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2013 Market Trends Report

Geothermal Technologies Office

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Photo credits clockwise from top left: Ormat turbine manufacturing and (r) DOE EGS Demonstration site at Raft River, Idaho, *courtesy of Geothermal Resources Council*; (bottom left) hydrothermal steam at a power station at The Geysers, California, *courtesy of Calpine Corporation*; Newberry Caldera, Oregon, site of a DOE EGS Demonstration, *courtesy of Lauren Boyd*; Caldwell Ranch, The Geysers, California, *courtesy of Calpine Corporation*.

Notice

Glossary

Term	Meaning
°C	Degrees Celsius
°F	Degrees Fahrenheit
Availability Factor	% of time a facility is able to produce electricity (i.e., may be called on to produce electricity by a grid operator)
Binary Cycle Geothermal	Heat from the geothermal fluid is exchanged to a secondary fluid with a lower boiling point. The secondary fluid flashes to vapor, which then drives the turbines and subsequently, the generators.
Capacity Factor	% of time a facility produces electricity
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
Dry Steam Geothermal	Dry steam plants use hydrothermal fluids that are primarily steam. The steam travels directly to a turbine, which drives a generator that produces electricity.
EGS	Enhanced Geothermal Systems (sometimes referred to as Engineered Geothermal Systems)
Flash Cycle Geothermal	Fluid at temperatures greater than 360°F (182°C) is pumped under high pressure into a lower pressure tank, causing some of the fluid to vaporize, or "flash." The vapor then drives a turbine, which drives a generator. The remaining fluid can be flashed again in a second tank to extract even more energy.
GEA	Geothermal Energy Association
GTO	U.S. DOE Geothermal Technologies Office
GW or GW_e	Gigawatt (electric)
$GW_{THERMAL}$	Gigawatt (thermal)
kW or kWe	Kilowatt (electric)
kWh	Kilowatt-hour
LCOE	Levelized Cost of Electricity
MIT	Massachusetts Institute of Technology
MW or MW_e	Megawatt (electric)
NGDS	National Geothermal Data System
NREL	National Renewable Energy Laboratory
O&M	Operation and Maintenance
PPI	Producer Price Index
R&D	Research and Development
Recovery Act	American Recovery and Reinvestment Act of 2009
U.S. BLS	Bureau of Labor Statistics
U.S. EIA	Energy Information Administration
USGS	U. S. Geological Survey

Executive Summary

The potential geothermal energy resource base of the United States is a major natural asset, on the order of more than 100 gigawatts (GW) of clean renewable energy. As shown in Figure ES-1, conventional hydrothermal technologies could be utilized for 6 GW of additional potential beyond what has already been developed. There are an estimated 30 GW of additional conventional resources yet to be discovered[1] in the western United States. (Note: 1 GW is roughly equivalent to the electricity demand for 1 million homes.[2]) The next generation of geothermal technologies, enhanced geothermal systems (EGS), is positioned to access additional geothermal resources by adding either permeability or a heat exchange fluid to a geological formation with sufficient heat. A breakthrough in EGS could expand the U.S. geothermal resource base dramatically. Early estimates of the potential resource (only a fraction of which will be technically, economically, and legally feasible to develop) are necessarily imprecise, but the scale of the resource EGS would potentially unlock spans from 518 to as high as 15,900 GW,[3] and could expand geothermal energy's geographic impact beyond the western United States—where it is concentrated today—to essentially the entire United States.

Potential Geothermal Resource

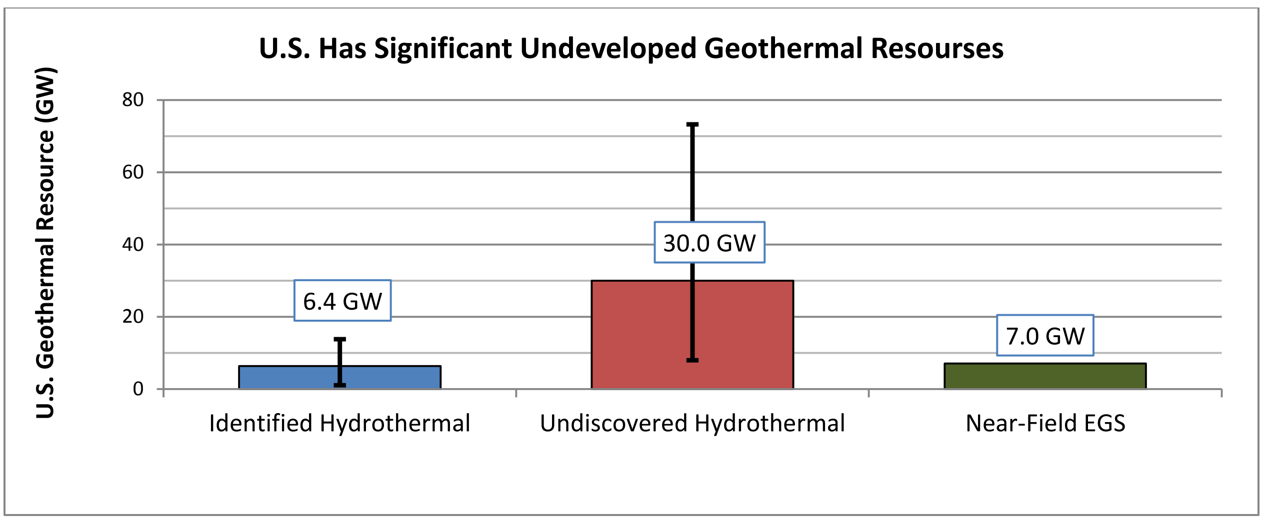

Figure ES-1
Identified and Undiscovered Hydrothermal Resource Compared with EGS Resource Near Hydrothermal Fields.[4]

[1] Like any natural resource, only a portion of the potential geothermal resource base is technically, economically, and legally feasible for development (referred to as the geothermal reserve).
[2] (Geothermal Energy Association, 2012, p. 9)
[3] Identified Hydrothermal and Undiscovered Hydrothermal: (U.S. Geological Survey, 2008); Near-Field EGS: (Augustine, 2011)
[4] (U.S. Geological Survey, 2008) and (Augustine, 2011)

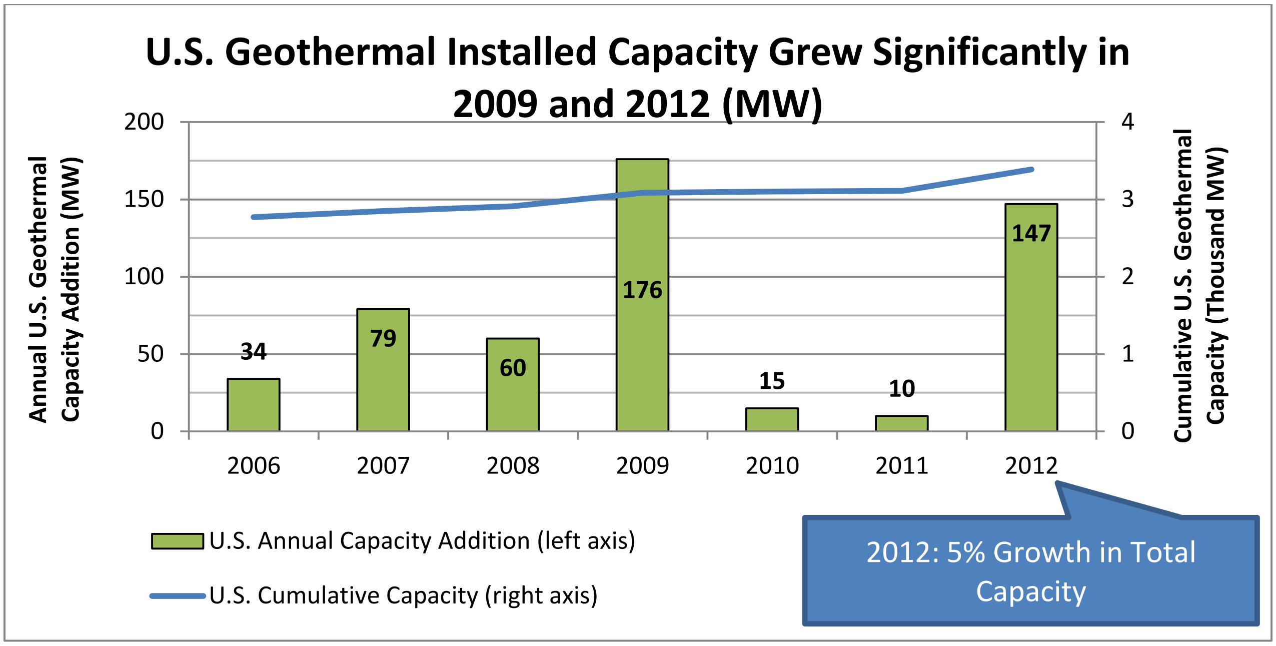

Figure ES-2
U.S. Annual and Cumulative Geothermal Capacity (2006–2012).[5]

Recent U.S. Activity

The U.S. geothermal industry's activity in 2009 and 2012 are relative standout years. As shown in Figure ES-2, the 147 megawatts (MW) of capacity installed in 2012 increased the cumulative or total U.S. capacity by 5 percent.

Although the geothermal industry benefits by leveraging the research and development (R&D) and drilling capacity built to service the oil and gas industry, it is also exposed to sometimes volatile drilling price swings. The oil and gas drillers' Producers Price Index (PPI) increased significantly between 2004 and 2006 (150 percent between monthly low and high points) as a result of macro-economic changes and increased levels of domestic oil and gas drilling. Although this price increase improved slightly in the late 2000s, its influence shows that development trends in the geothermal industry should be viewed in the context of wider market forces.[6]

Geothermal resource exploration, confirmation, and drilling costs front-load the risks of geothermal development—about half the cost of a facility is expended at or before the production wells are drilled. This result is that significant capital must be raised and spent before a developer can be confident that a site is economically feasible to develop. In addition, project developers have reported difficulties in securing new Power Purchase Agreements (PPA), partially owing to the historic drop in U.S. natural gas prices.[7] Financing present-day, conventional hydrothermal projects is important to support the industry's short- and medium-term development, while venture capital and private equity investments are key enablers of long-term technologies such as EGS. To date, the geothermal industry has received only a fraction of the venture capital and private equity investment received by other renewable energy

[5] (Geothermal Energy Association, 2013, p. 9)
[6] Relationship of oil and gas drilling costs to geothermal drilling costs supported by (MIT Energy Initiative, 2006), (Mansure, et al., 2005), (Mansure, et al.), (Mansure & Blankenship, 2008), (Mansure & Blankenship, 2009), (Mansure & Blankenship, 2010). This relationship is more fully described in the drilling section of this report.
[7] Multiple Industry interviews, (Linvall, et al., 2012), and on-the-record comments made by Paul Thomsen (Ormat) and Joe Ricco (Terra-Gen) at the February'2013 GEA industry briefing and press event.

sources, such as the solar and wind industries.[8] This is largely a result of extremely long development cycles for geothermal technologies and facilities, which are estimated to require several years for a technology demonstration project and 5 to 7 years for an actual power plant.[9]

Already operable hydrothermal, coproduction, and low-temperature geothermal technologies are competitive with other energy generation technologies given the right circumstances and assuming they can overcome development risks. Project-specific development risks—such as over-estimating the size of a geothermal resource, placing geothermal wells in sub-optimal locations, or enduring protracted development periods—increase capital costs and expense. Many of these project-specific issues remain an impediment to industry growth.

Future Prospects for Geothermal

The U.S. industry has built a healthy project development pipeline, especially in California and Nevada, and the State of Hawaii has recently shown interest in deploying at least 50 MW of capacity within the next 10 years.

Internationally, geothermal energy's prospects in several markets (e.g., Kenya, Indonesia, New Zealand, and the Philippines) appear bright based on the level of development work in the field as well as supportive policies instituted by the respective governments. However, when the United States is examined using those same measures, its short- and medium-term outlooks are more uncertain.

On the other hand, R&D projects such as the EGS projects supported by the Recovery Act, and projects that work to adapt technologies developed by the oil and gas industry, have shown encouraging results. As examples, AltaRock and Ormat's EGS demonstration projects, as well as Sandia National Laboratory's polycrystalline diamond drill bit (PDC) demonstration project, have advanced potential long- and medium-term technologies, respectively, that may help to transform the geothermal industry. EGS in particular holds the potential to unlock a massive amount of energy that is presently inaccessible because of a lack of fluid permeability or a heat exchange fluid.

However, in interviews, industry members have stated that it is unlikely that the industry or private actors alone will invest the necessary R&D funding for EGS technologies given that they are still 10 to 15 years from commercial maturity with significant technological risks.[10] In the past, U.S. Department of Energy (DOE) funding of early R&D for shale gas development and related horizontal drilling, fracturing, and multistage stimulation techniques in the late 1970s through early 1990s catalyzed growth—supporting the oil and gas industry's development and deployment activities that have enabled today's shale gas revolution.

In general, R&D has the potential to stimulate significant growth in geothermal capacity. Through strategic R&D investments, especially technologies enabling EGS in or near existing hydrothermal fields, the geothermal industry could unlock a vast reserve of reliable and clean energy.

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[8] (Bloomberg New Energy Finance, n.d.)
[9] (World Bank Group, Energy Sector Management Assistance Program (ESMAP), 2012, p. 50)
[10] Industry interviews with the assumption that public-sector R&D continues.

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I. Geothermal Market Structure

The U.S. geothermal market is structured around independently owned facilities selling to electric utilities under long-term Power Purchase Agreement (PPA) contracts, or more rarely, as merchant facilities selling in the wholesale electricity market. The U.S. geothermal industry produced 15,316 gigawatt-hours (GWh) of electricity in 2011 (i.e., not including direct-use capacity), representing total annual revenue of between \$1.5 and \$0.8 billion.[11] Collectively, the global industry generated about 70,000 GWh of electricity in 2010 using 11 GW of installed electric capacity. This represents a total turnover between \$3.5 and \$7.0 billion per year in global electricity sales.[12]

As shown in Figure 1, which was drawn from the recent World Bank Energy Sector Management Assistance Program's (ESMAP) *Geothermal Handbook*, production well drilling and facility construction (e.g., power plant, steam collection system, grid interconnection) are the two most costly stages of project development. As shown in Figure 2, the global geothermal industry comprises at least 20 large, well-established firms pursuing a wide range of development models. As a facility this has developed multiple important but "niche" firms, which engage in a specific set of services for a project developer. A geothermal facility's development process typically lasts 5 to 7 years. In addition, about half of the cost of a geothermal facility is incurred prior to or during the drilling of production wells—front-loading both the costs and risk profiles of a geothermal project compared with alternative technologies. As shown in Figure 2, a few vertically integrated firms are active at all stages of a project's development; however, the majority of geothermal firms specialize in a specific niche or set of niches. One such firm is a leader in the exploration and confirmation of geothermal resources, through the use of geophysical, geological, and geochemical analyses.

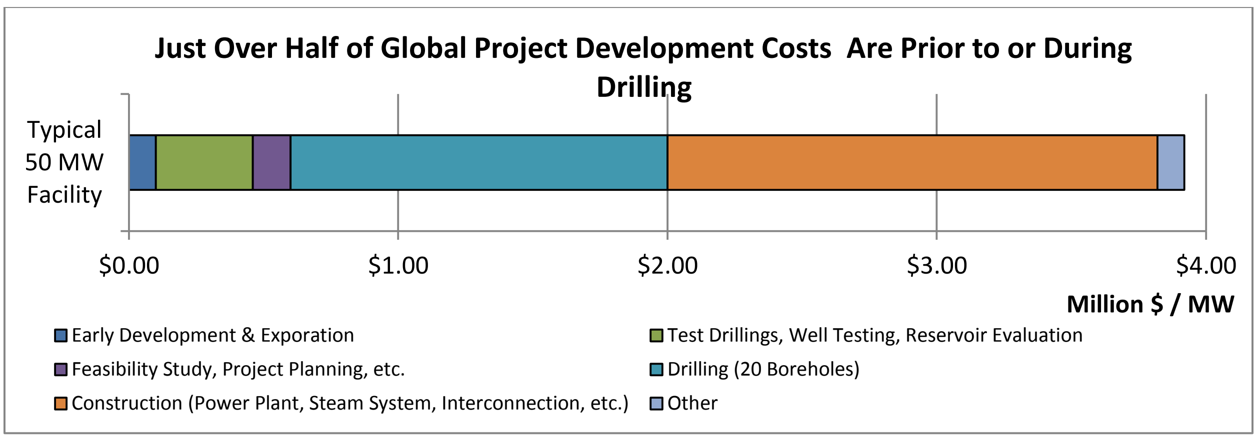

Figure 1
Project Development Cost Profile for a Typical 50-MW Geothermal Facility.13

[11] (U.S. Energy Information Administration, n.d.) and (U.S. Energy Information Administration, 2012, p. 256). Revenue range assumes \$0.10 - \$0.05 per kWh, the same implicit assumption used in (World Bank Group, Energy Sector Management Assistance Program (ESMAP), 2012, p. 25).
[12] Adapted from (World Bank Group, Energy Sector Management Assistance Program (ESMAP), 2012, p. 25).
[13] (World Bank Group, Energy Sector Management Assistance Program (ESMAP), 2012, p. 41) Medium Estimate. Source includes several detailed footnotes on assumptions utilized in arriving at this estimate of the indicative costs of a 50 MW hydrothermal facility with 20 wells drilled to a depth of approximately 2 km.

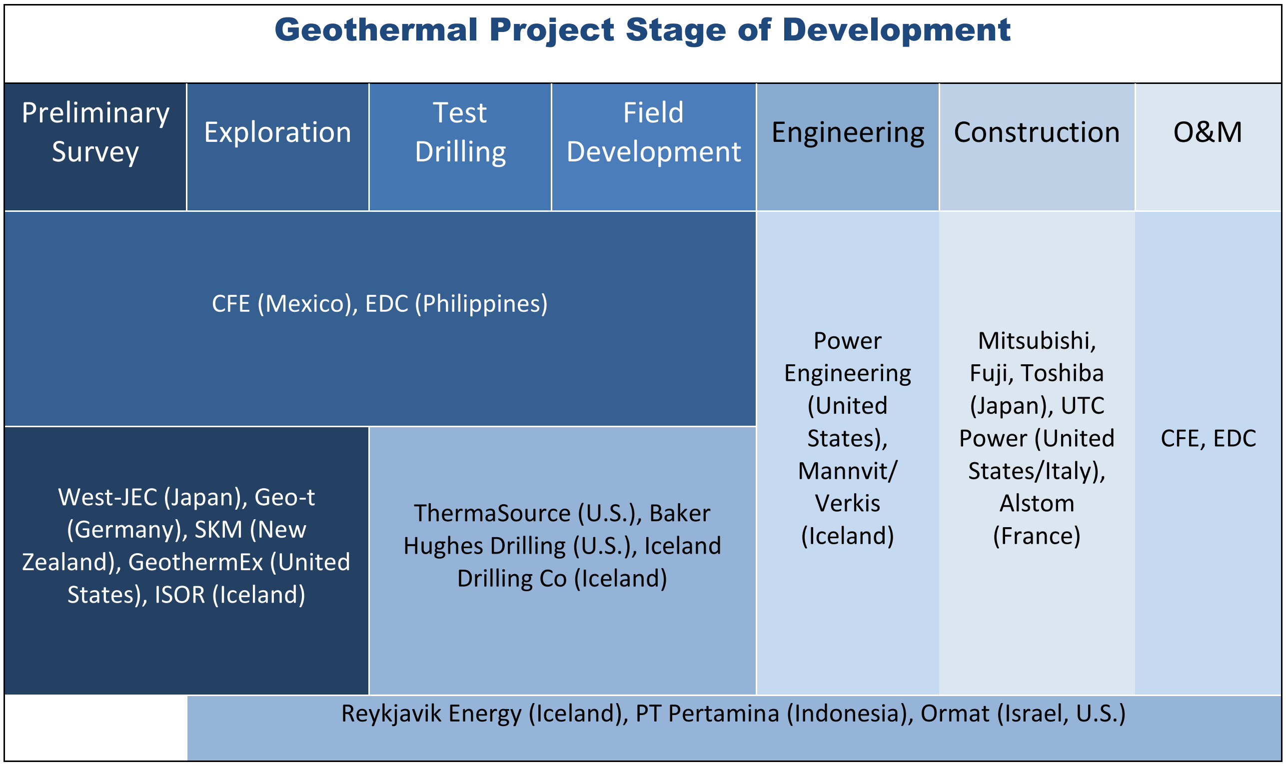

Figure 2
Geothermal Value Chain with Major Market Participants.[14]

Globally, fewer than 5 firms specialize in geothermal drilling as their core business; while an additional 20 firms (mostly oil- and gas-focused drilling firms) conduct geothermal drilling as a secondary line of business.[15] Drilling equipment for geothermal and oil and gas development is somewhat interchangeable; as a result, the geothermal industry can use the large drilling capacity created to serve the global oil and gas industry. However, geothermal drilling is significantly different from oil and gas drilling in actual operation. Overall, the geothermal industry is affected by price shifts in the oil and gas industry. To combat this influence, a few firms have created in-house drilling capabilities. For instance, one company has established a wholly owned drilling subsidiary in 2007 and has since expanded its rig count from five in 2010 to nine by 2012.[16]

With the exception of the steam turbine, most of the balance-of-plant systems and components are manufactured and marketed in a highly competitive market.[17] The global steam turbine market is dominated on a MW-basis by Toshiba, Mitsubishi, and Fuji because of their focus on larger "flash steam" turbines. However, this apparent market control masks Ormat's dominance in the lower-temperature market niche, which is expected to make up a larger share of the global geothermal market in the coming years.[18]

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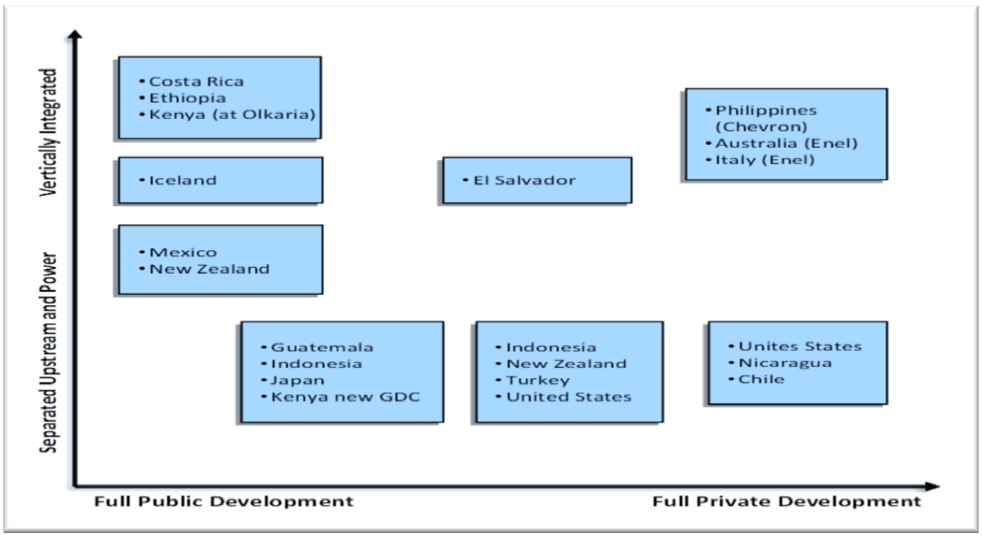
[14] (World Bank Group, Energy Sector Management Assistance Program (ESMAP), 2012, p. 28)
[15] (World Bank Group, Energy Sector Management Assistance Program (ESMAP), 2012, p. 27)
[16] (Ormat Technologies, Inc., 2011, p. 27) and (Ormat Technologies, Inc., 2013, p. 24)
[17] (World Bank Group, Energy Sector Management Assistance Program (ESMAP), 2012, p. 27)
[18] (Taylor, 2011, p. 11)

In the United States, significant new "dry steam" capacity, which formed the backbone of the U.S. geothermal industry's early years, is unlikely. Instead, binary or hybrid projects are expected to make up the majority of near-term U.S. development. Several firms are pursuing modular binary systems that generate significant amounts of power from low-temperature geothermal systems as well as industrial waste heat.[19] More information on global and U.S. geothermal turbine manufacturer trends may be found on page 21.

Figure 3
Geothermal Development Pattern Framework of Vertical Integration versus Public–Private Financing by Nation.[20]



I.1 International Geothermal Industry Structures

As shown in Figure 3, a wide range of approaches to the level of government participation and vertical integration have been used around the world. For instance, the countries shown in the upper left-hand corner, e.g., Kenya, Ethiopia, and Costa Rica, have used vertically integrated public utilities that are responsible for developing projects from inception to operation. In contrast, in Indonesia, New Zealand, and Mexico, exportation drilling, field development, and other value chain segments are separated among multiple public actors, or, in Mexico's case, a private firm constructs the facility that is then operated by a public utility. El Salvador is using a vertically integrated public-private partnership, LaGeo, which is jointly owned by the Government of El Salvador and the Italian company Enel Power. Although there are policy differences among them, the United States, New Zealand, and Indonesia have developed geothermal projects with public sector support for resource exploration, with the private sector following up with further investment. A few vertically integrated firms (e.g., Chevron in the Philippines and Enel Power in Italy) have developed sites with little to no public sector support, including at the earlier development

[19] (Taylor, 2012, p. 12), (Ormat Technologies, Inc., n.d.), (TAS Energy, n.d.), and (ElectraTherm, n.d.).
[20] Ibid

stages.[21] From the perspective of the geothermal value chain, public sector investment—at the earlier higher-risk development stages when confirming and characterizing a geothermal resource—can be quite effective in catalyzing a comparatively large investment of private-sector capital.

II. Recent U.S. and International Installation Trends

This section examines recent U.S. and global trends in the installation, use, and price of geothermal energy. Geothermal energy was first employed as an electricity source in the early 1920s, and development work for utility-scale projects started in the 1960s.[22] During the 1970s and 1980s, the U.S. geothermal industry experienced sustained growth, with a cumulative 2,700 MW of geothermal capacity installed, peaking in 1985 with 470 MW installed in a single year.[23] The U.S. geothermal industry has supported comparatively limited levels of deployments throughout the 1990s and 2000s. From 1975 to 1980, U.S. geothermal capacity grew by 19.6 percent per year on average (14.7 percent Compound Average Growth Rate [CAGR]). This growth accelerated to an average 29.5 percent per year (19.9 percent CAGR) from 1980 to 1985, but then declined to 10.9 percent (9.1 percent CAGR) from 1985 to 1990. Following 1990, average growth rates continued to decline—1.8 percent (1.7 percent CAGR) from 1990 to 1995, 0.9 percent from 1995 to 2000, and -0.3 percent from 2000 to 2005, with an uptick to 2.7 percent average annual growth from 2005 to 2010. Percentage growth rates obscure absolute or nominal growth over time; for instance, U.S. capacity grew by almost the same amount in absolute terms from 1975 to 1980 as it did from 2005 to 2010, 316 MW and 364 MW, respectively. However, the annual percentage growth in the late 1970s approached 20 percent while the annual growth rate in the late 2000s was under 3 percent.[24]

As of the end of 2012, 63 utility-scale geothermal facilities were in operation in the United States, representing roughly 3,386 MW of generating capacity.[25] Both 2009 and 2012 were excellent years for the U.S. geothermal industry for a wide range of reasons. It is not possible to isolate a single cause-and-effect relationship explaining why 2009 and 2012 were such strong years; however, a hypothesis can be formed based on a confluence of short- and long-term events. It is likely that projects benefited from project development work, financing, and PPAs completed before the economic downturn in 2008. Installations in 2009 likely also benefited from longer-term trends, such as: (1) increased attention paid by the investment and policy communities as a result of publications such as the Massachusetts Institute of Technology's (MIT) 2006 *The Future of Geothermal Energy* report, (2) increased focus on the risks associated with anthropogenic climate change, and (3) growing concern in Europe regarding the long-term stability of Russian natural gas supplies owing to the interruptions during the winter of 2006. Similarly, installations in 2012 were likely driven by: (1) the Recovery Act, (2) a short-term decrease in drilling costs in late 2009 through 2011 due to the temporary decrease in global oil prices resulting from the recession, (3) the looming expiration of the Production Tax Credit at the end of 2012 (which was later extended), and (4) the economic recovery, which increased demand for tax equity investment opportunities. Geothermal energy's long development time (5 to 7 years, with a high degree of variability based on project-specific

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[21] (World Bank Group, Energy Sector Management Assistance Program (ESMAP), 2012, p. 103)
[22] (Geothermal Technologies Office (GTO), n.d.)
[23] (U.S. Energy Information Administration, 2013)
[24] (Geothermal Energy Association, 2013) (Geothermal Energy Association, 2012) and personal communication via email with Matek, Benjamin. Data are in five-year increments.
[25] (U.S. Energy Information Administration, 2013) and (Geothermal Energy Association, 2013)

characteristics[26]) makes it doubly difficult to ascribe cause to an individual market condition in a single year. The causes for 2009 and 2012 being such strong years, while 2010 and 2011 were relative laggards, are likely to be some combination of these factors.

As shown in Figure 4, although the majority of existing U.S. geothermal capacity is located within California and, to a lesser degree, Nevada, significant project development pipelines exist throughout several western states, including Utah, Idaho, Oregon, and Hawaii. Geothermal energy's geographic diversity is expected to increase as EGS technologies advance in maturity, opening the eastern United States to geothermal development (see page 39 for more information on EGS).

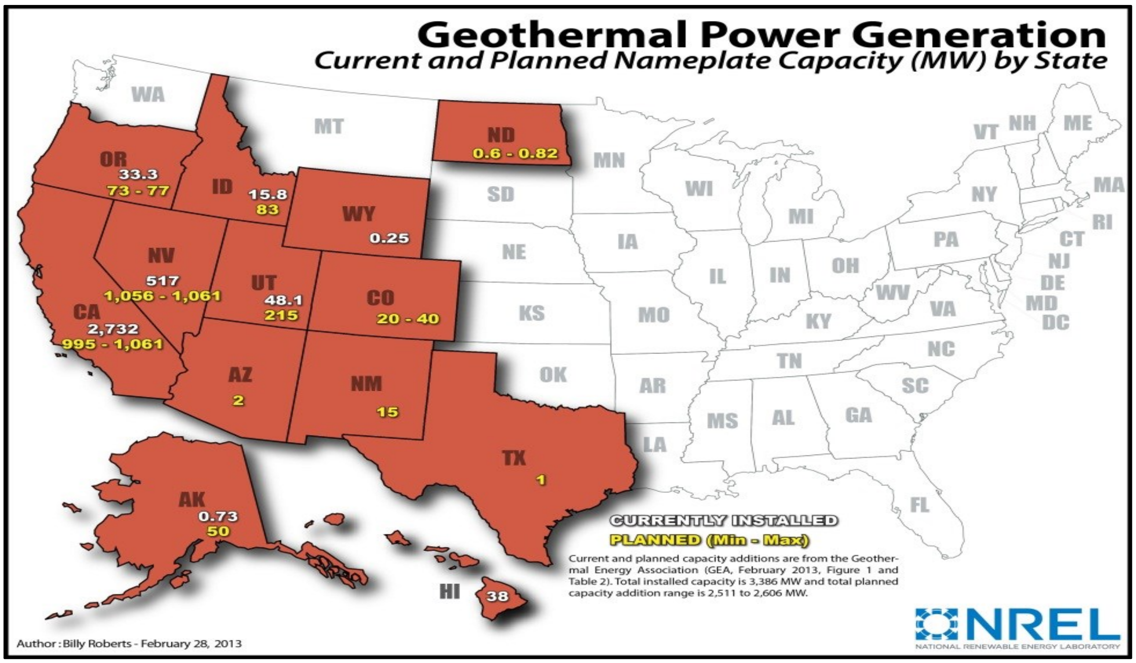

Figure 4 Current and Planned U.S. Geothermal Capacity by State.[27]

With 3,386 MW of installed capacity, the U.S. geothermal industry supplied 17 million MWh of electricity to the U.S. grid in 2012; this is equivalent to the energy consumed by 1.4 million U.S. homes, or 0.45 percent of total U.S. electricity production.[28] In 2001, there was just under twice as much U.S. wind capacity as there was geothermal capacity; however geothermal sources actually produced twice the amount of electricity compared to wind power for that year. In 2011, wind capacity had grown to almost 19x that of geothermal, only producing 8x as much electricity. The reason for this apparent discrepancy is that geothermal energy installations have significantly higher capacity factors than wind and solar facilities. As shown in Table 1, geothermal energy capacity has grown slightly over the past 10 years while wind capacity grew almost 1,100 percent (27.8 percent CAGR). In 2011, each MW of installed geothermal capacity produced about 6,400 MWh of electricity per year, compared with 2,700 and 1,200 MWh for wind and solar, respectively. Industry sources and the U.S. Energy Information Administration (EIA) itself

[26] (World Bank Group, Energy Sector Management Assistance Program (ESMAP), 2012, p. 50)
[27] (Roberts, 2013)
[28] (U.S. Energy Information Administration, 2013)

typically apply a 90- to 95-percent capacity factor to new geothermal facilities.[29] However, as shown in Table 1, production data reported to the EIA yields a capacity factor of 73 percent for geothermal energy. The lower than expected observed capacity factor is potentially a result of methodological issues involving net summer capacity at geothermal facilities that have experienced thermal resource declines.

Table 1 U.S. Geothermal, Wind, and Solar Capacity and Energy Production.[30]

Major U.S. Renewable Electricity Sources (2001–2011)	Total Capacity (GW)		Electricity Production (Thousand MWh)		Capacity Factor (%)	
	2001	2011	2001	2011	2001	2011
Geothermal	2.2	2.4	13,741	15,316	**71%**	**73%**
Wind	3.9	45.2	6,737	120,177	**20%**	**30%**
Solar	0.4	1.5	543	1,818	**16%**	**14%**

The rapid growth in wind energy has improved the outlook for geothermal energy as a form of dispatchable generation and not solely a baseload source. Geothermal energy is “firmly flexible” in nature; i.e., geothermal facilities can potentially offer both stable baseload power or ancillary services and flexible power. Grid operators depend on baseload sources to produce a stable amount of power throughout the day and night for long periods. Grid operators also depend on dispatchable resources to react quickly to changes in demand, supply, or other events in the electric grid. For instance, although a large nuclear or coal power plant provides cheap and reliable baseload power, the plant may have difficulty reacting quickly as demand for power peaks and then declines, increasing production if another generating station unexpectedly shuts down, or decreasing production if a transmission line or large industrial consumer suddenly goes off-line. Geothermal power’s potential to react, such as through load following or droop response with rapid ramp rates (the latter capabilities being dependent on a project’s design), offers significant value to grid operators as they seek to maintain and improve system reliability while encouraging the growth of renewable energy sources. This potential, and especially ancillary services (e.g., voltage regulation), has recently received renewed attention in the media as a result of work supported by both the Geothermal Energy Association (GEA) and industry.[31] Because this apparent trend is a relatively recent change, upcoming Requests for Proposals (RFP) should be examined to see whether they consider this issue.

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[29] (U.S. Energy Information Administration, 2013)
[30] Note: these are national averages which vary regionally. Source: (U.S. Energy Information Administration, n.d.) & (U.S. Energy Information Administration, 2012, p. 256) Note: EIA uses summer net capacity while GEA capacity figures (which are used throughout this report to maintain consistency) are gross output.
[31] (Trabish, 2013) and (Trabish, 2013)

II.1 Recent U.S. Geothermal Projects

As shown in Figure 5, 2009 and 2012 were exceptional years for the U.S. geothermal industry. The 176 MW of geothermal capacity installed in 2009 was the most in recent memory and increased cumulative U.S. capacity by 6 percent, while the 147 MW installed in 2012 increased total U.S. capacity by 5 percent. However, 2009 and 2012's newly installed capacity was spread across just five and six facilities, respectively. An industry with its activity concentrated in such a relatively small number of projects may experience higher than expected capital cost volatility due to project-specific factors.

Indeed, 2010 and 2011's low levels of deployment are indicative of the challenges facing the geothermal industry. Geothermal energy projects face significant permitting, financial, and resource confirmation risks. Activities in 2010 and 2011 should also be viewed in the context of the adverse economic conditions occurring during the economic downturn of 2008 and 2009, whereas projects that came online during 2009 were likely financed and under construction before the recession. To put this issue in perspective, assuming a 7-year development period for a project that came online in 2009, the developer may have begun survey and exploration work in 2003 and 2004, proceeded to test drilling and regulatory reviews in 2005 and 2006, drilled production and injection wells in 2006 and 2007, and completed the facility's infrastructure in 2008 and 2009.[32] However, changes in the wider financial markets, such as the financial turmoil seen in 2008 and 2009, may have had significant impacts on projects that would have been completed in 2010 and 2011.

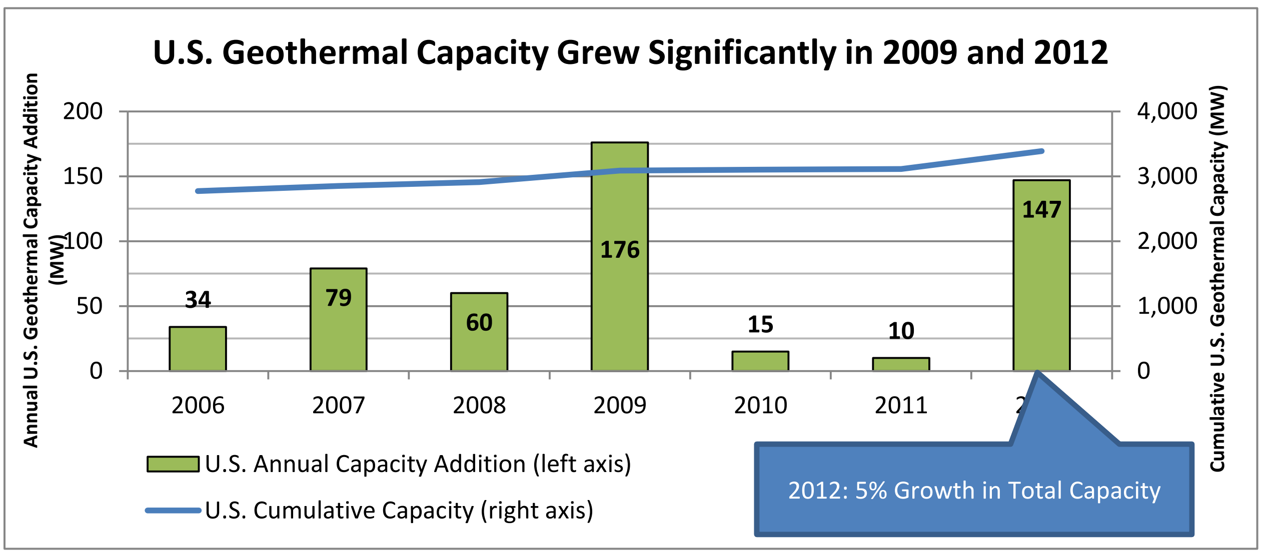

Figure 5 U.S. Annual and Cumulative Geothermal Capacity (2006–2012).[33]

[32] (World Bank Group, Energy Sector Management Assistance Program (ESMAP), 2012, p. 52)
[33] (Geothermal Energy Association, 2013, p. 9)

Table 2 summarizes the 14 U.S. utility-scale geothermal installations representing a combined 347 MW that came online between 2009 and 2012. Several notable facilities include:

- In 2009, Enel North America's Stillwater facility was the world's first geothermal-solar hybrid facility.[34] The facility incorporates 47 MW of geothermal capacity from 2009, 26 MW_{DC} of solar photovoltaic (PV) capacity from 2011, and 4 MW of geothermal capacity from 1989. Combining geothermal and solar PV capacity has several key attributes, especially in the U.S. southwest. Electricity production by an air-cooled power plant is significantly degraded by high air temperatures. High temperatures also strain the electric grid due to increased demand. PV-geothermal hybrid installations allow partial offset of a decline in production precisely when power production is most valuable to the grid operator. An additional (although non-technical) advantage of hybrid facilities is that the surface-level equipment is more readily visible to the public, potentially increasing public awareness of and support for further geothermal development. In part owing to the success of the PV-geothermal hybrid, Enel is also developing a geothermal Concentrating Solar Power (CSP) system at the Stillwater facility.[35] In addition, Stillwater and its companion facility, Salt Wells, are the first in the world to use large-scale submersible electric motors.

- In 2012, EnergySource LLC's John L. Featherstone 49.9 MW facility (also known as Hudson Ranch 1), which uses a triple flash project design, was the only U.S. utility-scale flash plant to enter service over the entire 2009 to 2012 period. Featherstone was somewhat unusual in securing a $15 million debt financing from the Icelandic bank Glitnir (now Islandsbanki) to conduct its test-drilling phase.[36] Featherstone is also the first new stand-alone geothermal facility in California's Salton Sea in more than 20 years; it will supply brine to Simbol Materials' lithium extraction facility (see page 40 for more information on Simbol Materials).

[34] (Fehrenbacher, 2011)
[35] (Clean Energy Action Project, n.d.)
[36] (Lowder, 2012)

Table 2 Utility-Scale U.S. Geothermal Installations Entering Service 2009–2012.[37]

Project Name	Location	Initial Installed Capacity (MW)[38]	Start of Operation	Technology	Developer	Project Type
John L. Featherstone (Hudson Ranch 1)	Imperial, CA	49.9	2012	Flash	EnergySource	Greenfield
Neal Hot Springs	Malheur, OR	30.1	2012	Binary	U.S. Geothermal	Greenfield
McGinness Hills	Lander, NV	30	2012	Binary	Ormat	Greenfield
Tuscarora	Elko, NV	18	2012	Binary	Ormat	Greenfield
San Emido Repower	Washoe, NV	12.75	2012	Binary	U.S. Geothermal	Expansion
Dixie Valley	Churchill, NV	6.2	2012	Binary	Terra-Gen	Expansion
Puna Expansion	Puna (Big Island), HI	8	2011	Binary	Ormat	Expansion
Beowawe 2	Beowawe, NV	1.9	2011	Binary	Terra-Gen	Expansion
Jersey Valley	Jersey Valley, NV	15	2010	Binary	Ormat	Greenfield
Blue Mountain	Humboldt County, NV	50	2009	Binary	Alternative Earth Resources Inc.	Greenfield
North Brawley	Brawley, CA	50	2009	Binary	Ormat	Greenfield
Stillwater	Fallon, NV	47[39]	2009	Binary	Enel North America	Expansion
Salt Wells	Fallon, NV	18	2009	Binary	Enel North America	Greenfield
Hatch	Beaver Creek, UT	10	2009	Binary	Raser Technologies	Greenfield
Total Capacity Installed (2009–2012)		310.55				

[37] (Geothermal Energy Association, 2013), (Geothermal Energy Association, 2012), (Geothermal Energy Association (GEA), 2011), U.S. Federal Energy Regulatory Commission (FERC) filings, company websites, and company press releases.
[38] Initial Installed Capacity as reported by firms to GEA for the purposes of GEA's annual market report. These values do not include later capacity declines subsequent to the plant first entering service, such as those seen at Blue Mountain, North Brawley, etc. In addition, capacities for expansion projects do not include the previously installed capacity (i.e., the value shown is not cumulative).
[39] Not including solar capacity located at the same site.

II.2 Recent U.S. Geothermal Cost Trends

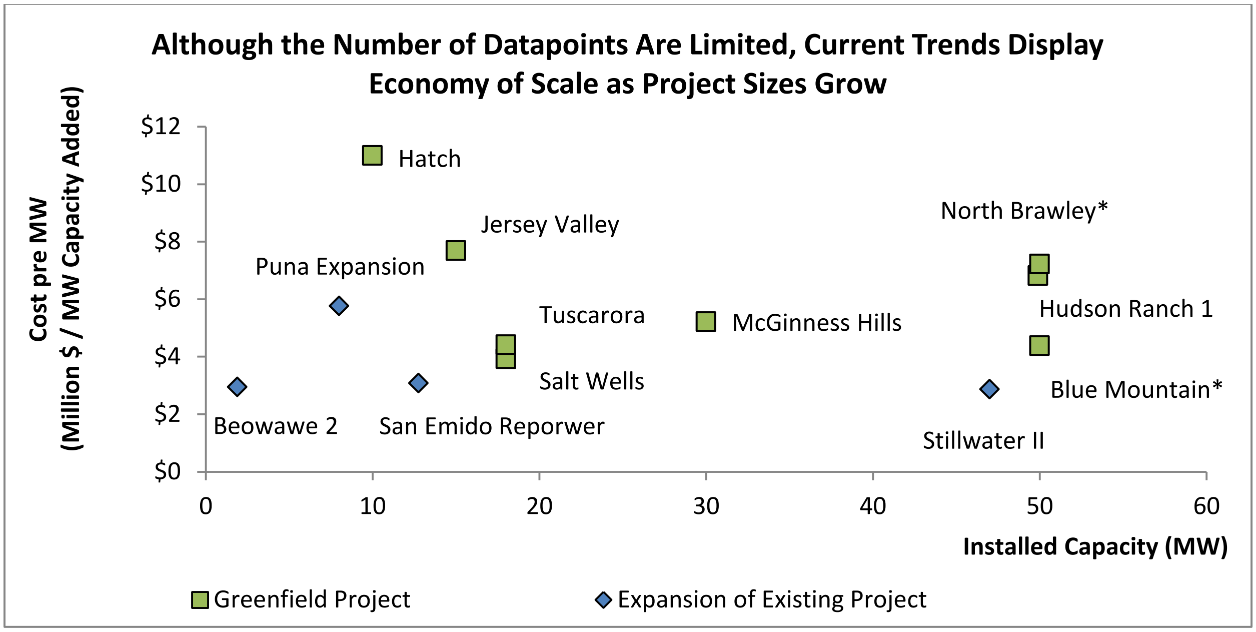

Figure 6 Installed Cost Per MW for U.S. Utility-Scale Geothermal Projects (2009-2012).[40]

Figure 6 and Table 3 compare the cost per MW ($/MW) of recent U.S. geothermal installations with each project's overall capacity. Figure 6 was created using publicly available data from the U.S. Treasury's Sec. 1603 grant database as of February 19, 2013. Sec. 1603 grant values are set using documentation submitted by a project developer to establish an approved total "cost basis" under the Internal Revenue Code (IRC). This approach to using the Sec. 1603 implied total cost basis was a proxy for total project costs, which was recently used in two separate Lawrence Berkeley National Laboratory (LBNL) reports on the solar sector.[41] Although the cost basis treats some costs differently than might be ideal for analytical purposes (e.g., transmission line upgrades are excluded while financing costs may be included based on the project deal's structure), it is essentially the only publicly available data that can be compared across projects. Information from individual developers is likely to be proprietary and may not be comparable to other developers' projects. Finally, the Sec. 1603 dataset is an unusual data source because information relating to more conventional Production Tax Credits (PTC) or Investment Tax Credits (ITC) is held confidential by the U.S. Internal Revenue Service under the IRC.

The Sec. 1603 dataset is too small to allow firm conclusions. While some portions of a geothermal project scale linearly as projects expand in size, other project-related expenses should decline on a $/MW basis as projects expand in size (e.g., regulatory costs, geothermal resource modeling, balance-of-plant systems).

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[40] Gross Capacity data were drawn from (Geothermal Energy Association, 2013), (Geothermal Energy Association, 2012), (Geothermal Energy Association (GEA), 2011), and Company websites. FERC filings were used to confirm the specific legal entity associated with each project, which was then cross-referenced to the U.S. Treasury's public Sec. 1603 database as of 2/19/13. The grant value for San Emido was corrected upward based on U.S. Geothermal's 3/6/13 press release. See Footnote 38 above, to maintain methodological consistency with industry reports, this figure uses the initially expected capacity values. If the present capacities for North Brawley and Blue Mountain were utilized, those projects would display increased $/MW values.

[41] See (Barbose, et al., 2012, p. 7) and (Feldman, et al., 2012, p. 21)

Figure 6 also shows that expansion projects are consistently less expensive than "greenfield" projects on a $/MW basis. This is not surprising given that expanding an existing project avoids or significantly decreases infrastructure costs; however, such projects frequently still require long periods of time for regulatory and National Environmental Policy Act (NEPA) reviews. Reinvestment in existing geothermal fields provides a cost-effective route for expanding geothermal capacity and offers a nearer-term proving ground for EGS technologies.

Table 3 Utility-Scale U.S. Geothermal Installations Entering Service for 2009–2012 with Associated Cost Information.[42]

Project Name	Location	Initial Installed Capacity (MW)[38]	Year	Technology	Project Type	1603 Grant ($M)	Implied Total Cost Basis ($M)	Implied $/MW ($M)
John L. Featherstone (Hudson Ranch 1)	CA	49.9	2012	Triple Flash	Greenfield	$102	$340	$6.82
McGinness Hills	NV	30	2012	Binary	Greenfield	$47	$156	$5.22
Tuscarora	NV	18	2012	Binary	Greenfield	$24	$79	$4.41
San Emido Repower	NV	12.75	2012	Binary	Expansion	$12	$39	$3.07
Puna Expansion	HI	8	2011	Binary	Expansion	$14	$46	$5.76
Beowawe 2	NV	1.9	2011	Binary	Expansion	$2	$6	$2.95
Jersey Valley	NV	15	2010	Binary	Greenfield	$35	$115	$7.69
Blue Mountain	NV	50	2009	Binary	Greenfield	$66	$219	$4.38
North Brawley	CA	50	2009	Binary	Greenfield	$108	$361	$7.22
Stillwater	NV	47	2009	Binary	Expansion	$40	$134	$2.86
Salt Wells	NV	18	2009	Binary	Greenfield	$21	$71	$3.93
Hatch	UT	10	2009	Binary	Greenfield	$33	$110	$11.00

[42] See citations for Figure 6.

Recent Geothermal Technologies Office Accomplishments

The following are selected examples of recent GTO-funded project successes:

- **Enhanced Geothermal Systems:** The EGS demonstration project at the Geysers in California—the first-ever sustained EGS demonstration at commercial scale in the nation—proved that a manmade reservoir can be created in impermeable rock via injection of fluid into an unproductive portion of a natural reservoir. This project has the potential to produce 5 MW from the newly created reservoir. Also, the EGS Desert Peak project completed successful stimulation of an existing sub-commercial well and became the first EGS project in America to generate commercial electricity, by providing an additional 1.7 MW at the existing well field, a 38-percent increase in capacity.

- **Hydrothermal/Low-Temperature Resources:** For the first time (both for the technology and for this project)), the Beowawe low-temperature demonstration project in Nevada showed that production from bottoming-cycle, low-temperature resources (at 205° F) is economically feasible and can be a viable contributor to the geothermal and renewable energy mix. This binary plant is the first high-output refrigeration-based waste heat recovery cycle in the industry.

- **Systems Analysis:** The U.S. Department of Energy (DOE) has taken the global lead in establishing an Induced Seismicity Protocol, which assesses the impacts of induced seismic events and establishes procedures that ensure safety at injection sites. The National Research Council has recommended the Protocol as a "best practice" document for use by all other subsurface technologies.

II.3 U.S. Oil, Natural Gas, and Geothermal Drilling

Because of the small number of geothermal wells drilled per year compared with the oil and gas industry, and the proprietary nature of the cost information associated with them, it is difficult to collect actual cost data on recent geothermal well drillings (as opposed to published results from cost models). However, the 2006 MIT study on EGS systems did compile a reasonably complete dataset covering 34 geothermal wells drilled between 1972 and 2004. This dataset is presented in Figure 7. In general, geothermal wells are slightly more expensive to drill than oil and gas wells of the same depth. This is expected, given the exponentially greater number of oil and gas wells drilled per year, geothermal wells' wider diameter to accommodate higher fluid flow rates (i.e., the well-bore has a larger circumference to allow more fluid to flow, a necessity given that water is less valuable per unit of volume than hydrocarbons), and the fact that geothermal wells must usually be drilled through higher-temperature heterogeneous rock formations than oil and gas wells.

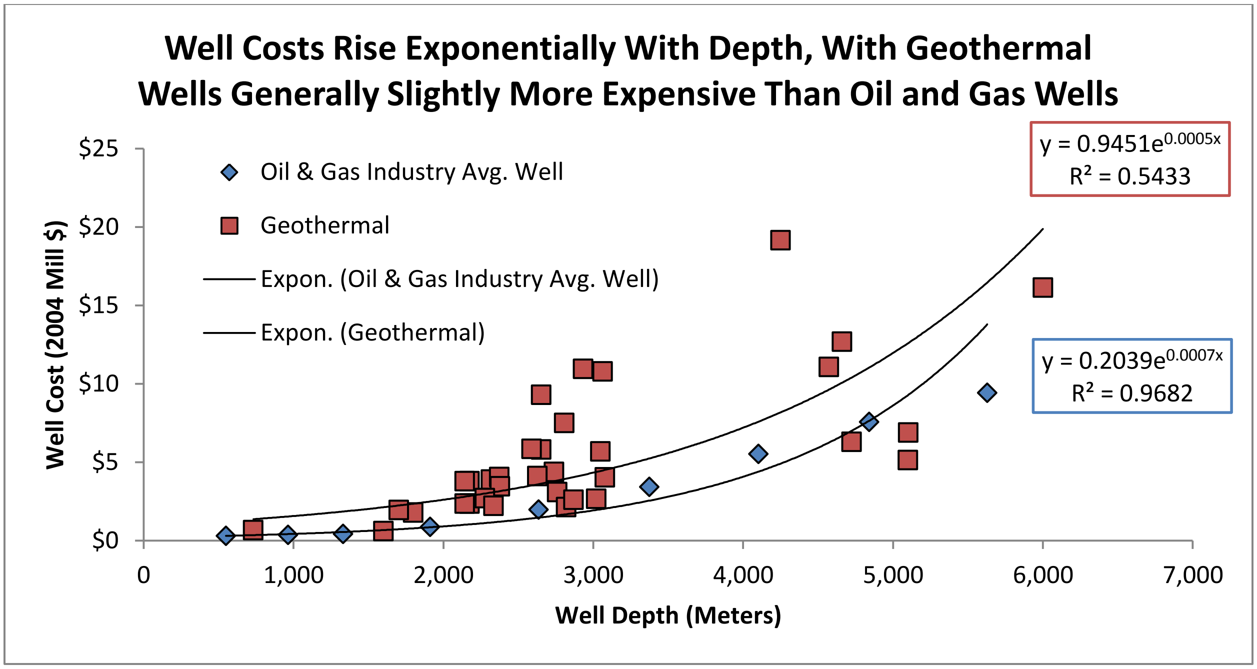

Figure 7 Geothermal and Oil and Gas Industry Average Well Costs Compared With Well Depth.[43]

The U.S. drilling industry is almost exclusively devoted to the oil and gas industry, so geothermal drilling costs are deeply interrelated with trends in the oil and gas market. For context,

Figure 8 and Table 4 compare the number of active oil, gas, and geothermal drilling rigs while Figure 9 summarizes the number of active U.S. geothermal drilling rigs by trajectory type (i.e., vertical, horizontal, directional). Over the past few years, the number of active drilling rigs in the United States has oscillated between a more than 20-year high of 2,000 active drilling rigs of all types in September 2008, to a low of 1,000 in mid-April 2009, which was followed by a rapid recovery projected to continue through the end of 2014.[44] Recent application of new drilling technologies has increased natural production. However, the decline in natural gas drilling rigs has been more than made up for by a boom in oil drilling.

[43] (MIT Energy Initiative, 2006, pp. 6-33, 6-34). Data for modeled wells have been excluded
[44] (Baker Hughes, n.d.).

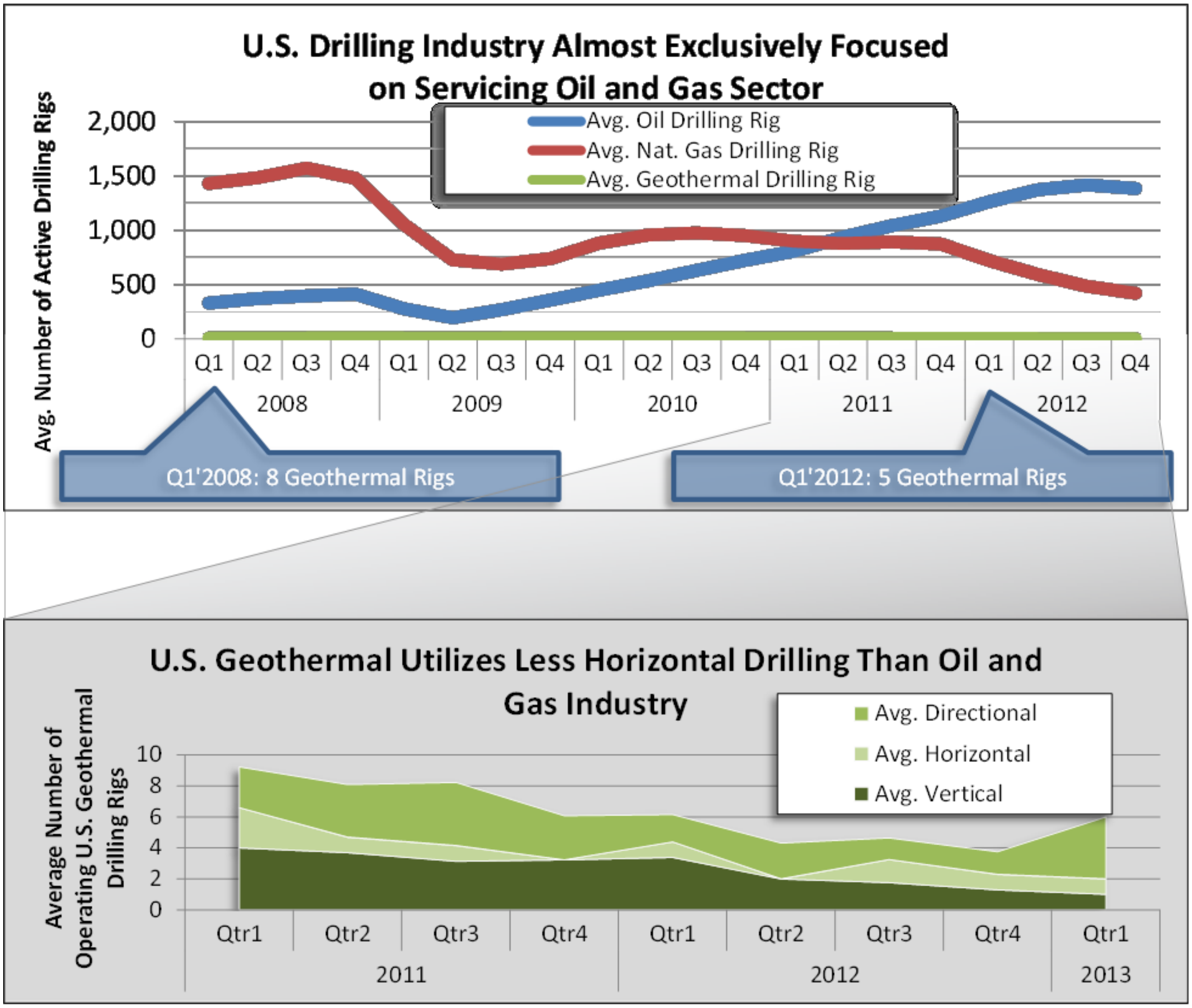

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Figure 8 (upper). Avg. Number of Operating U.S. Oil, Natural Gas, and Geothermal Drilling Rigs by Quarter (2008-12).

Figure 9 (lower) Active. Geothermal Drilling Rig by Trajectory (Q1 2011–Q1 2013).[44]

Table 4 Quarterly Avg. of Weekly Number of Active U.S. Oil, Natural Gas and Geothermal Drilling Rigs (Q1 2008–Q4 2012).[45]

Year	Qtr	Average Number of Oil Drilling Rigs	Average Number of Natural Gas Drilling Rigs	Average Number of Geothermal Drilling Rigs
2008	Q1	332	1,430	8
	Q2	372	1,483	9
	Q3	398	1,571	10
	Q4	414	1,479	11
2009	Q1	279	1,053	12
	Q2	196	729	10
	Q3	270	689	11
	Q4	359	738	11
2010	Q1	450	882	13
	Q2	536	957	12
	Q3	631	977	11
	Q4	725	952	10
2011	Q1	808	900	9
	Q2	938	880	8
	Q3	1,043	894	8
	Q4	1,130	874	6
2012	Q1	1,262	722	5
	Q2	1,373	593	4
	Q3	1,417	486	3
	Q4	1,383	423	2

[45] (Baker Hughes, n.d.). Assumed "miscellaneous" drilling projects were geothermal, which was the same methodology used in (Taylor, 2012). Confirmed methodology (for U.S. data) with Baker Hughes via telephone conversation with Holcomb, Eric on 4/10/13.

Although recent data on geothermal well drilling costs are not available, it is likely that costs have increased over the last 2 years because of underlying changes in the broader drilling industry.[46] While it is likely difficult to convert drilling rigs themselves between geothermal and oil or gas drilling, many of the cost drivers for geothermal, oil, and gas wells are the same. The price of steel for well casings, drilling mud, third-party service providers, wages for skilled drill technicians, etc., affect the geothermal, oil, and gas industries generally. As shown in Figure 10, the non-seasonally adjusted oil and gas drillers Producer Price Index (PPI) rose 28 percent between September 2009 and September 2012. The large increase earlier in the decade is largely attributed to the scarcity of steel and cement and increased rig rentals caused by high crude oil and natural gas prices (which led to increased demand for oil and gas drilling).[47] Although this trend affects geothermal drilling costs, the effect is probably more muted than the rise shown in Figure 10 would lead one to believe. Underlying the increase in the oil and gas driller's PPI is a long-term shift away from vertical and toward horizontal well drilling. Horizontal drilling increased from 10 percent of oil and gas wells at the beginning of 2005 to 61 percent in June 2013. (Directional drilling also decreased from 25 percent to 15 percent over the same period).[48] Horizontal drilling involves a wellbore "drilled vertically to a kickoff depth above the target formation and then angled through a wide 90-degree arc such that the producing portion of the well extends horizontally through the target formation." [49] Directional drilling involves "drilling at an angle from a surface location to reach a target formation not located directly underneath the well pad,"[50] often with rapid changes in direction over the course of just a few feet and at times, allowing drilling of several wells from the same well pad.

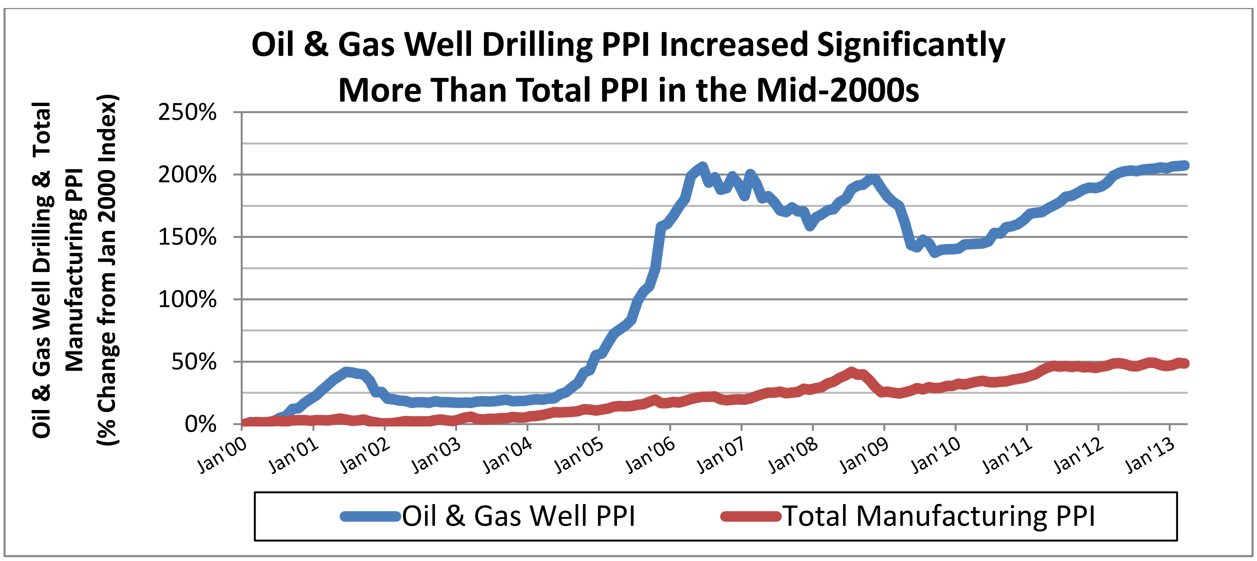

Figure 10 Oil and Gas Well Drilling PPI Index Compared With Total Manufacturing PPI (January 2000–March 2013).[51]

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[46] (Mansure & Blankenship, 2011), also mirrors underlying methodology in the Geothermal Electricity Technology Evaluation Model (GETEM) model that the oil and gas driller's PPI related to geothermal drilling (Augustine, 2011).
[47] (Augustine, et al., 2010, p. 7)
[48] (Baker Hughes, n.d.)
[49] (U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory, 2009, p. 82)
[50] (U.S. Department of Energy Office of Fossil Energy and National Energy Technology Laboratory, 2009, p. 81)
51 (U.S. BLS, n.d.) PCU: 213111213111 and PCU: OMFG.

II.4 International Geothermal Capacity

International markets, such as Indonesia, New Zealand, Kenya, and others have seen significant geothermal growth in recent years. While the United States leads the world in existing installed geothermal capacity, that capacity has remained relatively flat from 1990 to 2011, although increases in 2009 and 2012 have begun to overcome this long-term trend. New U.S. installations in the 1990s and early to mid-2000s have largely been limited to counteracting declines in already operating cumulative capacity.[52] However, international market activity has increased, as outlined in Table 5 and Figure 11. Electricity is produced using geothermal energy in approximately 25 nations, with more than 45 additional nations using direct-use geothermal capacity, as well as at least 20 nations having identified geothermal resources.[53] International growth in geothermal energy is driven by a desire to ensure national energy and economic security, as well as a wide range of other factors affecting a nation's development patterns. Among this broad array of nations, a few stand out:

- The United States and Philippines, with more than 3,386 and more than 1,900 MW of geothermal capacity, respectively, lead the world in total installed capacity. [54]
- With approximately 25 percent of their electricity supply generated with geothermal energy, Iceland and El Salvador lead the world in utilization of geothermal as a share of their electricity supply. Iceland has 1.92 MW of geothermal capacity per capita versus El Salvador's 0.03 MW per capita. (Iceland has a significantly smaller population that consumes significantly more electricity than El Salvador.)[55] Although Iceland began deploying geothermal energy more than 30 years ago, it added significant capacity during the 2000s, including during the economic crisis of 2008, to diversify away from hydroelectricity.[56]
- Japan is motivated to develop its geothermal resources by a strong desire to hedge or protect its economy from energy price shocks—a virtual necessity given that a large share of its electricity is generated from imported fuels. Japan is the world's third largest net importer of oil, second largest importer of coal, and the largest importer of liquefied natural gas.[57] This economic reality has been exacerbated by the decline in nuclear energy production following the 2011 Fukushima Daiichi disaster.[58] As a result, while Japan is offering generous Feed-In-Tariffs (FIT) for geothermal energy, there are also market barriers for entry into the Japanese market, especially because the Japanese energy industry partially deregulated only relatively recently. [59]
- With approximately 28 GW of geothermal resource potential and 1.18 GW of operating geothermal capacity,[60] Indonesia has enormous potential for growth. However, regulatory uncertainty regarding whether the state electric utility is bound to purchase electricity under Indonesia's FIT is expected to be an issue in the short term.[61]
- With support from the World Bank, German Development Bank (Bank aus Verantwortung (KFW)) and its own national government, Kenya has emerged as a leader in the development of

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[52] (Doris & and Young, 2009, p. 9)
[53] (World Bank Group, Energy Sector Management Assistance Program (ESMAP), 2012, p. 22)
[54] (World Bank Group, Energy Sector Management Assistance Program (ESMAP), 2012, p. 22)
[55] (Central Intelligence Agency (CIA), n.d.) and (Central Intelligence Agency (CIA), n.d.)
[56] (World Bank Group, Energy Sector Management Assistance Program (ESMAP), 2012, p. 22 and 24)
[57] (U.S. Energy Information Administration, 2012)
[58] Ibid.
[59] (Fukushima, 2012), (Semmler, 2012, p. 20), and (European Trade Comission, p. 5)
[60] (Stopforth, 2013)
[61] (Taylor, 2012) and (Taylor, 2012)

geothermal energy. With approximately 10 GW of geothermal resource potential and approximately 200 MW of operating geothermal capacity, Kenya also has significant potential for growth.[62] Kenya is using a public–private partnership model with the Geothermal Development Company—a public company focused on exploring and developing geothermal resources and assuming responsibility for the highest risk development stages. Private developers are expected to complete projects and use a FIT to support long-term operation.

- Canada has significant geothermal resource potential, but no operating geothermal power plants as yet. There are several Canadian firms with international geothermal experience, international players with Canadian subsidiaries, and a recently formed (2007) geothermal industry association. Certainly the remoteness of some potential development sites, combined with the low price of competing electricity sources, form part of the barrier to developing Canada's first geothermal power installation. Even so, the Canadian geothermal energy pipeline spans seven potential projects at various stages of development. Interestingly, while British Columbia is the only Canadian province to have enacted a specific legal framework facilitating geothermal development, Borealis GeoPower's 0.6 MW Fort Liard project in the Northwest Territories and Deep Earth Energy Production Corporation's (DEEP) 5 MW Rafferty project in Saskatchewan are seen as close to fruition. In addition to this development activity, the industry association has recently issued reports on the overall sector in Canada, supply chain, and maps of geothermal resource potential. Although the Canadian geothermal industry is still nascent and faces a steep climb given its first-of-a-kind status in Canada, its strong underlying fundamentals stimulate optimism for the long-term future.[63]

Table 5 Global Installation of Geothermal Energy Capacity by Country by Year (2006–2012).[64]

Geothermal Installation (MW)	2006	2007	2008	2009	2010	2011	2012	Total (2006–2012)
United States	34	79	60	176	15	10	147	521
Indonesia	0	170	0	137	0	25	170	502
New Zealand	97	17	134	0	163	0	20	432
Kenya	0	2	48	0	35	0	5	90
Philippines	142	0	20	0	0	0	0	162
Mexico	100	0	0	0	0	0	50	150
Rest of world	294	177	47	85	59	132	76	870
Total	**667**	**445**	**310**	**398**	**272**	**167**	**469**	**2,727**

[62] (Stopforth, 2013)
[63] (Richter, 2013) and (Grasby, et al., 2012)
[64] (Taylor, 2012) Data for United States (and as a result Total) adjusted to conform to GEA annual market reports.

Figure 11 displays the 2010 cumulative installed geothermal capacity and geothermal as a percentage of total electricity generation. While the United States leads the world in total geothermal capacity, geothermal energy supplies only about 0.4 percent of U.S. electricity. El Salvador, Iceland, and the Philippines use geothermal more intensely by supplying 25.5, 24.5, and 17.6 percent of each nation's electricity supply, respectively. Of course, it is important to note that their total populations and electrical demand are significantly smaller than those of the United States.

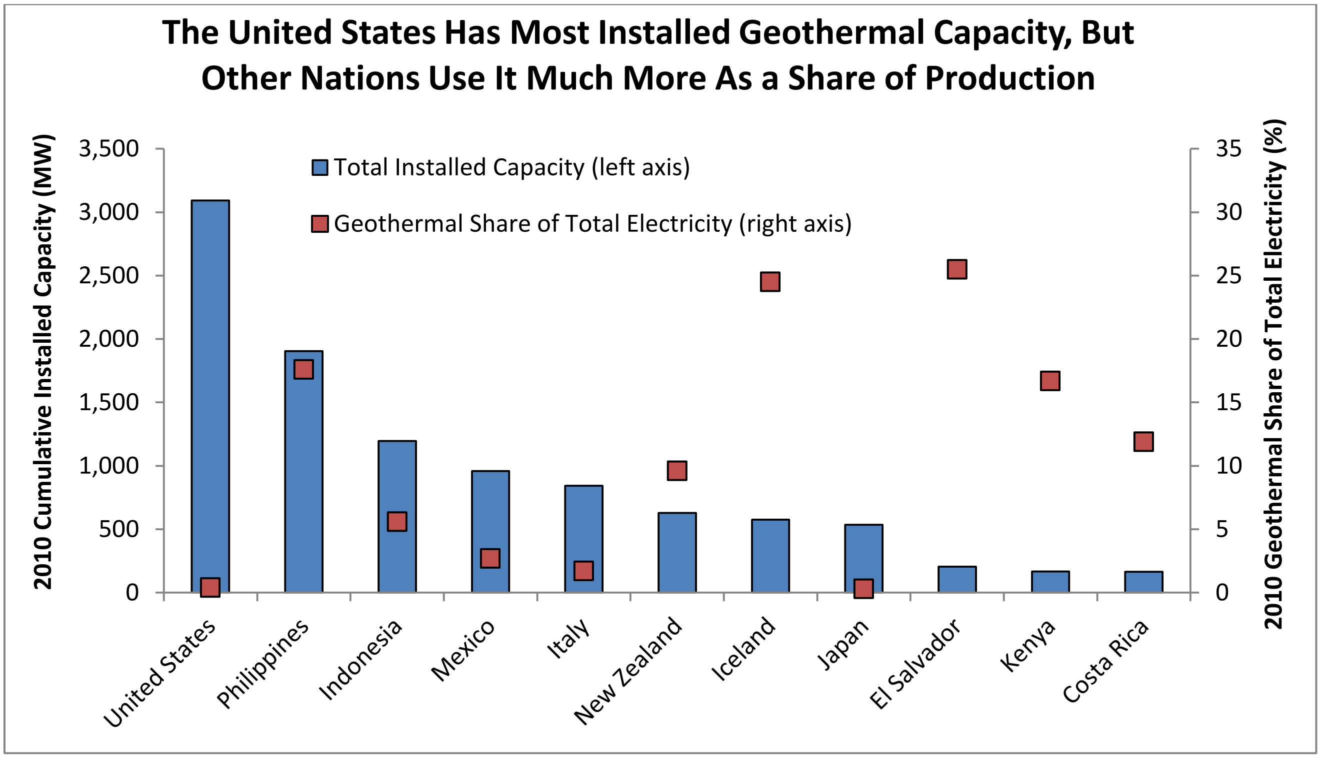

Figure 11. 2010 Total Installed Capacity and Geothermal Electricity as a Share of Total Generation for Selected Countries.[65]

II.5 Geothermal Direct-Use Technologies

Geothermal direct-use technologies do not attract as much attention as other geothermal technologies. Direct-use technologies can and have been used for myriad purposes, including heating and cooling entire neighborhoods, growing plants, pasteurizing milk, and keeping roads and sidewalks clear of snow. While direct-use installations are inherently limited by the need for demand to be collocated with the geothermal resource, they are also inherently more efficient than alternative approaches. Direct-use technologies span a wide range of applications. Ground source heat pumps use closed loops running through shallow wells. Other direct-use technologies most closely resemble geothermal electric systems, except the heat is used for a purpose (e.g., heating aquaculture ponds or greenhouses, drying crops) other than spinning an electric generator. Resources and their intended use align by temperature. For instance,

[65] (World Bank Group, Energy Sector Management Assistance Program (ESMAP), 2012, p. 24)

the coolest resources, starting at about 70° F, align with the snow-melting, aquaculture, and bathing. Warmer resources of about 150° F are useful for concrete curing or some forms of food processing. Higher temperature resources of between 250° F and 350° F can actually be used for refrigeration and ice making.[66]

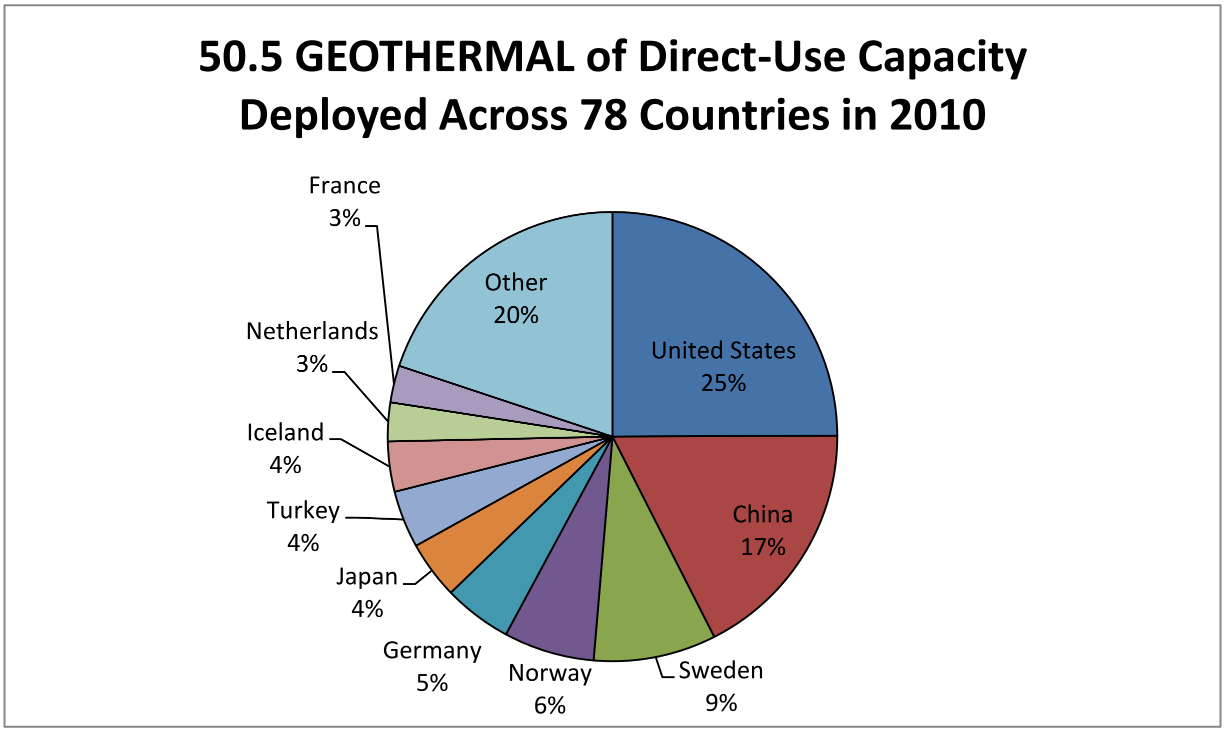

Figure 12 Global Geothermal Direct-Use Capacity by Country. [68]

Direct-use technologies represent roughly 50.5 GW_t of global capacity. Direct-use geothermal facilities have up to a 70-percent systems-level thermal efficiency. By comparison, a geothermal electric system has a lower thermal efficiency (between 5 percent for binary and 20 percent for higher-temperature flash or dry steam); while a conventional coal facility has a thermal efficiency of 34 percent.[67] [68]

The U.S. leads the world with 25 percent of global direct-use capacity as shown in Figure 12. As shown in Figure 13, the majority of recent direct-use capacity growth is attributable to ground source heat pumps.

[66] (Lund, 2011)
[67] (U.S. Energy Information Administration, 2013)
[68] (Lund, et al., 2010)

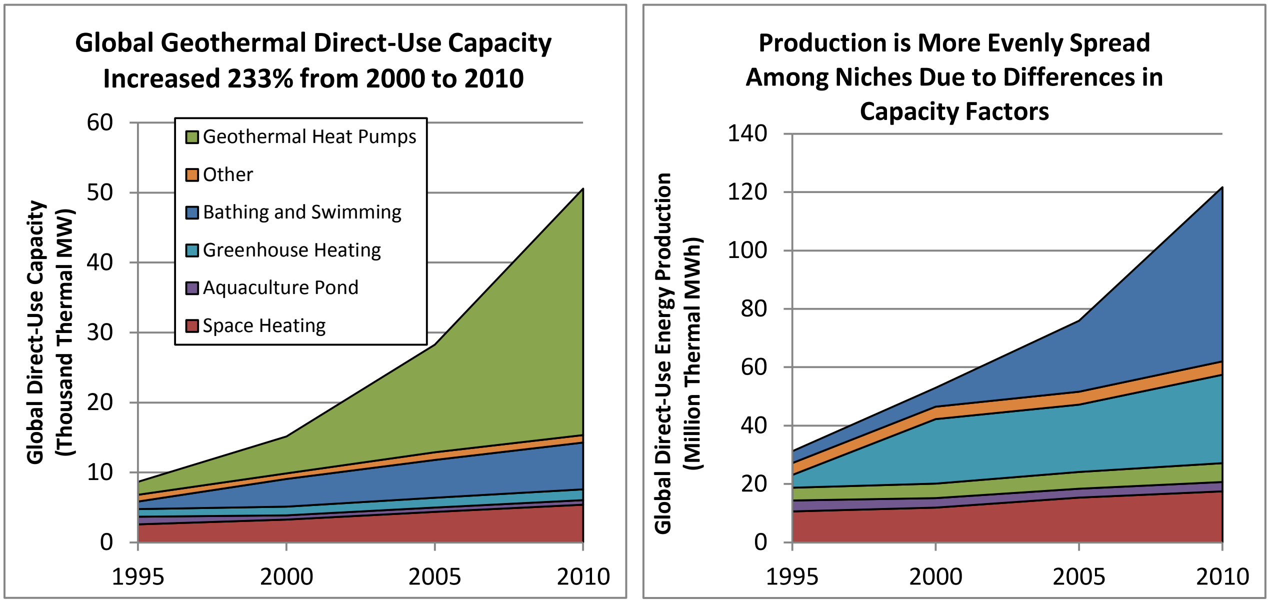

Figure 13 Global Geothermal Direct-Use Capacity and Energy Production (1995–2010).[70]

Several recent projects funded by the Recovery Act have enabled new large ground source heat pump installations. For instance, in 2012, Ball State University in Muncie, Indiana, completed work on the largest geothermal heating and cooling system in the United States. This system uses 3,600 boreholes that will heat and cool 47 buildings on 5.5 million square feet across a 660-acre campus. This has enabled the University to retire four coal-fired boilers, saving an estimated $2 million in annual operating costs and reducing the campus' carbon footprint by nearly 50 percent.[69] [70]

II.6 Global and U.S. Turbine Market Share Trends

As shown in Figure 14 the global cumulative geothermal turbine market has changed considerably over time. Telent PLC, of New Zealand, dominated the much smaller geothermal industry of the 1960s, followed by Mitsubishi Heavy Industries growth through the 1970s and early 1980s. Ormat's growth since the late 1980s has been particularly notable, signifying a shift towards lower temperature technologies. In 2012, Ormat accounted for 27 percent of cumulative global turbine capacity, compared to 26, 18, and 15 percent for GE Energy, Mitsubishi Heavy Industries, and Toshiba Power Systems, respectively.

As shown in Figure 15, the U.S. geothermal turbine market displays many of the same dynamics as the global industry. For instance, Ormat's U.S. market share has grown significantly since 1990, from 13 to 24 percent in 2012. No other major turbine manufacturer grew its U.S. market share over that time-period, indicating a long-term shift towards binary turbines in the U.S. Ormat's U.S. market share slightly lags its global market share, highlighting the global nature of its project development pipeline. In addition,

[69] (U.S. DOE, Office of Energy Efficiency and Renewable Energy, 2012)
[70] (Lund, et al., 2010)

Mitsubishi Heavy Industries' approximate 5 percent U.S. market share from 1990 to 2012, significantly lags its global market share over that same time.

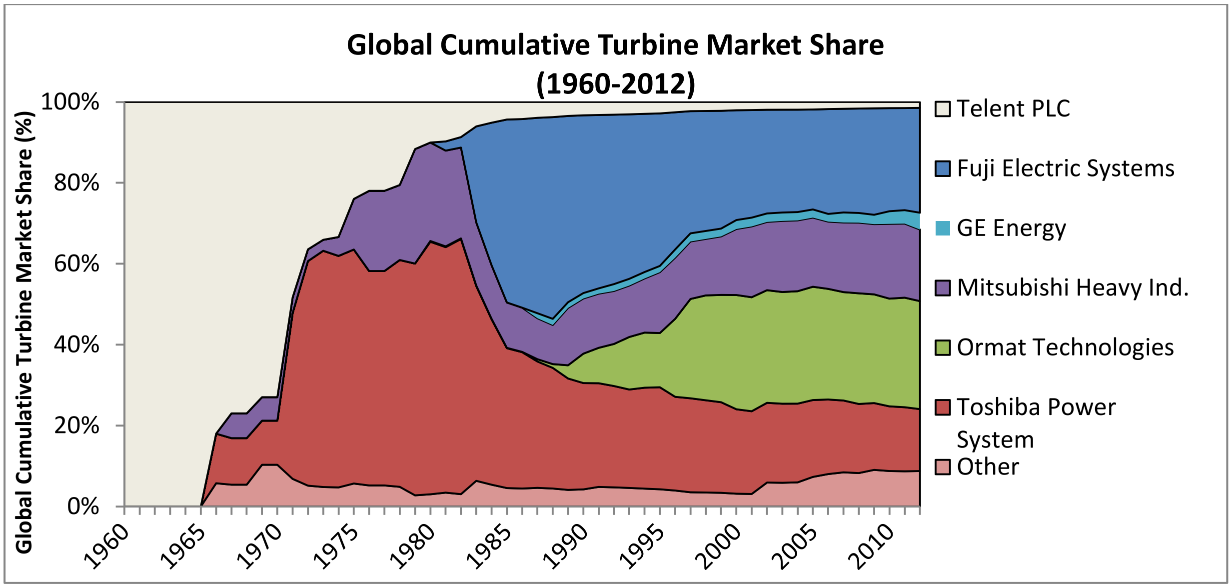

Figure 14 Global Cumulative Turbine Market Share (1960-2012).[71]

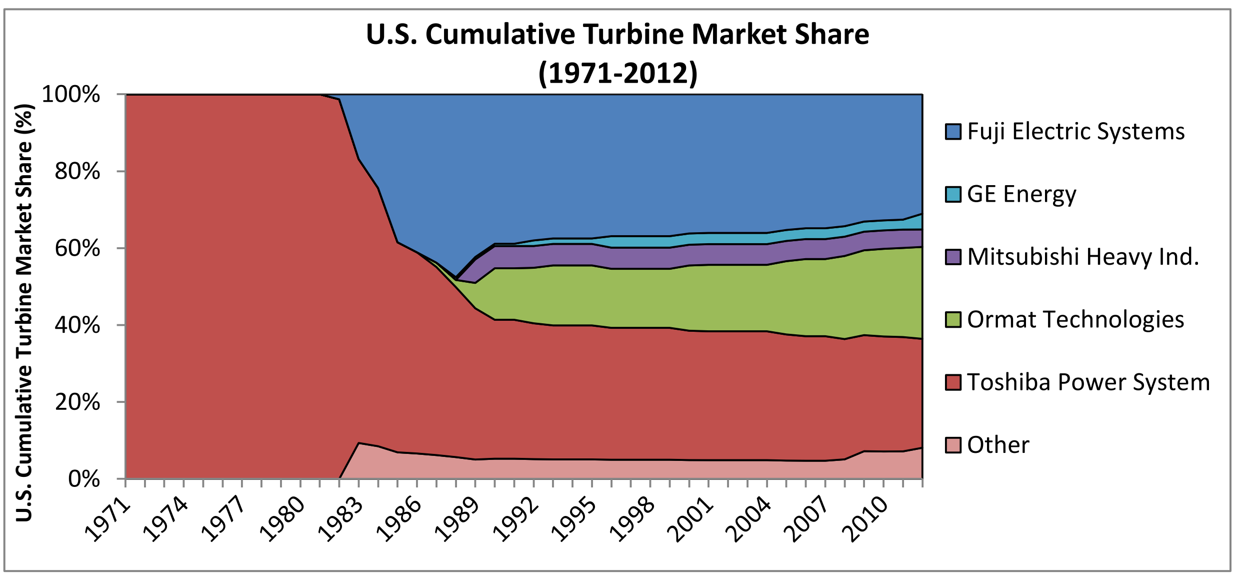

Figure 15 U.S. Cumulative Turbine Market Share (1971-2012).[72]

[71] (Bloomberg New Energy Finance, n.d.) and analysis performed by Christopher Richard (BCS).
[72] Ibid.

III. Geothermal Investment Trends

III.1 U.S. Investment

This section explores capital investment in geothermal energy, including debt, asset finance, mergers and acquisitions (M&A), public equity, venture capital (VC), and private equity (PE). As shown in Figure 16, U.S. geothermal investments saw a significant one-time increase in 2008 debt transactions largely because of a single $6 billion credit facility related to Calpine's financial reorganization. U.S. geothermal investments have largely mirrored global investment trends, with strong though variable aggregate annual investment levels in 2007 through 2011, followed by a significant decline in 2012.

The U.S. market's debt and asset finance shares are somewhat difficult to examine because of the size of the 2008 Calpine transaction. If the 2008 Calpine debt transaction is included, then cumulative 2007 through 2012 U.S. geothermal debt transactions comprise 60 percent of total U.S. geothermal debt volume; however, if it is excluded, then debt shrinks to just 9 percent of total U.S. geothermal debt volume.

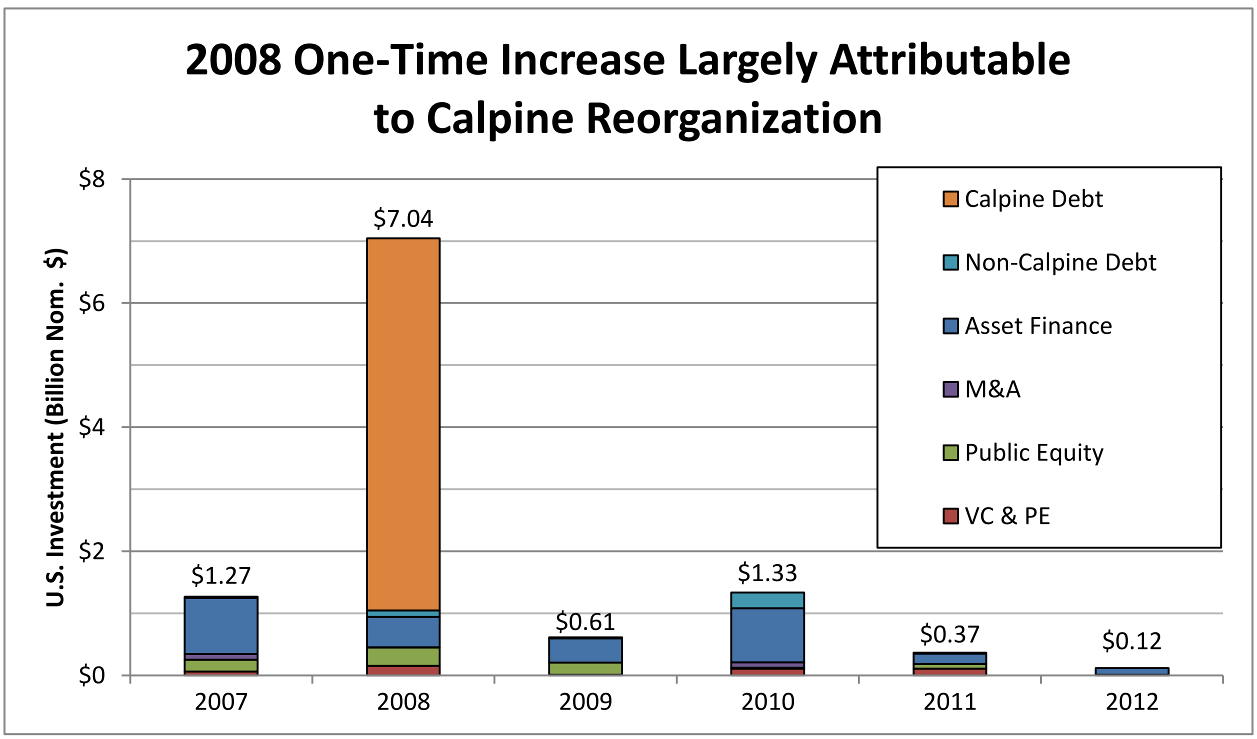

Figure 16 U.S. Geothermal Investment 2007–2012.[73]

[73] (Bloomberg New Energy Finance, 2013) Figure excludes government research and development; however Bloomberg NEF does include finalized Sec. 1705 loan guarantees as asset finance transactions. Data for recent time periods is often revised by Bloomberg NEF as financial terms for recent deals are disclosed.

While a decline in U.S. investment in 2012 is shown in Figure 16, there are a number of factors to take into account. For instance, all of the U.S. projects completed in 2012 were financed under transactions closed in prior years, so slowdowns in actual development work in the field likely follows a slowdown in project and developer financings.[74] In interviews, industry participants noted difficulties in gaining access to capital during the resource exploration phase of a project, as well as difficulties gaining permits and PPAs, especially in Nevada and California. In 2011, geothermal projects accounted for 1,300 MW of applications to the California Independent Systems Operator (ISO) interconnection queue, but fell to 144 MW by mid-2013.[75] As the grid operator, Cal ISO's interconnection queue indicates the near-term geothermal development pipeline in California has shrunk considerably compared with just a few years ago. Geothermal energy projects' higher capacity and availability factors, as well as lower grid infrastructure-related costs compared with other renewable energy sources, are not fully integrated during an electric utilities project selection process.

Geothermal energy can act as both a renewable baseload and a load-following resource. California Public Utility Commission staff publicly stated in June 2013 that geothermal energy's flexibility will become increasingly valuable in coming years. This change is driven by the need for dispatchable generation, which can provide ancillary services, especially in early evenings during the fall and spring months when the decline in solar generation precedes the decline in demand (i.e., the solar production curve peaks before the demand curve).[76]

Several factors are worth considering that would support future U.S. industry growth. Chevron announced in October 2012 that it was reentering the U.S. geothermal market as a strategic partner (i.e., not as a standalone developer).[77] Vendor financing, in which a large and well-capitalized supplier offers attractive financing terms, may allow geothermal developers to access lower-cost capital than they would otherwise. For instance, in 2010, Siemens was a member of the syndicate that provided $400 million in asset financing for the 49.9 MW John L. Featherstone facility, while SAIC provided $36 million in asset financing for the 13 MW San Emidio I facility.[78] Firms such as Mitsubishi and Fuji have made similar forays into international markets to finance geothermal projects.

In a related but separate topic, the U.S. tax equity market is expected to continue its rebound from its 2009 low. Cumulative U.S. tax equity investment for renewable energy increased from $1.2 billion in 2009, to $3.7 billion in 2010, to $6 billion in 2011, but then declined to $2.5 billion in 2012, reported to be largely owing to fears that the wind PTC would not be extended.[79] Although demand is expected to continue to outstrip the supply of tax equity investment for renewable energy, there are three notable geothermal examples. In 2011, J.P. Morgan Capital invested $25 million in Ormat's portfolio of Nevada projects, and in 2012, Chevron invested $99 million into the Featherstone project.[80] The Featherstone project also received $300 million of debt finance and $100 million of equity investment from GeoGlobal Energy, LLC, which is backed by Mighty River Power of New Zealand.

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[74] (Geothermal Energy Association, 2012) and (Bloomberg New Energy Finance, 2013)
[75] (California ISO, n.d.) and (Trabish, 2013)
[76] (Elder, 2012), (Trabish, 2013), and (Crawford, 2012)
[77] (Crawford, 2012)
[78] (Geothermal Energy Association (GEA), 2012) compared with (Bloomberg New Energy Finance, 2013)
[79] (Mintz, Levin, Cohn, Ferris, Glovsky and Popeo, P.C., 2012, p. 17) and (Chadbourne & Parke LLP, 2013, p. 1)
[80] (Bloomberg New Energy Finance, 2013)

Large profitable firms are able to use tax equity internally while smaller developers must incur high process costs to create a specialized tax equity partnership structure with another firm. That said, geothermal energy does have one major advantage in its competition with wind energy for the limited supply of tax equity investment. Geothermal energy's higher and more stable capacity factor means that a given amount of geothermal capacity will generate significantly more energy per year, thus yielding a larger PTC value. However, this advantage may be difficult to capitalize on because of the limited supply of tax equity investment.

III.2 Non-U.S. (International) Investment

As shown in Figure 17, international geothermal investments (excluding U.S.) grew significantly—reaching a peak of $3.6 billion in 2008—followed by a decline and then a partial recovery. From 2009 to 2011, international geothermal investments stabilized at between $3.3 billion and $2.7 billion. In 2012, global investments declined to $0.8 billion. From 2007 through 2012, international asset finance volumes made up 47 percent of the total deal volume.

State development banks, multilateral institutions, and other quasi-public sector institutions have taken on an increasingly important role in financing the deployment of geothermal capacity outside of the United States and other Organization of Economic Cooperation and Development (OECD) nations (e.g., Kenya). For instance, in 2011 the Japan International Cooperation Agency ($326 million for Indonesia) and the World Bank ($300 million for Indonesia) were the second and third largest global arrangers of asset finance capital, while in 2012, the Overseas Private Investment Corp ($265 million for Kenya) and the African Development Bank ($125 million for Kenya) were the largest and second largest arrangers, respectively.[81] Kenya has risen to become the leading cumulative recipient of geothermal development bank financing ($1 billion), with Iceland ($528 million), Indonesia ($340 million), the Philippines ($94 million), and Nicaragua ($71 million) all receiving significant investments as well.[82]

As these entities have taken a leading role in developing markets (e.g., Kenya), there is no similar public sector actor in the U.S. market. The DOE Loan Programs Office temporarily filled this niche (although it was focused on overall project financings instead of early stage development). However, the program's temporary statutory authority under the Recovery Act (i.e., Title XVII Sec. 1705) expired on September 30, 2011.

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[81] (Bloomberg New Energy Finance, 2013)
[82] Values are 20032012 inclusive. Source: (12/19/2012) (Taylor, 2012)

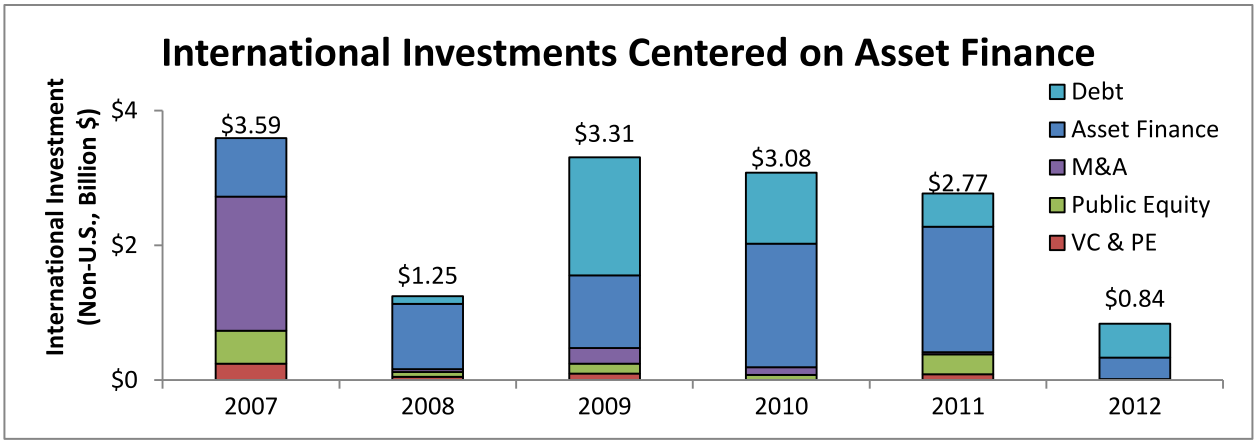

Figure 17 International (i.e., Non-U.S.) Geothermal Investment (2007–2012).[83]

As shown in Figure 18, global (i.e., international and U.S.) investments in renewable energy grew significantly between 2007 and 2011, with the majority of this investment going toward solar and wind energy. Geothermal energy annually received between 3.6 and 0.7 percent of total capital investments in renewable energy. This includes venture capital (VC) and private equity (PE) investments in technological development as well as project finance investments in present-day deployments. Industry sources largely attribute this long-term trend to VC and PE firms shying away from geothermal energy's relatively high capital intensity, public markets' aversion to long-term deals with high up-front drilling risks, and private debt providers having few well-capitalized partners to which to lend.

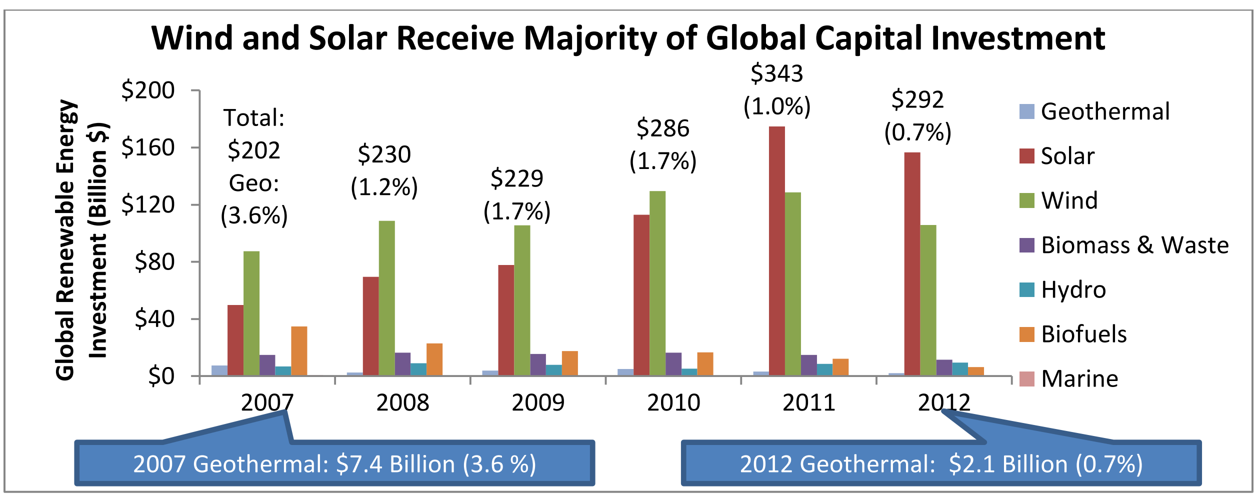

Figure 18 Global Renewable Energy Investment (2007–2012)[84]

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[83] (Bloomberg New Energy Finance, 2013). Data as of 2/5/13. The figure excludes government research and development; however Bloomberg NEF does include finalized Sec. 1705 loan guarantees as asset finance transactions. Data for recent time periods is often revised by Bloomberg NEF as financial terms for recent deals are disclosed.

[84] (Bloomberg New Energy Finance, 2013)

III.3 Trends in Global M&A, Public Equity, and VC and PE Investments

The previous two sections discussed U.S. and international (i.e., non-U.S.) investments. However, trends in geothermal M&As, public equity, VC, and PE investments are obscured by the size of debt and asset finance investments. As a result, this section discusses these forms of investment on a global level (i.e., U.S. and non-U.S.). Figure 19 displays trends in global M&A, public equity, as well as VC and PE, all of which are forms of investment that may support R&D and development of the next generation of geothermal technologies.

Disclosed global M&A deals raised new equity of $2.08 billion, $45.8 million, $230.5 million, $202.3 million, $29.6 million, and $2.50 million from 2007 to 2012 sequentially. The spike in 2007 is largely attributable to the $1.9 billion partial privatization of the Philippines Energy Development Corporation.

Public equity offerings of geothermal companies accounted for $681.5 million, $365.0 million, $349.7 million, $88.1 million, $373.8 million, and $12.25 million from 2007 to 2012 sequentially. While reforms in April 2012 through the Jumpstart Our Businesses Startups Act (P.L. 110-106) (the JOBS Act) might open the door to increased public equity investments, this mode of investment appears unlikely to grow significantly in the future.[85]

Combined geothermal VC and PE investments make up about 4 percent of the 2007 through 2012 cumulative geothermal investments on the global and U.S. levels. This is likely a result of a confluence of factors, including geothermal projects' long development timeframes, front-loaded risk and capital-intensity, and the availability of higher returns over a shorter period in other industries. VC and PE investments typically serve as an important support for the development of future technologies,[86] although present geothermal investment levels have been modest compared with the amounts invested in solar or other renewable energy technologies. For instance, development of EGS technologies in Oregon was supported by a combined $30 million of early-stage VC investment, while deployment efforts by a separate firm were supported with a combined $314 million of PE investment.[87]

[85] (Goodwin Procter LLP, 2012)
[86] (Jenkins & Mansur, 2011)
[87] (Bloomberg New Energy Finance, 2013)

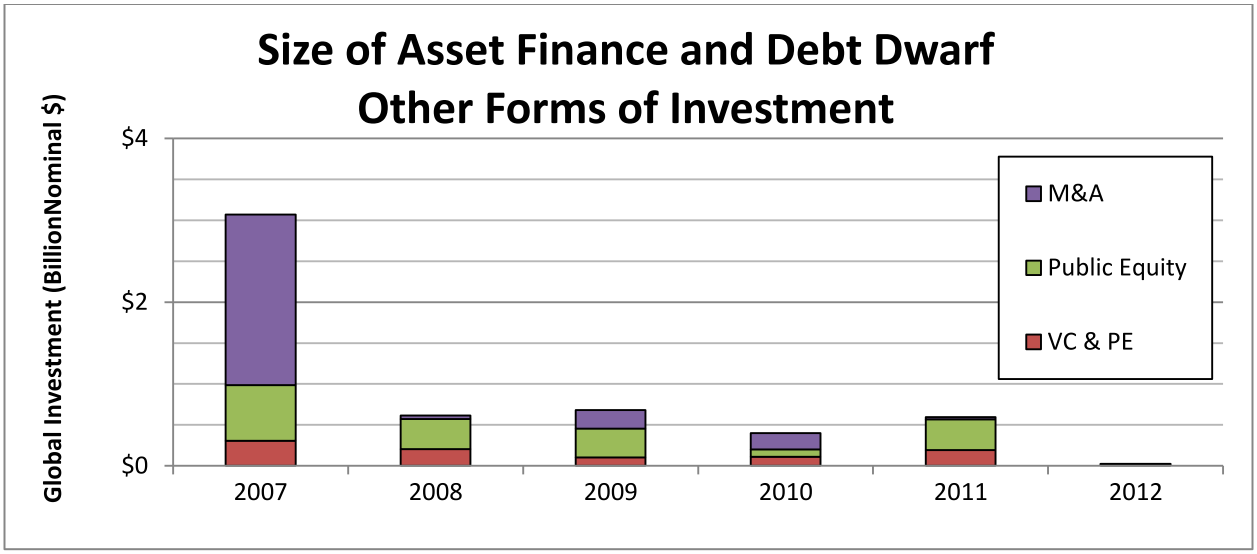

Figure 19 Global M&A, Public Equity, VC, and PE Investment 2007-2012.[88]

The United States and Iceland account for the vast majority of global VC and PE investments. From 2007 through 2012, buy-out and corporate spinoff PE investments were the dominant investment model in Iceland. The United States has followed a slightly more diversified approach, with PE expansion capital accounting for 75 percent of investments versus 25 percent for VC investments. However, if judged solely on the basis of VC investments, the United States accounts for 66 percent of global VC investments.[89]

In conclusion, between 2007 and 2012, global geothermal capital investments held reasonably stable at between 3.6 and 0.7 percent of global renewable energy investments. Global and U.S. geothermal investment levels declined in 2012 compared with the prior years, although it is too early to tell whether this is a long-term trend. Geothermal energy projects' long development time may slightly offset the year-to-year volatility of the market as projects financed in earlier years continue to mature in later years. International development in South America, east Africa, and Indonesia has continued to attract both attention and investment.

IV. U.S. and Global Geothermal Policy and Market Drivers

The following sections examine each of the major geothermal policy mechanisms in detail. On the U.S. federal level, these policies include R&D funding from the DOE-GTO, the PTC and Sec. 1603 grants, loan guarantees, and small but significant changes to the environmental review processes. The following sections also focus on the effect of U.S. state-level Renewable Portfolio Standards (RPS), as examples of international policies, such as FITs and drilling insurance or revolving loan funds.

[88] (Bloomberg New Energy Finance, 2013). The figure excludes government R&D; however Bloomberg NEF does include finalized Sec. 1705 loan guarantees as asset finance transactions. Data for recent time periods is often revised by Bloomberg NEF as financial terms for recent deals are disclosed.

[89] (Bloomberg New Energy Finance, 2013)

Successfully harnessing geothermal energy depends on technological innovation coupled with favorable market conditions. Focused policies provide valuable support as the industry matures. Aside from the DOE-GTO's R&D projects, the vast majority of U.S. geothermal support policies can only be used once a project has successfully entered operation. This poses a greater barrier for geothermal projects compared with wind or solar projects because of the front-loaded and site-specific nature of a geothermal project's risk profile (see Figure 20). Unlike other technologies, a geothermal developer must expend potentially tens of millions of dollars, over several years, before it can even know whether a potential site is worth developing. Wind and solar developers' risks are not as front-loaded as those faced by a geothermal developer, and they are less site specific. The result is that broad policies designed for a wide range of energy technologies (e.g., tax credits, Sec. 1603 grants, RPSs, etc.) are of limited utility for geothermal developers whose biggest risks lie at the earlier development stages.

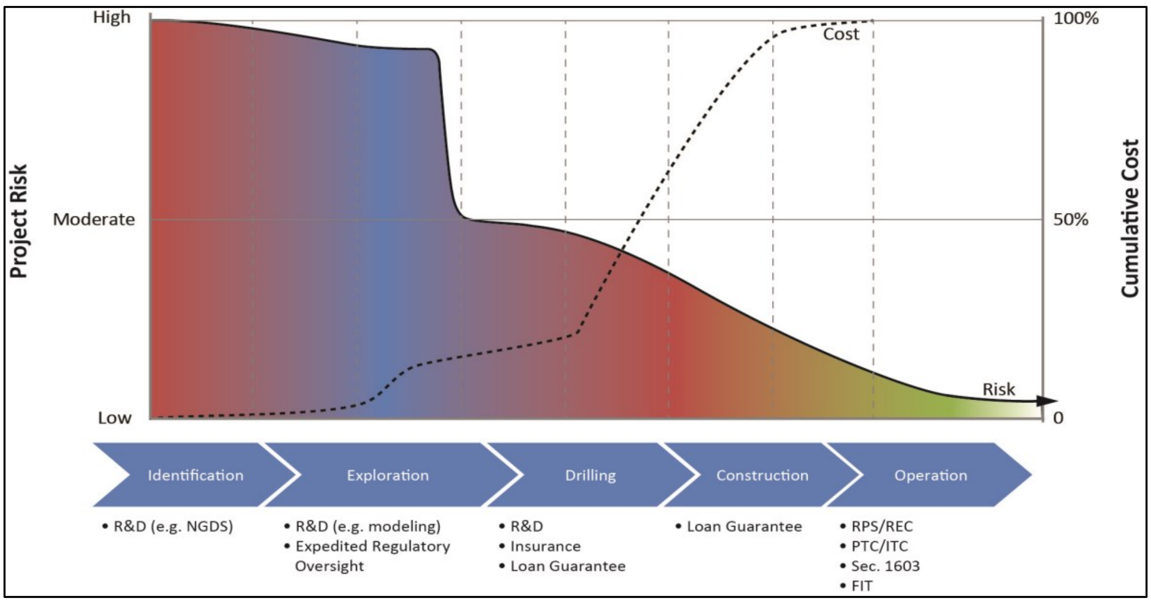

Figure 20 Typical Project Risk and Cumulative Cost Compared with a Conceptual Diagram of Policy Supports Applicable to Each Stage of a Geothermal Project.[90]

IV.1 U.S. Federal Role

Agencies and departments throughout the federal government actively engage with each other to fund and otherwise support the development and deployment of geothermal resources in the United States.

Figure 21 illustrates the roles and activities of several such key funding agencies and departments, which are discussed in further detail below.

[90] Adapted from (World Bank, 2013, p. 69)

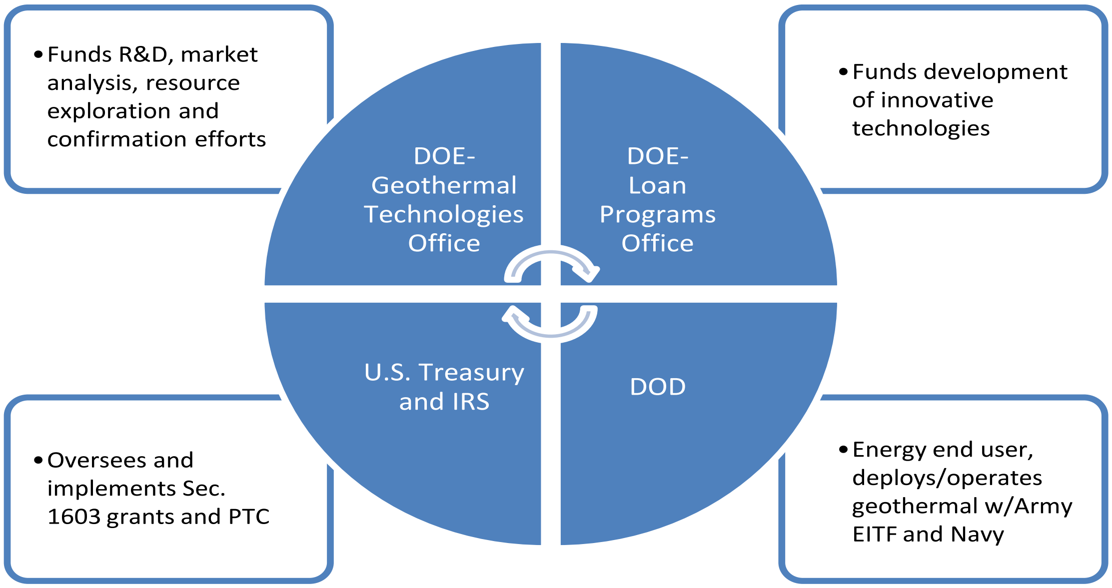

Figure 21 Diagram of Major Non-Regulatory U.S. Federal Programs Affecting the Geothermal Industry

IV.1.a DOE Geothermal Technologies Office (GTO)

To accelerate the development of clean, domestic geothermal electricity, DOE's GTO invests in technologies that increase operational performance while reducing the costs and risk of bringing geothermal power online. GTO sustains a research portfolio of more than 200 projects, partnering with industry, academia, and national laboratories to focus on technologies that deliver a significant and measureable impact on facilitating installed electrical capacity by addressing technical and market barriers. Reducing upfront risk by improving characterization of the subsurface is critical to securing financing and ultimately lowering overall costs of geothermal development.

Program priorities include low-temperature and coproduced resources in the near term, identification of 30 GW of new undiscovered hydrothermal resources (nearly 10 times the current level of geothermal power deployment), innovative tools for exploration that reduce upfront risk, and transformative technologies that create and sustain large-scale EGS reservoirs (estimated at 100+ GW) in the long term.

IV.1.b U.S. Federal Loan Guarantees and Tax Incentives

While R&D investments help pave the way for future successes, the industry has had to contend with the issue of the "valley of death" as new technologies transition from the R&D stage to full commercial deployment. To help overcome this challenge, Congress enacted Title XVII of the Energy Policy Act of 2005 (i.e., the Sec. 1703 program), which provided the DOE Loan Programs Office with loan guarantee authority to support innovative clean energy technologies. In 2009, Title XVII was temporarily expanded by the Recovery Act (i.e., the Sec. 1705 program), which gave the program increased capacity to issue loan guarantees to support commercial technologies as well as innovative technologies. Authority to issue loan guarantees under the Sec. 1705 program ended on September 30, 2011; however, the program still has authority to issue loan guarantees under the Sec. 1703 program, including $1.5 billion in loan guarantee authority available for eligible renewable energy or efficient end-use energy technologies.

Three geothermal loan guarantees (supporting a combined five projects) listed in Table 6 were issued by DOE. Debt financing for U.S. Geothermal, the developer of Neal Hot Springs, was provided by the Federal Financing Bank (FFB) under the terms of the original Sec. 1705 renewable energy solicitation, while Ormat and Blue Mountain's debt financing was provided by a private sector entity under the terms of a later solicitation that created the Financial Institution Partnership Program (FIPP).[91] These three geothermal transactions collectively represent just 3 percent of the $16.1 billion guaranteed under Sec. 1705. As of the time of each deal's closing, they were collectively expected to support approximately 175 MW of binary geothermal (net) capacity. All of the projects have now entered operation: Blue Mountain in 2009, Jersey Valley in 2010, and Tuscarora (phase 1), McGinness Hills (phase 1), and Neal Hot Springs in 2012.[92] While there is no renewable energy solicitation currently open for applications, the program supported a significant fraction of the U.S. geothermal capacity that came online in 2009, 2011, and 2012.

Since 2009, the Blue Mountain facility, which was developed by Alternative Earth Resources Inc. (which changed its name from Nevada Geothermal Power on April 2, 2013, as part of a share consolidation and corporation reorganization)[93], like Ormat's North Brawley and Raser Technologies' Hatch facilities (with were not supported by DOE loan guarantees), has underperformed compared with its originally expected capacity. Blue Mountain has been unable to reach its originally planned 39 MW (net) capacity since it came online, and its resource temperature has been forecasted to decline more rapidly than originally expected. As a result, Alternative Earth Resources Inc. reached an agreement with funds managed by EIG Global Energy Partners (EIG), the project's mezzanine lender, to transfer all its equity in the project to EIG in full satisfaction of the then outstanding obligations owed under its loan agreement with EIG, effective March 28, 2013.[94] Overall, situations such as Blue Mountain underscore the importance of highly accurate resource models when planning a geothermal project and that some geothermal project risks extend beyond the drilling phase.

Table 6 List of Sec. 1705 Geothermal Loan Guarantees

Project Name (Developer)	Location (Expected Net Capacity at Closing)	Total Debt Financing (Debt Arrangement)
Blue Mountain (Alternative Earth Resources Inc.) (Formerly Known As Nevada Geothermal Power)	Humbolt County, NV (39 MW)	$98.5 million (FIPP) (partial guarantee)
(Ormat Nevada, Inc.)	Jersey Valley, NV; McGinness Hills, NV; and Tuscarora, NV (113 MW)	$350 million (FIPP) (partial guarantee)
Neal Hot Springs (US Geothermal, Inc.)	Malheur County, OR (23 MW)	$97 million (FFB)

Source: DOE Loan Programs Office

Loan guarantees are not the only federal policy support available to geothermal energy. The PTC and ITC support investments in geothermal energy. The PTC allows an asset owner to receive a tax credit worth $0.023 per kWh of electricity produced from a qualifying geothermal facility for the first 10 years of its life. The ITC allows a geothermal electricity system owner to receive a tax credit the year it enters service

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91 (U.S. DOE Loan Programs Office, n.d.) and (U.S. DOE Loan Programs Office, n.d.)
92 Company press releases and quarterly investor earnings presentations.
93 (Alternative Earth Resources Inc., 2013)
94 (Linder, 2013) and (Alternative Earth Resources Inc., 2013)

worth 30 percent of the total cost of an asset. (The total cost, as determined by the IRS, may be thought of as the "fair market value" because it may include financing or other costs if they are properly included in the investment's cost basis.[95]) The PTC is most advantageous for technologies with a high capacity factor and low up-front capital costs (e.g., wind), while the ITC is more advantageous for technologies with lower capacity factors or higher up-front capital costs (e.g., solar). In general, it is typically more advantageous for geothermal projects to select the PTC over the ITC, although the decision is slightly more balanced if a higher discount factor, capital cost, or lower capacity factor are assumed. Bolinger et. al. (2009) provides a more in-depth analysis of the tradeoff between selecting the PTC or the ITC.[96]

However, both the PTC and the ITC require an existing income tax liability greater than the value of the credit in order for the credit to be fully used. This was a significant limitation during the recent economic downturn because firms experienced reduced profit margins and lower tax liability due to short-term losses. To overcome this issue, the Recovery Act allowed entities to convert their PTC into an ITC, and temporarily allowed entities to convert the ITC directly into a cash grant as long as they entered service or began construction during the period 2009 to 2011.[97] This change allowed geothermal energy projects to almost immediately receive (i.e., as opposed to applying a tax credit over several years) a cash grant worth 30 percent of the total cost of a project upon coming online. In turn, the tax credit enabled renewable energy developers to avoid turning to the more expensive and time-consuming tax equity market during the depths of the recent economic downturn.[98] Because of its eligibility sunset,[99] the Sec. 1603 program will play a lesser role in 2013 than in prior years.[100] As shown in Figure 22, the program provided more than $520 million in support for geothermal energy projects, helping enable an estimated $1.7 billion in total project investment.[101] More recently, the Treasury has determined that Sec. 1603 awards granted between March 1, 2013, and October 1, 2013, shall be reduced by 8.7 percent under sequestration.[102]

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[95] (U.S. Treasury, n.d.)

[96] (Bolinger, et al., 2009, p. 6 and 18)

[97] Under the Recovery Act, projects had to enter service or begin construction during 2009–2010; however this was later extended to include 2011 in the *Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010*. To qualify, projects also had to be operating before the "Credit Termination Date," which varies by technology. While the *American Taxpayer Relief Act of 2012* did change the eligibility requirements for the PTC/ITC, this change apparently does not affect eligibility for a Sec. 1603 payment (Hunton & Williams LLP, 2013).

[98] Summary information on these policies is available at (Database of State Incentives for Renewables and Efficiency (DSIRE), n.d.) while a more in-depth analysis of these policies is available in (Bolinger, et al., 2009).

[99] In order to qualify, a project had to "break ground" or otherwise qualify for the 5 percent safe harbor provision by December 31, 2011. See: (Office of the Fiscal Assistant Secretary, U.S. Treasury Department, 2011)

[100] More information and a periodically updated database available at http://www.treasury.gov/initiatives/recovery/Pages/1603.aspx.

[101] A Sec. 1603 grant for a geothermal project is worth 30 percent of the total allowable project cost basis. The total investment figure was derived by dividing the total value of geothermal Sec. 1603 grants by 0.3.

[102] (U.S. Treasury, 2013)

Recent Changes to the PTC in 2013

One major and a few minor changes have been made to the PTC in 2013. Prior to passage of the American Taxpayer Relief Act of 2012, a geothermal project had to come online by the end of 2013 to qualify for the PTC. Now the project simply needs to have "begun construction" by the end of 2013 to be eligible to receive the PTC or ITC when the project enters service. The IRS provided guidance in mid-April 2013 that it would allow projects to qualify either by (1) paying, or incurring 5 percent of the expected total project cost (including drilling and exploration expenses if they may properly be included in the facility's depreciable basis), or (2) starting physical work of a "significant nature" (which specifically excludes test well drilling).[103]

This approach largely mirrors the approach used by the U.S. Treasury in the Sec. 1603 program, a structure that project developers and the financial industry grew comfortable using in project finance deals. This policy may seem inconsequential, but it is a major, if temporary, step toward policy stability. It is likely to induce several projects to begin construction in late 2013 to qualify, assuming the projects maintain their eligibility and eventually come online.[105]

When the PTC was first enacted in 1992, the IRS was directed to periodically adjust it to keep pace with inflation. In early April 2013, the IRS did so by increasing the credit from $0.022 to $0.023 per kWh.[107]

Taken together, these changes have the potential to support geothermal for several years to come, assuming developers can access early-stage development capital in 2013. Geothermal developers may qualify by beginning construction of a significant nature, although with some exceptions, the IRS would require construction to proceed continuously once that path is chosen. Alternatively, developers may choose to qualify through the 5 percent safe harbor, although that poses legal risks associated with when the costs are legally incurred. Overall, the modifications to the PTC in 2013 have been a partial step away from policy instability, which is a heightened risk for geothermal energy because projects take 5 to 7 years to develop.[108]

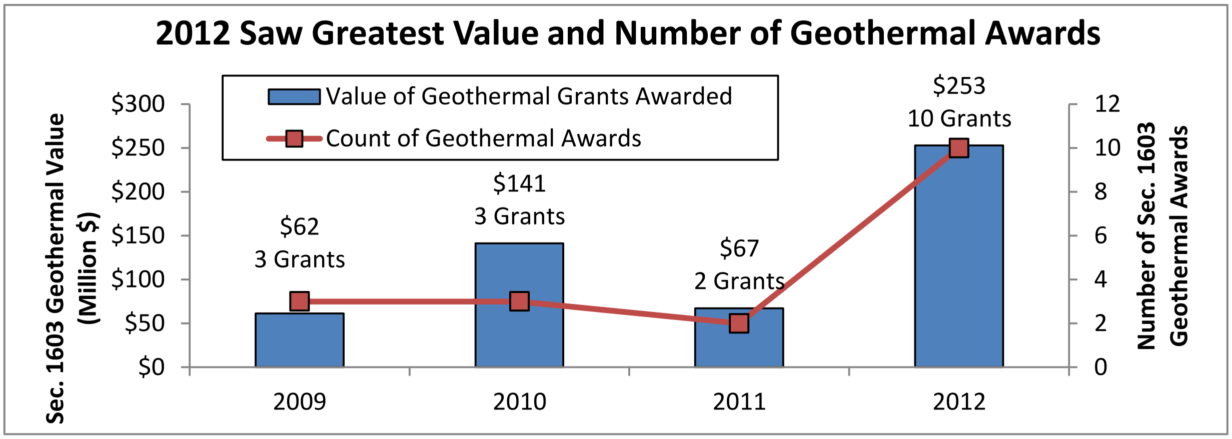

Figure 22 Sec. 1603 Geothermal Grants by Year (2009–2012)[103]

IV.1.c U.S. Department of Defense

Because the U.S. Department of Defense (DOD) is one of the largest consumers of energy in the world, it has and continues to have a significant role in commercializing and deploying new technologies through its procurement practices. "DOD is increasing its use of renewable energy supplies and reducing energy demand to improve operational effectiveness, reduce greenhouse gas emissions in support of U.S. climate change initiatives, and protect the Department from energy price fluctuations."[109] For example, the Navy Geothermal Program Office (GPO), which was formed in 1977, developed the Coso geothermal field located within the Naval Air Weapons Station at China Lake, California. Power sales from the field began in 1987, peaking at a capacity of 270 MW in 1993, and have since declined to about 200 MW today. The facilities are owned and operated by Terra-Gen Power, and the revenues support the Navy GPO's resource exploration and confirmation activities.

In May 2013, the Army Corps of Engineers, in conjunction with the Army Energy Initiatives Task Force (EITF), awarded the first set of Indefinite Delivery Indefinite Quantity (IDIQ) Multiple Award Task Order Contracts (MATOC). These first groups of five awardees are focused on geothermal electricity and ground source heat pumps. The contracts allow developers to enter negotiations to construct facilities at Army bases in the next 3 to 10 years, which would then operate under PPAs for as long as 30 years. The overall program (i.e., all technologies) is meant to support PPAs worth up to $7 billion in total.[110]

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[103] Data from (U.S. Treasury, 2013) as of 2/19/13. Geothermal heat pumps are not included.
[104] (U.S. Internal Revenue Service, 2013) and (Martin & Marciano, 2013)
[105] (Martin & Marciano, 2013)
[106] (Ormat Technologies, Inc., 2013)
[107] (Database of State Incentives for Renewables and Efficiency (DSIRE), 2013)
[108] See: (U.S. Energy Information Administration, 2012) or (Plumer, 2012).
[109] (U.S. Department of Defense (DOD), 2011, p. 86)
[110] (U.S. Army Corps of Engineers, 2013)

IV.2 State Incentives

State and local policies work in parallel with federal initiatives to stimulate adoption of geothermal technologies. State legislators and utility commissioners have primary responsibility for setting a state's overarching course on energy policy and regulation. Beyond geographic restrictions, how geothermal technologies are treated in this process significantly affects how, and if, a geothermal market develops in a state.

States and regions with stronger and longer-term policies and incentives, coupled with a favorable electricity market and adequate geothermal resource, such as California and Nevada, have established relatively dense pockets of geothermal development. California, for instance, has broad and long-term support for its *33 percent by 2020* RPS, higher than average wholesale electricity rates owing to its geographic location and environmental policy decisions, and large geothermal resource. Nevada has several of the same conditions and is located within the same electricity market as California, thus enabling it to potentially export some of its energy to California. The vast majority of U.S. geothermal capacity is located in either California or Nevada, with Reno, Nevada, in particular, hosting a dense pocket of geothermal firms' headquarters.

An RPS requires utilities to purchase a defined share of electricity from renewable resources. As indicated in Figure 23, 29 states plus Washington, D.C. and Puerto Rico had RPSs in place as of February 2013. An additional eight, including two territories, have non-binding renewable energy production goals. Most of these policies were established through state legislation, but some were initially enacted through regulatory action (New York, Arizona) or ballot initiatives (Colorado, Missouri, and Washington). While the majority of U.S. states now have an RPS in place, no new state has enacted an RPS since Kansas did so in 2011.[111] As a result, the renewable energy industries are focusing more on the policies surrounding implementation of existing RPSs' levels than on enacting new ones in the remaining states. Members of the industry have also publicly stated their concerns that utilities are treating state RPS targets as a maximum rather than a minimum target, with significant declines in new solicitations once utilities expect to meet their minimum goals.[112] If this trend were to continue, the renewable energy industry might see demand for new projects significantly decline as utilities reach the renewable energy targets called for in state RPSs. However, this apparent trend may have already abated, due in part to the unexpected closure of the San Onofre Nuclear Generating Station (SONGS) in California and retirement of legacy coal generating capacity in Nevada.[113]

[111] (Barbose, 2012)
[112] Remarks by industry participants at the GEA State of the Industry Briefing, January 17, 2013.
[113] (Thurston, 2013)

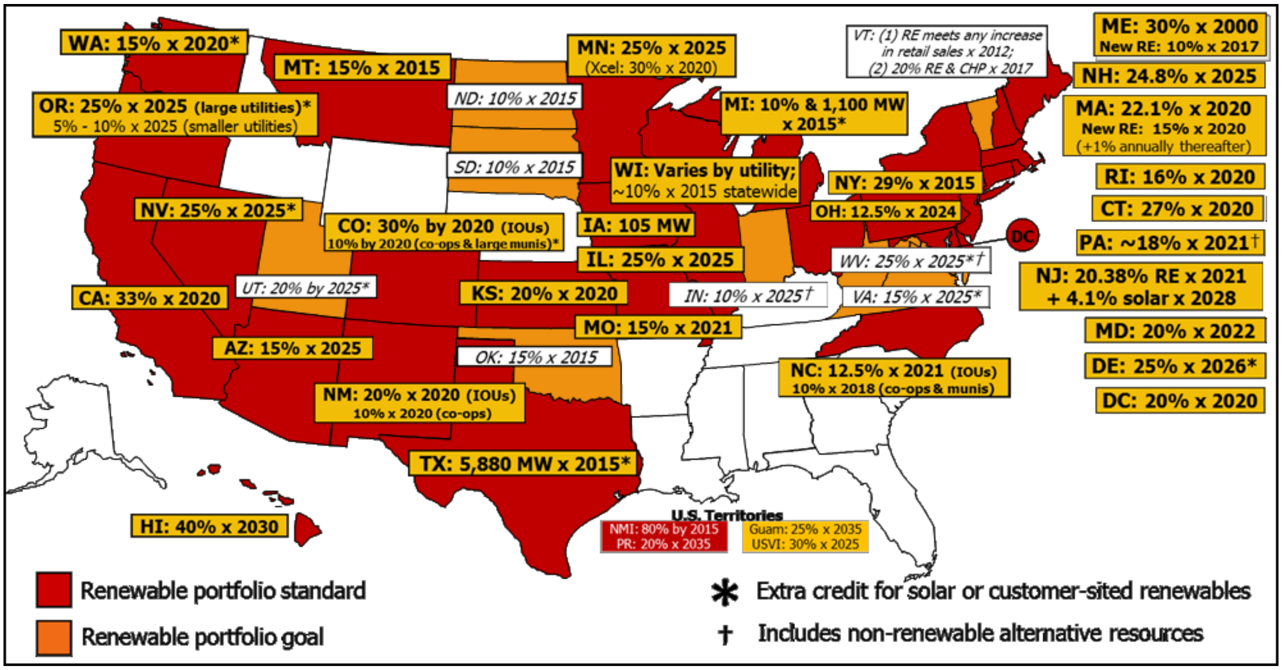

Figure 23 State Renewable Portfolio Standards and Goals as of February 2013.[114]

Members of the geothermal industry have specific recommendations for state policy leaders.[115] They believe California and other states' procurement policies could be modified to fully value geothermal energy's "firmly flexible" operational attributes. For instance, members of the industry have urged utilities to offer contract terms enabling geothermal facilities to be used for their highest value use as system conditions change (i.e., transition between baseload, variable generation, and ancillary services as market conditions change). Industry also stresses that recent procurement cycles in the western United States have focused too heavily on an individual project's cost per MWh, without taking into account resource integration costs. "Fixing procurement will require two simple steps. First, the full value of all attributes offered by geothermal resources should be included in energy resource cost comparisons. Second, all of the costs avoided by geothermal should either be counted as an added value provided by geothermal projects or should be counted against projects that impose system costs."[116] As was described earlier in this report, grid operators may use geothermal capacity to supply electricity with a higher degree of confidence and a higher capacity factor than other renewable energy technologies.[117]

IV.3 International Policy and Market Drivers Activities

While the United States has focused more on RPS targets, several countries have committed themselves to fostering renewable energy deployment through FITs—fixed-price payment for renewable energy generation over a defined period of time, coupled with policies to ensure renewable energy installations can be efficiently permitted and granted grid access. Policymakers often differentiate FIT payments

[114] (Database of State Incentives for Renewables and Efficiency (DSIRE), 2013)
[115] (Linvall, et al., 2012)
[116] (Linvall, et al., 2013, pp. 3, 4)
[117] (Linvall, et al., 2012)

according to the technology type, project size, quality of the resource, and a number of other project variables.[118]

Figure 24 shows a high-level overview of several current FITs in major international geothermal markets. While several countries have chosen to enact comparatively attractive FIT rates, it is important to note several mitigating factors that these policies are attempting to overcome. For instance, entry into the Japanese market by non-Japanese companies is difficult because of institutional barriers and lack of a domestic oil and gas drilling industry, while the German FIT is attempting to overcome comparatively lower-quality hydrothermal resources. Differences in costs of doing business should also be taken into account when comparing national FITs.

As stated previously, policies such as FITs that support improved returns for projects that actually succeed in entering operation, are generally less effective at overcoming geothermal energy's exploration risk hurdle. However, the German Federal Environment Ministry (BMU), the State Development Bank (KFW), and Munich RE have created a partial solution to this dilemma. By working in concert, the three institutions offer both low-interest, long-term financing as well as drilling risk insurance policies. These policies are having a significant impact on both the German and Kenyan geothermal markets. The latter policy holds great promise if applied to the U.S. market.[119] As stated previously, policies such as FITs that support improved returns for projects that actually succeed in entering operation, are generally less effective at overcoming geothermal energy's exploration risk hurdle. However, the German Federal Environment Ministry (BMU), the State Development Bank (KFW), and Munich RE have successfully created a partial solution to this dilemma. By working in concert, the three institutions offer both low-interest, long-term financing as well drilling risk insurance policies.

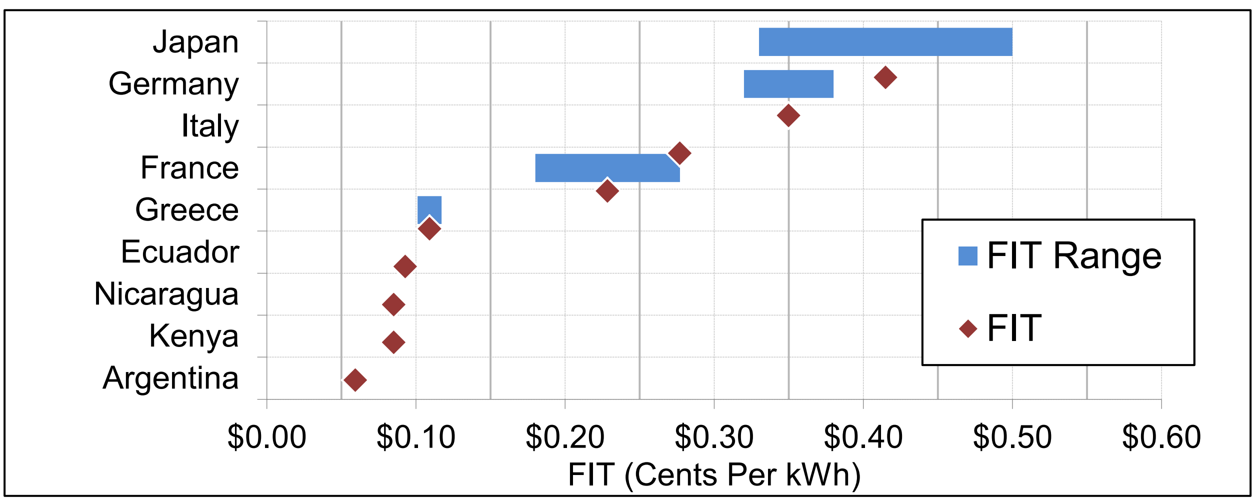

Figure 24 Global Geothermal Feed-in Tariffs, Q2 2012.[121]

[118] (Doris & and Young, 2009, p. 27)
[119] (Cory, et al., 2012)
[120] (Audinet, 2012) (World Bank, 2013) (World Bank, 2013)
[121] (Taylor, 2012)

World Bank Calls for $500 Million in Support for Geothermal Deployment in Developing Nations

The Global Geothermal Development Plan (GGDP) was announced by World Bank Managing Director Sri Mulyani Indrawati at the Iceland Geothermal Conference on March 6, 2013. "Geothermal energy could be a triple win for developing countries: clean, reliable, locally-produced power. And once it is up and running, it is cheap and virtually endless," said Indrawati. The GGDP will be managed by the World Bank's ESMAP and will build atop ongoing work being performed in Africa's Rift Valley under the Iceland-World Bank Geothermal Compact. GGDP is intended to mobilize $500 million for geothermal development, mostly for resource exploration and test drilling. Donors (including national and multilateral entities) can help identify viable projects, provide direct bilateral assistance, and offer assistance through existing vehicles such as the Climate Investment Funds (CIF) or the Global Environment Facility (GEF). While up to 38 developing nations from across the globe could receive support under the GGDP, Turkey, Kenya, Ethiopia, and Indonesia have been targeted for near-term action.

Overall, the World Bank Group's geothermal development financing has increased from $73 million in 2007 to $336 million in 2012 and presently represents almost 10 percent of the Bank's total renewable energy lending.[120]

U.S.–Asia-Pacific Comprehensive Energy Partnership

President Obama jointly announced with Sultan Haji Hassanal Bolkiah of Brunei and President Susilo Bambang Yudhoyono of Indonesia the United States–Asia-Pacific Comprehensive Energy Partnership for a Sustainable Energy Future at the East Asia Summit November 2012.[122] As part of the ongoing initiative, the United States has pledged to provide $6 billion over several years by refocusing existing U.S. economic development efforts (see below for a breakdown). The funds will support sustainable development, including investment in geothermal energy. According to public statements made by U.S. Department of State staff at the 2013 GEA Industry Briefing, the majority of the funding is expected to be devoted to geothermal energy. However, this initiative is still evolving, and more information is not expected to be released until September 2013 at the Association of Southeast Asian Nations (ASEAN) Summit.[123] Currently, these specifics are known:

- The U.S. Trade and Development Agency (USTDA) is focusing on geothermal power development in Indonesia, as part of a larger effort on power distribution modernization, assistance with upgrading grid efficiencies to accommodate renewable power, and unconventional gas development.
- The Export-Import Bank of the United States (EX-IM) is making up to $5 billion available in export credit financing to the East Asian region over the next 4 years. If successful, this will increase local access to American technology, services, and equipment for the deployment of energy infrastructure.
- The Overseas Private Investment Corporation (OPIC) is providing up to $1 billion in financing for sustainable energy infrastructure projects. [124]

[122] (U.S. Executive Office of the President (White House), Office of the Press Secretary, 2012)
[123] Confirmed no new information is available via email with GEA staff on 5/7/13.
[124] (U.S. Trade and Development Agency (USTDA), 2013)

V. Future Outlook of the Geothermal Industry

V.1 Recent Industry Activities

V.1.a Conventional Hydrothermal

Conventional hydrothermal development accounts for the vast majority of current geothermal project growth. In recent years, the U.S. industry has faced depressed wholesale electricity rates owing to historically low natural gas prices and the effects of the economic downturn. However, there have been encouraging developments as well. Under the Recovery Act, the PTC could be temporarily converted into a 30-percent cash grant, which would be a more than $540 million boon to liquidity-constrained geothermal developers. In 2013, the IRS adjusted the PTC upward 4.5 percent from $0.022 to $0.023 per kWh[125] and released guidance on how the new "start of construction" qualification would be interpreted: projects may qualify for the PTC either (1) by paying, or incurring 5 percent of the expected total project cost (including drilling and exploration expenses if they may properly be included in the facility's depreciable basis), or (2) by starting physical work of a "significant nature" (which specifically excludes test well drilling). This interpretation largely aligns with industry expectations.[126]

V.1.b EGS

The primary technical barriers facing EGS technologies are high drilling costs and the ability to add fluid and permeability where they do not already exist (i.e., stimulating the rock in a sustainable way). EGS technologies have been successfully applied on the pilot scale at the Soultz project in Europe[127] and were given a major boost with three DOE-GTO funded demonstration projects. Developing reservoirs at the edge of or in unproductive areas of existing reservoirs is a realistic short- to medium-term application of EGS technologies. These demonstration projects, as well as the crosscutting R&D work, that affect all geothermal technologies are an important step, but EGS technologies are nascent and will continue to need support as they move toward deployment and commercialization.

V.1.c Coproduction

Producing geothermal energy along with a secondary revenue stream has received renewed attention as an area where near-commercial technologies can have an immediate impact. Firms are taking several unique approaches in the coproduction area. With $1.5 million from DOE-GTO, Universal Geo-Power is focused on overcoming the technical and economic challenges inhibiting the generation of electricity from abandoned oil and gas wells that access high-pressure, high-temperature brine formations. Alternatively, ElectraTherm has developed a modular waste heat to power system that can be integrated into a wide

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[125] (Database of State Incentives for Renewables and Efficiency (DSIRE), 2013)
[126] (U.S. Internal Revenue Service, 2013) and (Martin & Marciano, 2013)
[127] (Genter, et al., 2009)

range of situations; a unit is currently producing power from the brine stream used in the gold-leaching process at the Florida Canyon Mine in Nevada.[128]

Coproduction of electricity from operating oil and gas wells is an attractive opportunity with many positive attributes such as use of already existing wells and large, somewhat homogenous, and well-capitalized potential partners. However, it faces several non-technical market barriers. Depending on the location, well leases may need to be re-negotiated because the classification of the geothermal resource as a mineral or as water varies by jurisdiction. In addition, oil and gas projects expect significantly higher rates of return on their investments than are currently earned via coproduction activities and many prospective well sites are already grid-connected in areas of the country with extremely low retail electricity rates.

Geothermal fluids may carry more of value than just heat. Simbol Materials received $3 million from DOE-GTO to demonstrate the technical and economic feasibility of extracting lithium, manganese, and zinc from water already used by EnergySource LLC's John L. Featherstone facility. If successful, this could open the possibility of using secondary revenue streams to make formerly uneconomic geothermal projects viable in locations where there are materials of value in the geothermal fluids.

Recent EGS Demonstration Project Successes Show Technology's Promise

AltaRock Energy announced in January 2013 that it was the first company in the world to stimulate multiple geothermal zones from a single well. With a $21.5 million investment from DOE-GTO, AltaRock's Newberry project in Oregon used a non-toxic, biodegradable diverter to temporarily block portions of the well. This allowed focusing of moderate pressure and cold water sequentially on reopening fractures at specific depths in a process known as hydroshearing. Once the fractures are opened, the fluid circulation is halted, allowing the temperature to rise, degrading the diverter material and removing the temporary blockage.[129]
Ormat announced in April 2013 that its Desert Peak 2 project in Churchill County, Nevada, was the first U.S. EGS demonstration to deliver energy to the electric grid. The project, which received a $5.7 million investment from DOE-GTO, successfully stimulated an additional 1.7 MW of energy from an existing sub-commercial well, a 38-percent increase.[130]

Geodynamics announced in May 2013 that it had successfully commissioned Australia's first operating EGS demonstration facility, the 1 MW Habanero Pilot Plant. The company plans to operate the facility for 100 days, through August 2013, to gather data as part of a trial and testing program.[131]

[128] (Thurston, 2013)

V.2 Known Project Pipeline

The U.S. geothermal industry has built a significant project development pipeline, with particular focus on California and Nevada. Both of these states offer relatively more attractive wholesale electricity rates compared with other areas of the United States [132] and more readily accessible geothermal resources using today's technologies. As shown in Figure 25 and Table 7, according to the GEA, at the end of 2012 there were just over 2,000 MW of potential geothermal capacity in the U.S. industry's development pipeline. Not all projects in the earlier development stages will actually be constructed because the pipeline encompasses successive "down selects" as less promising sites are excluded. In addition, as projects take various periods of time to progress through the development stages, not all of the projected capacity in any stage will come online in the same time period. Table 7 displays the projects at the most advanced development stage as of the end of 2012. California has the majority of capacity at the permitting and initial development stage, while Nevada has the majority of the capacity at the two earliest development stages as well as the final development stage, resource production and facility construction. California has a single 4 MW facility at the final development stage compared with a single 60 MW facility in Nevada, with Utah (25 MW), New Mexico (15 MW), and Oregon (4 MW) making up the rest. Although California has the largest share of operating capacity, Nevada's large share of projects currently under construction, as well as at the earlier development stages, highlights the bright long-term prospects for geothermal energy in that state.

In addition to the project development pipelines identified by GEA, there is growing interest in the Big Island of Hawaii. The Hawaiian Electric Company (HECO) released an RFP for 50 MW of geothermal capacity in January 2013.[133]

Table 7 U.S. Utility-Scale Projects at the Resource Production and Power Plant Construction Phase in 2012.[134]

U.S. Project Development Pipeline (As of 2012)		California	Nevada	Other States	Total United States
Procurement & Identification	Capacity (MW)	125	255	79.8	459
	No. of Projects	*6*	*29*	*32*	*67*
Exploration & Confirmation	Capacity (MW)	270	302	36	608
	No. of Projects	*12*	*17*	*10*	*39*
Permitting & Initial Development	Capacity (MW)	562	49	80	690
	No. of Projects	*7*	*5*	*6*	*18*
Production & Construction	Capacity (MW)	4	60	44	108
	No. of Projects	*1*	*1*	*4*	*6*
Phase N/A*	Capacity (MW)	100	5	45	150
	No. of Projects	*5*	*3*	*2*	*10*

[129] (Profita, 2012), (AltaRock Energy Inc., 2012), and (Petty, 2010)
[130] (Ormat Technologies, Inc., 2013)
[131] (Geodynamics Limited, 2013)
[132] (U.S. Energy Information Administration, 2013)
[133] (Hawaii Electric Light Company (HELCO), 2013)
[134] (Geothermal Energy Association, 2013). Figure excludes a 0.4 MW facility in Alaska.

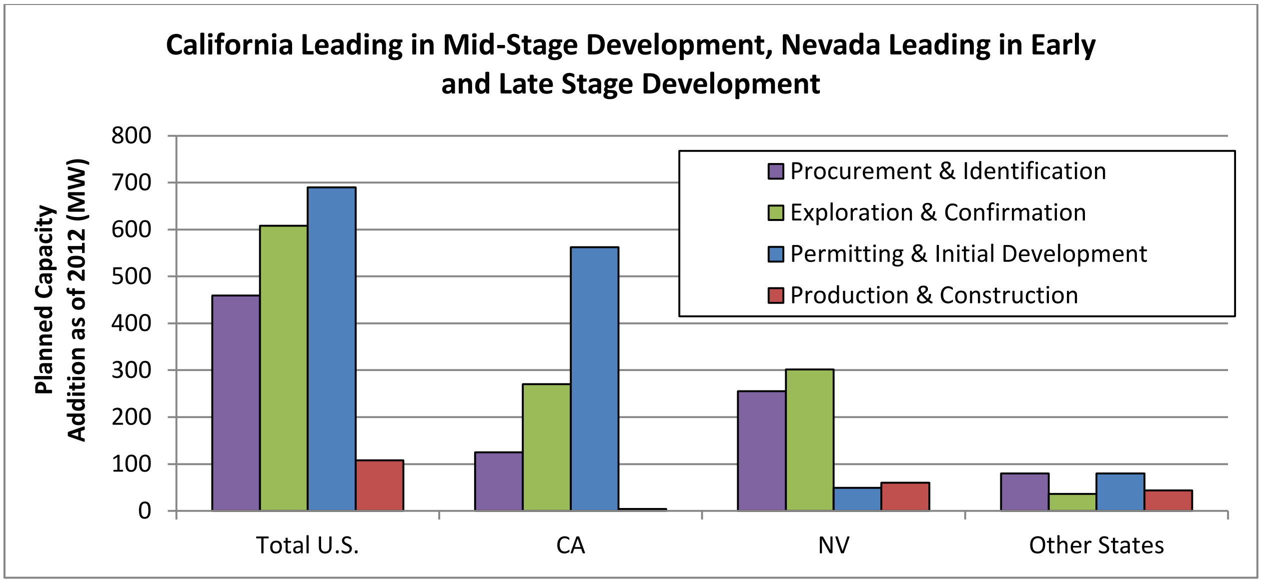

Figure 25 Planned Capacity Addition as of 2012 (MW).[135]

Table 8 U.S. Utility-Scale Projects at the Resource Production and Power Plant Construction Phase in 2012.[136]

Project Name	Location	Capacity (MW, lowest. if range provided)	Developer	Setting
Mammoth Complex Repowering	Mammoth Lakes, CA	4	Ormat	Expansion
Patua	Patua, NV	60	Gradient Resources	Greenfield
Paisley Geothermal	Paisley, OR	2	Surprise Valley Elec. Corp.	Greenfield
Cove Fort 1	Cove Fort, UT	25	Enel North America	New Facility at Previously Developed Resource

[135] (Geothermal Energy Association, 2013, p. 16). Figure excludes projects that were N/A. “Other States” includes Alaska, Arizona, Colorado, Idaho, New Mexico, North Dakota, Oregon, Texas, and Utah. Note: these data are reported by the developers themselves to GEA and are not independently verified.
[136] (Geothermal Energy Association, 2013). Figure excludes a 0.4 MW facility in Alaska.

As shown in Figure 26, hydrothermal facilities make up 96 percent of the U.S. geothermal industry's development pipeline (as measured by the number of projects): 84 percent to greenfield projects, 2 percent to expansions of existing hydrothermal facilities, and 10 percent to new hydrothermal facilities atop previously developed resources. Coproduction and EGS projects each make up about 2 percent of the industry's development pipeline. In the future, coproduction and EGS are expected to play a more significant role in the geothermal industry, but they are relatively minor components of the industry's present-day deployment efforts.

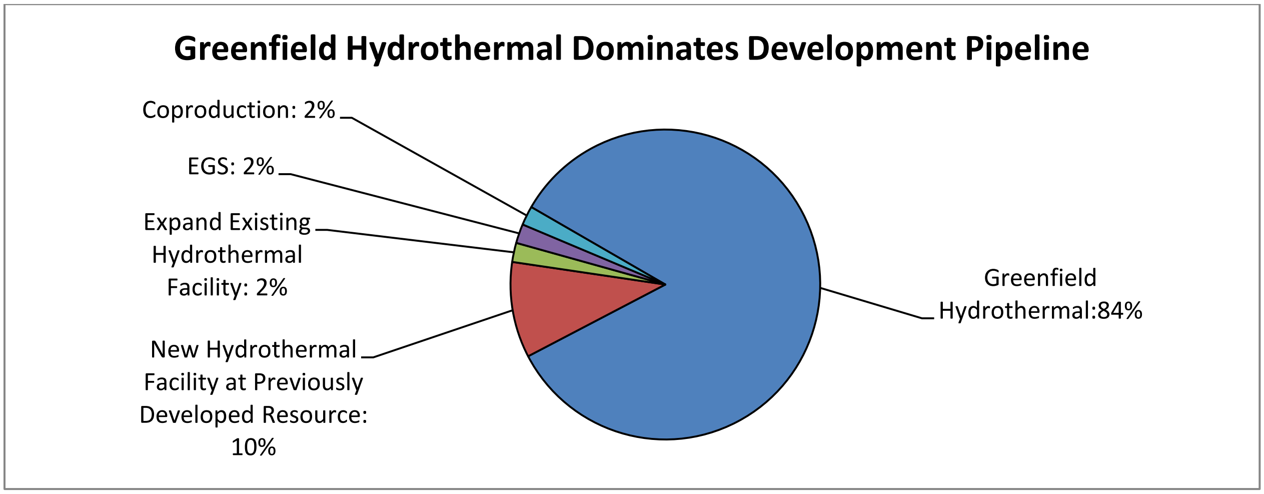

Figure 26 U.S. Geothermal Project Development Pipeline by Project Type as of 2012 (all development stages).[137]

V.3 Future Installation Projection

On the international stage, according to Navigant Research, North America leads the world with most projects in development, while the Asia Pacific region has the most aggregate capacity under development. The same research team estimates more than 4 GW of global geothermal capacity are expected to come online between 2013 and 2018, mostly in the United States, Philippines, and Indonesia.[138] Slightly more conservative (though in a shorter time span), Bloomberg NEF projects that growth in Indonesia, New Zealand, Kenya, and other nations are expected to drive market demand in the coming years. As shown in Figure 27, Indonesia is expected to remain the most active market in the short term, comprising about a third of the 2012–2016 expected capacity. Although the industry has spread to a diverse set of countries around the world, 84 percent of the 2012–2016 capacity is expected to be added in just six countries. NEF projects these six countries to remain among the leaders in long-term capacity deployment (through 2030), with Japan, Ethiopia, Turkey, and areas of Latin America taking on more prominent roles than at present.[139] NEF is also projecting a decline in U.S. installations in 2014, followed

[137] (Geothermal Energy Association, 2013, p. 17). Note: these data are reported by the developers themselves to GEA and are not independently verified.
[138] (Navigant Research, 2013)
[139] (Taylor, 2012, pp. 6, 7, 8)

by a recovery in 2015 and 2016, potentially driven by projects breaking ground in 2013 to take advantage of changes to the PTC.[140]

The global development pipeline is more fragmented when viewed from the perspective of the project developer, as shown in Figure 28.

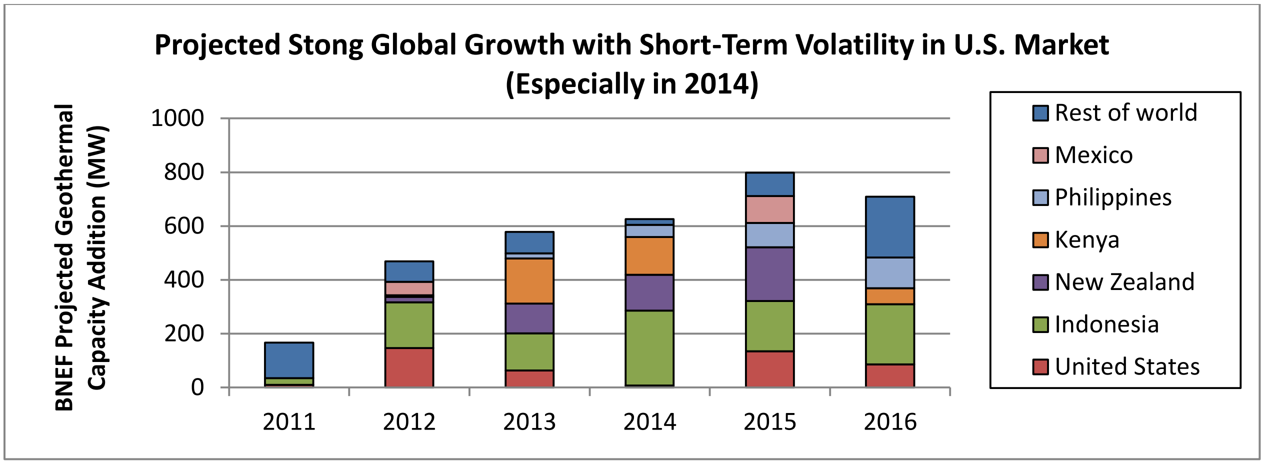

Figure 27 Bloomberg NEF Projection of Global Geothermal Capacity Growth by Country (2011–2016).[141]

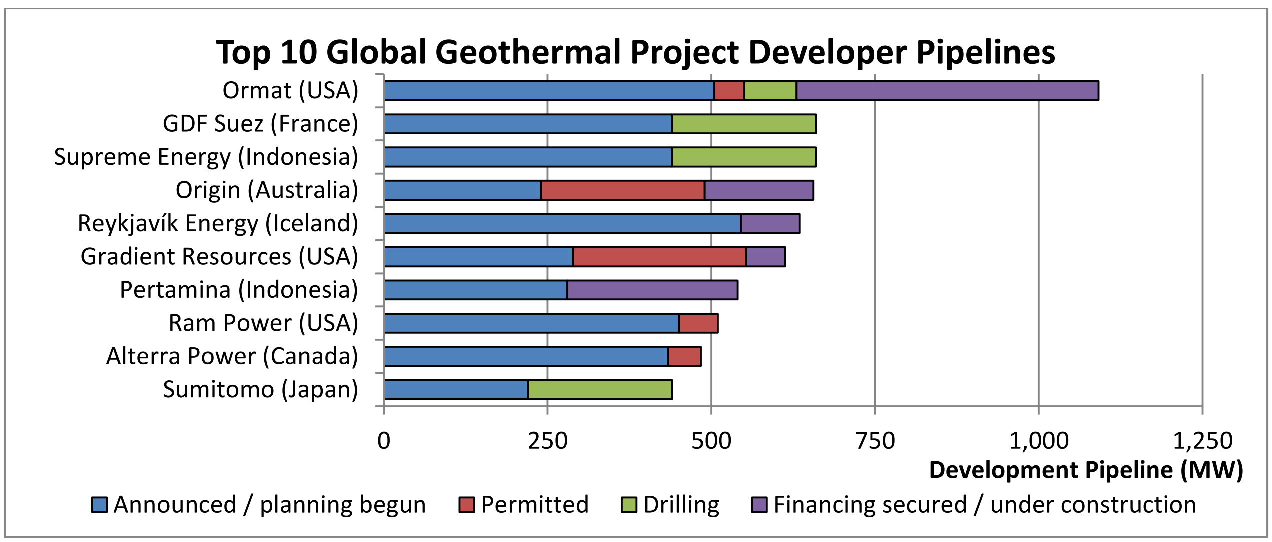

Figure 28 Top 10 Global Developer Pipeline as of Mid-2012.[142]

[140] (Taylor, 2013, p. 1)
[141] (Taylor, 2012, p. 3). 2011 and 2012 U.S. data were adjusted based upon (Geothermal Energy Association, 2013)2011 changed from 25 MW to 10 MW and 2012 changed from 90 MW to 147 MW).
[142] (Taylor, 2013, p. 4). Countries shown are locations of corporate headquarters, which is not necessarily the country where the capacity will be installed.

V.4 Conclusion

The geothermal industry faces significant headwinds in its effort to develop new projects and technologies. Well-capitalized utilities and equity investors are free to focus on competitor technologies that require less development time and are less affected by site-specific resource confirmation issues. Developers must expend significant capital in the resource exploration and confirmation phases before they know whether a site is economical, and most general policies, such as the PTC or ITC, which were crafted for the renewable energy sector as a whole, are of limited use to a geothermal developer. High development risk (and the increased capital costs associated with high development risks) remains an impediment to the industry. Even so, the United States has built a significant project pipeline, especially in California and Nevada, and the State of Hawaii has shown interest in deploying at least 50 MW of capacity within the next 10 years.

The U.S. near-term outlook is modest but promising. The recent changes to the PTC's eligibility requirements (i.e., the change to "start of construction" for potential eligibility versus the former exclusive focus on "start of operation") is expected to positively impact the industry, although it is too early to determine the actual effect of this policy change in the second half of 2013. Additional support for early-stage resource identification and confirmation has the potential to accelerate the deployment while decreasing the cost of conventional geothermal energy. EGS demonstration projects supported by the Recovery Act have shown encouraging results. EGS holds the potential of unlocking massive amounts of energy, including in the eastern United States.

However, industry members have stated that it is unlikely that the industry or other actors are willing or able to supply the necessary R&D funding, given that more than 90 percent of the present geothermal industry, focused on hydrothermal technologies and EGS technologies, has received relatively little support from non-public sector entities to date. Much as was the case in the 1980s with investments in hydraulic fracturing[143] and PDC drill bits, strategic R&D investment through DOE has the potential to catalyze significant economic growth. In contrast, nations as varied as Kenya, Indonesia, New Zealand, and the Philippines have committed themselves to the up-front development costs of geothermal capacity. Each of them has selected a unique development pattern born of its particular setting and needs. Regardless of the development path selected in the United States, the prospects for geothermal in these and several other international markets appear quite positive.

[143] (Burwen & Flegal, 2013)

Appendix A: U.S. Geothermal Resources

In the last few years, the estimated U.S. geothermal resource base has substantially increased as a result of advances in geothermal technologies and assessments performed by the U.S. Geological Service (USGS)—see Figure 31. As shown in Figure 30, the U.S. has roughly 6 GW[144] of identified but undeveloped conventional hydrothermal resources (roughly double the current U.S. installed geothermal capacity; the 6 GW does not include already developed geothermal resources[145]), with another 30 GW unidentified conventional hydrothermal resources expected to exist. Conventional hydrothermal technologies use naturally occurring geological formations to extract heat and have been successfully used around the world for decades.

Unconventional resources have sufficient heat, but lack either adequate permeability and/or fluid to use conventional geothermal technologies. If successfully developed, EGS technologies would unlock an extremely large resource base that spreads across most of the United States, as shown in Figure 29. While size estimates of this new resource vary, even the more conservative estimate made by the USGS, 518 GW, is 170 times greater than today's 3 GW of U.S. geothermal capacity and 5 times greater than the entire U.S. nuclear industry.[146] As shown in Figure 31, the USGS, MIT, and NREL studies came to a range of results because of the disparate methodologies each used. The USGS assessment was limited to the 11 western U.S. states and a depth of 3 to 6 kilometers (km). The NREL study included the entire continental United States with a depth of 3 to 10 km. NREL attributes a large portion of its 15,908 GW estimate to heat stored at greater depths than were included in the USGS assessment. MIT's study included the entire United States with a depth of 3 to 10 km, but separated its analysis into two alternative cases that assumed a 2- and 20-percent energy recovery factor as an order of magnitude estimate.[147] Overall, these estimates should be seen as a continuum; as EGS technologies mature, they should enable deeper and hotter geothermal resources to become accessible.

The approximately 7 GW[148] of unconventional resources located near conventional hydrothermal fields are likely to be among the first EGS fields developed, as shown in the right-most column in Figure 30. While a true "greenfield" artificial EGS system is likely at least a decade off, developing reservoirs at the edge of or in unproductive areas of existing reservoirs is a realistic short- and medium-term application of EGS technologies. This approach would allow developers to leverage investments in existing facilities and site studies.

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[144] 6 GW and 30 GW are the mean projection of (U.S. Geological Survey, 2008). USGS also calculated values at the 5-percent and 95-percent confidence levels, which are conveyed as error bars in Figure 31.

[145] (Geothermal Energy Association, 2012)

[146] (U.S. Energy Information Administration, 2012, p. 273),Table 9.2. Net Summer Capacity of Operable Units.

[147] (Augustine, 2011, p. 22) and (Brown & Whitney, 2011, p. 20)

[148] Note this is an order-of-magnitude estimate made in "Updated U.S. Geothermal Supply Characterization and Representation for Market Penetration Model Input" (2012) (http://www.nrel.gov/docs/fy12osti/47459.pdf).

[149] See http://en.wikipedia.org/wiki/Mineral_resource_classification for an explanation of the differences between resources and reserves in general, and (Williams, et al., 2011) for a discussion of these concepts as applied to geothermal energy in particular.

Potential Geothermal Resource versus Geothermal Reserve

Like any natural resource, only a portion of the potential ***geothermal resource*** base is technically, economically, and legally feasible to develop (referred to as the ***geothermal reserve***). Technological advancement allows the resource base to expand through better understanding of the underlying geology and inclusion of low-temperature and non-conventional resources that were originally excluded as impossible to develop. In turn, the geothermal reserve (the portion of the potential resource base that is both technically and economically feasible to develop) expands through advances such as better drilling, low-temperature energy conversion, and more accurate resource confirmation technologies.[149] The interplay between geothermal, mineral, and any harvestable resource base versus its reserve is typically depicted using what is known as a McKelvely diagram.

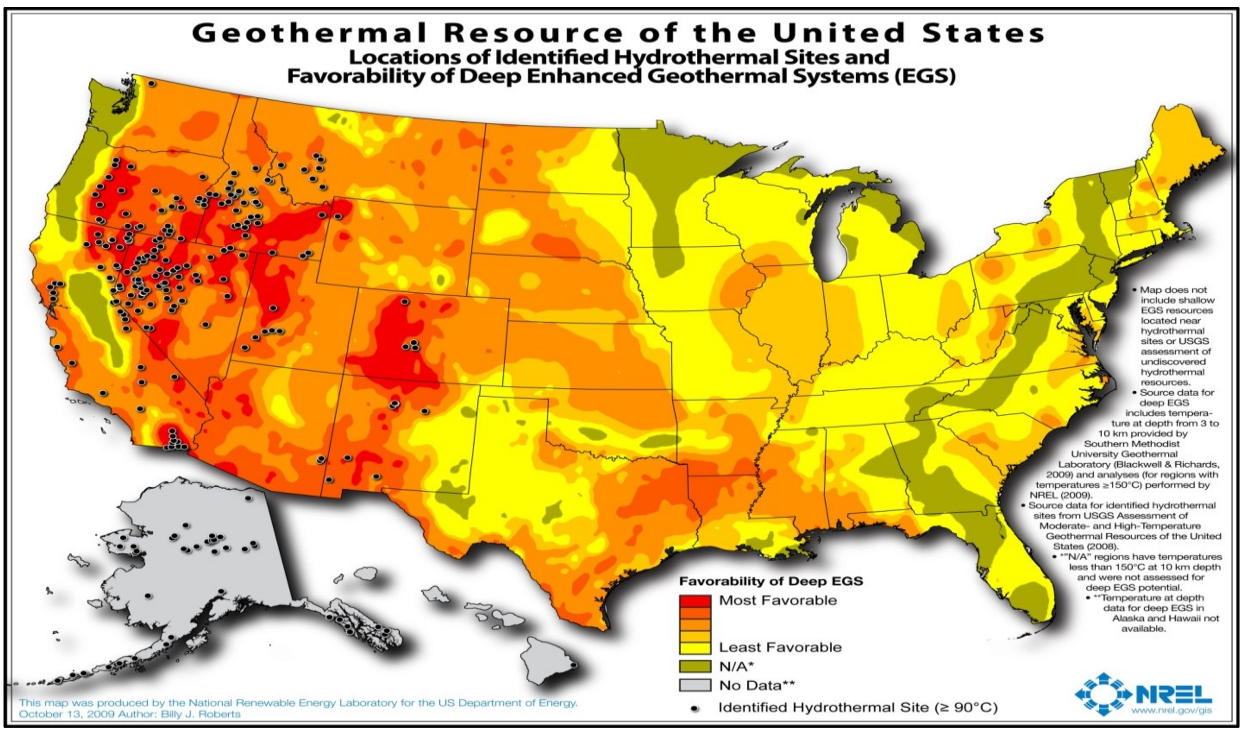

Figure 29 Map of Identified Hydrothermal and Favorable EGS Resources of the United States. [150]

[150] (Roberts, 2009)

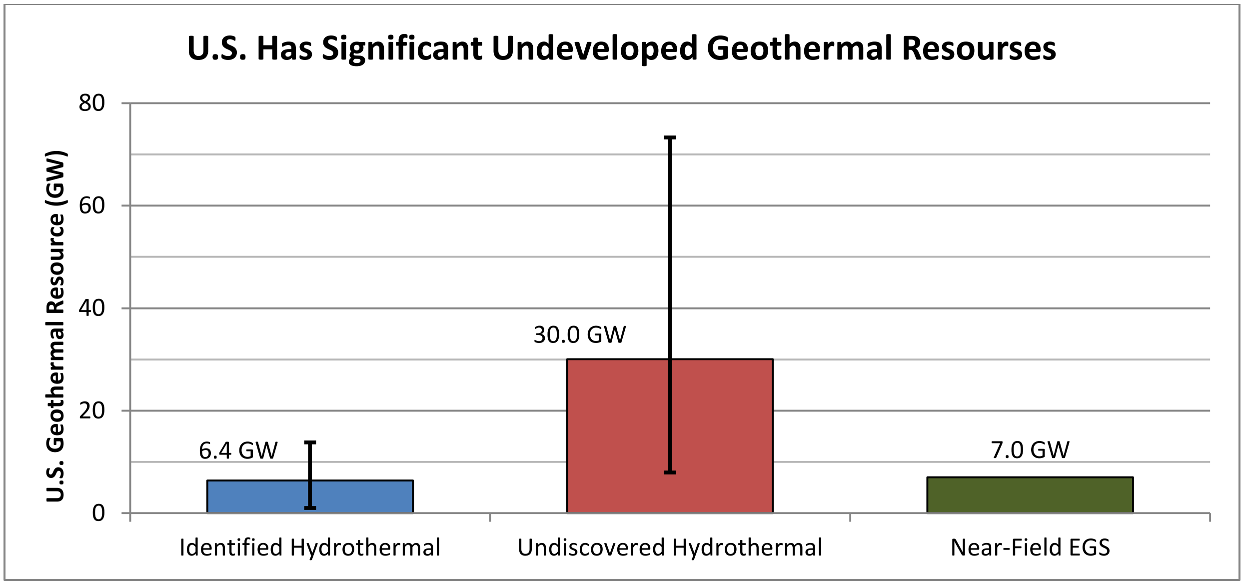

Figure 30
Identified and Undiscovered Hydrothermal Resource Compared With EGS Resource Near Hydrothermal Fields.[151]

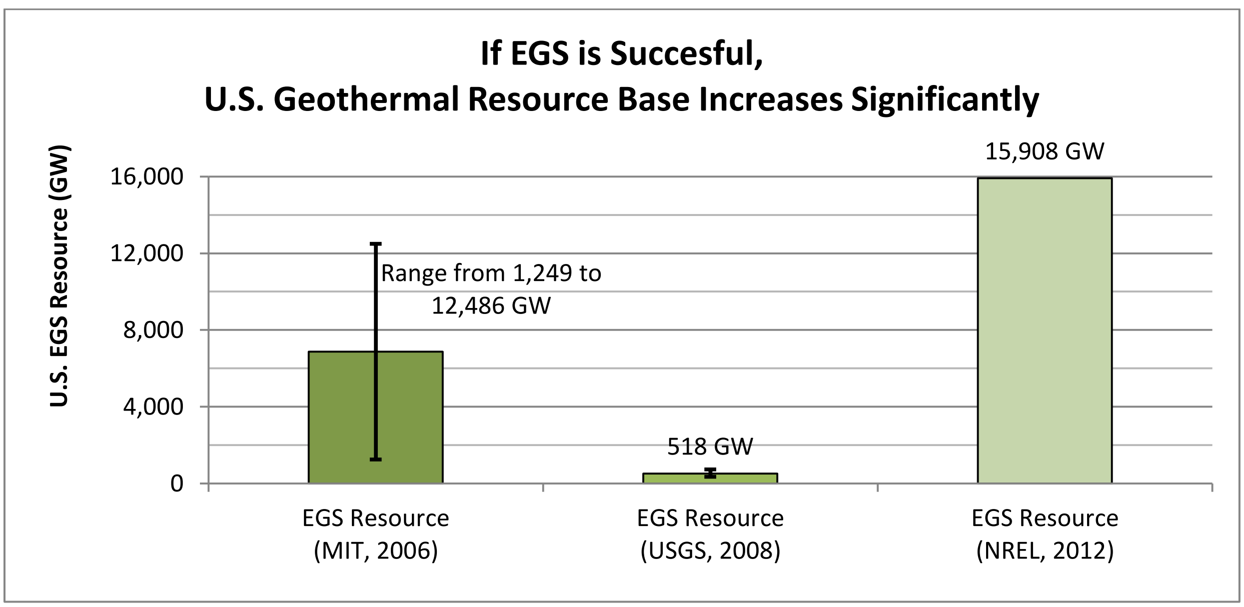

Figure 31 MIT, USGS, and NREL Estimates of U.S. EGS Geothermal Resource. [152]

[151] Identified Hydrothermal and Undiscovered Hydrothermal: (U.S. Geological Survey, 2008); Near-Field EGS: (Augustine, 2011)
[152] (MIT Energy Initiative, 2006, pp. 3-14, 3-15), (U.S. Geological Survey, 2008), and (Augustine, 2011, p. 26).

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