org/plants.aspx>*
Capacity Factor estimated from Table 8 of
NREL *Cost and Performance Assumptions for Modeling Electricity Generation Technologies. Rep. no. SR-6A20-48595 http://www.nrel.gov/docs/fy11osti/48595.pdf*