Should the U.S. Expand Its Use of Geothermal Resources?

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Lessons from Iceland

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Introduction

Geothermal Energy is heat collected from the Earth to produce electricity.

The U.S. consumption of energy is projected to grow. The Department of Energy has received increased funding towards the development of geothermal technologies. Leading critics predict an exponential expansion of geothermal energy, but is this accurate?

In this capstone project, geothermal energy is investigated both in its role in the United States, as well as in Iceland. The feasibility of geothermal energy for electricity production is analyzed within a framework of technical, economic, environmental, and political implementation. The United States and Iceland's resource bases differ, and does their approaches to utilize this renewable resource. This analysis is demonstrative of the challenges any energy resource faces.

Aim

- Assess the feasibility of geothermal energy production expansion in the U.S.

- Evaluate claims of a landmark study on the potential of Enhanced Geothermal Systems by Tester et al., 2006, "The Future of Geothermal Energy: Impact of Enhanced Geothermal Systems on the United States in the 21st Century."

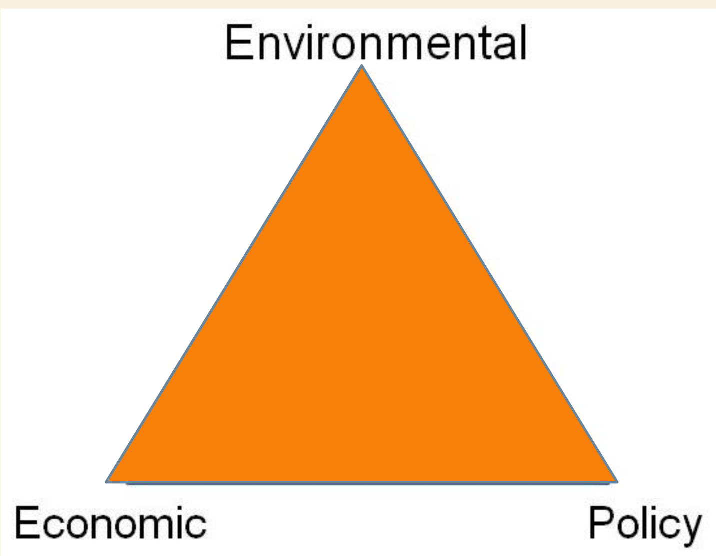


***Figure 1** Feasibility of using a renewable resource is controlled by these factors.*

Method

A literature review was conducted on the subject of Geothermal Energy. An educational background from Environmental Studies and Geology coursework served as a starting point. The student traveled abroad to Iceland with The Green Program to study renewable energy and took classes at Reykjavik University's School of Energy.

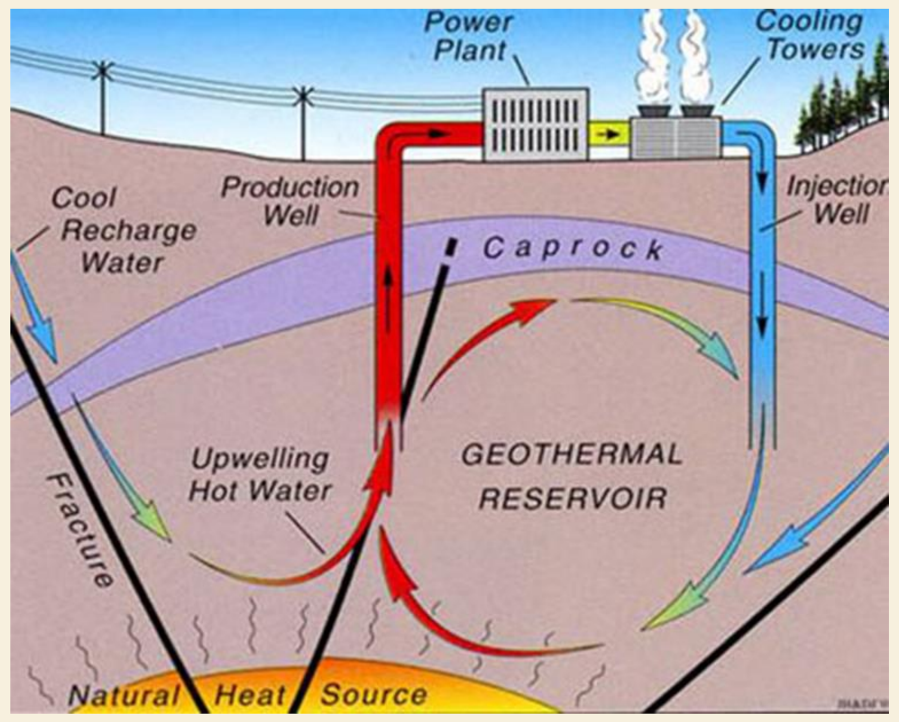


***Figure 2** Typical setup for a geothermal plant. Heat from the mantle is available through fracture networks and permeating hydrothermal fluids. These fluids are captured by the production well and the decrease in pressure converts the fluid to steam. The steam passes through a separator to remove the steam from the remaining fluid. The steam turns a steam turbine that runs a generator. The fluids recondense and are returned to the reservoir through the production well. (Nevada Geothermal Power, A Natural Source of Clean Power, 2009).*

Enhanced Geothermal Systems (EGS), also called Hot Dry Rock (HDR) involves the stimulation of deep heat reservoirs either by fluid pressurization, hydro fracture, or chemical stimulation in order to improve circulation of fluids and better recover heat from the rock fractures (Majer,2012). This aids in producing steam at a proper thermal gradient. Conventional reservoirs already have Fluid present from natural fracture networks (Ehrlich, 2013). There are no commercially active EGS sites operating at this time. The technology has been demonstrated at The Geysers(DOE, FORGE). *Drilling cost and siting are often prohibitive.*

"The EGS geothermal resource at a depth from 3.0 to 10.0 km in USA is equivalent to 2800 times of USA's 2005 annual total energy consumption if only 2% of the EGS resource can be recovered" (Tester, et al, 2006)

Results

Today, Iceland is powered 75% by hydropower and 25% by geothermal, with 575 MW of installed geothermal capacity (Miethling, 2011). This makes Iceland's electric grid 100% renewable. Yet, the U.S. actually has the highest installed capacity of geothermal in the world, 3,000 MW. This is only less than 1% of the total U.S. power supply- behind wind and solar (Li, 2013). However, 188 new projects may *double* this capacity (GEA).

EGS requires substantial amounts of water injection into the reservoir. This requirement may limit its feasibility in water stressed regions, such as the Western U.S. (Glassley, 2010).

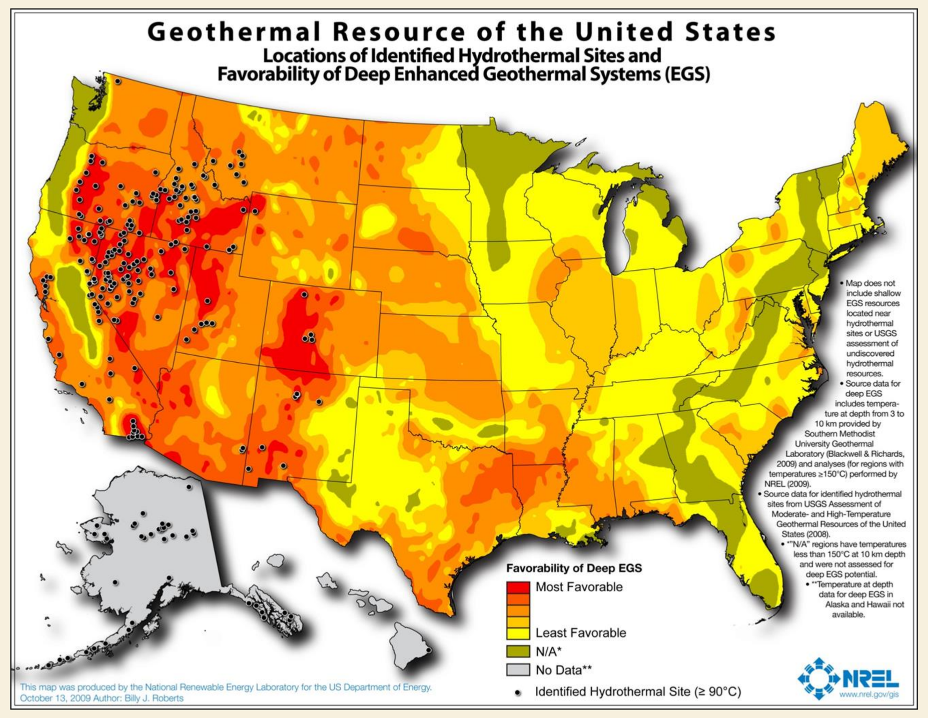
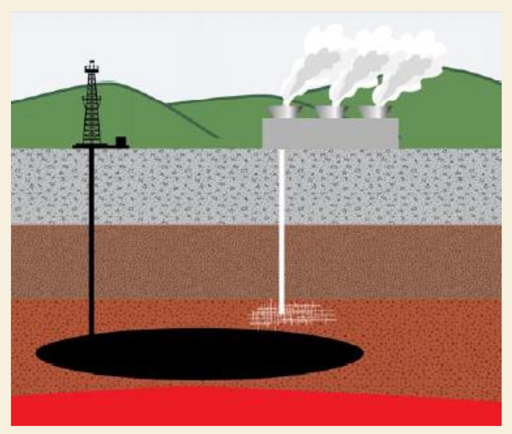


***Figure 3** The Western U.S. has heat flow conducive to The generation of geothermal electrical energy. This map depicts the favorability of EGS based upon thermal conductivity of the geologic material at depth (in mW/m^2) and access to hydrothermal fluids (dots). Roberts, B. J.,(2009). National Renewable Energy Laboratory, U.S. DOE.*

Future Directions



Coproduction of geothermal with O&G wells will allow development of key technology. There are also abandoned wells, >4,000 in Texas alone. If all those were developed, the capacity would be equivalent to 2 coal power plants.

Conclusions

- The immature state of key technology such as spallation drilling, high temperature monitoring equipment and borehole casings for EGS reservoirs *does not lend itself to the short term expansion of geothermal energy in the United States.*
- Furthermore, the recent dip in oil prices attributed to domestic use of hydraulic fractionation will also hamper expansion of all renewable resources, to the extent of being fiscally competitive in the next few years.
- The key to expanding geothermal energy may be co-production with oil and natural gas wells. During this co-production phase, key technology may be developed for eventual use in EGS reservoirs. The poor heat flow (Figure 3) outside the Western states means that geothermal will probably never develop as a base load energy resource for most of the country**.** Instead, using Geothermal Heat Pumps (GHPs), district heating, or heating domestic water supplies like Iceland may reduce energy consumption.

Sources

Tester, J.W., Anderon B.J., Batchelor, A.S., Blackwell, D.D., DiPippo, R., Drake, E.M., Garnish, J., Livesay, B., Moore, M.C., Nichols, K., Petty, S., Toksoz, M.N., Veatch Jr, R.W. 2006. The Future of Geothermal Energy: Impact of Enhanced Geothermal Systems on the United States in the 21st Century." *MIT*. *Idaho National Laboratory.*

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