IEA GEOTHERMAL

United States Country Report
2012

IEA Geothermal
Implementing Agreement

National Activities

Chapter 22 of Draft 2012 GIA Annual Report

United States of America

22.0 Introduction & Overview

The United States remained the world leader in geothermal energy with 3.2 GW_e of installed capacity. During 2012, the Geothermal Energy Administration reported that 147.05 MW of additional capacity was brought online through the following projects (GEA, 2013):

- John L. Featherstone (CA) – 49.9 MW, Flash
- McGinness Hills (NV) – 30 MW, Binary
- Neal Hot Springs (OR)- 30.1 MW, Binary
- Tuscarora (NV) – 18 MW, Binary
- San Emidio (NV) – 12.75 MW, Binary
- Dixie Valley I (NV) – 6.2 MW, Binary expansion
- Florida Canyon Mine (NV) – 0.1 MW, Co-produced

(Name, State, Capacity, Technology)
CA – California, NV – Nevada, OR – Oregon

A significant amount of geothermal resource potential exists across resource types, which include conventional geothermal, EGS, low-temperature, and co-production with oil & gas wells. The United States Geological Survey (USGS) has estimated 9,057 MW for known geothermal, 30,033 MW for undiscovered geothermal and 517,800 MW for EGS (Williams et al., 2008). This potential is driving development in the industry, supporting the Geothermal Energy Association (GEA) reporting 2,511-2,606 MW of geothermal planned capacity additions in development in 2013 and beyond (GEA, 2013). Geothermal co-production, resources based on low-temperature geothermal fluid derived from oil & gas wells, may represent an additional resource base of 3,000 MW (GTO, 2012). Although geothermal energy production comprised ~0.3% of the national energy mix, geothermal energy has the ability to play a key part in combating climate change and providing reliable baseload energy in support of intermittent renewable energy sources.

In 2012, the United States government remained committed to advancing the deployment of geothermal energy through RD&D and resource assessment work. The primary funding mechanism, the Department of Energy (DOE) Geothermal Technologies Office (GTO), had a number of notable successes ranging from non-technical barriers to EGS demonstration projects. For example, Calpine's EGS demonstration at the Geysers completed a full year of stimulation in 2012, generating 5 MW of equivalent steam (GTO, 2012), which signified a major milestone for in-field EGS to increase power generation at existing facilities.

Table 22.1 Status of geothermal energy use in the United States for 2012.

Electricity	
Total Installed Capacity (MW_e)	3187 (GTO, 2012)
New Installed Capacity (MW_e)	147.05 (GEA, 2013)
Contribution to National Capacity (%)	0.3
Total Generation (GWh)	16,791 (EIA, 2013)
Contribution to National Generation (%)	0.4
Target (MW_e, % national generation)	NA
Estimated Country Potential (MW_e)	9,057/30,033/517,800 (Williams et al., 2008)
Direct Use	
Total Installed Capacity (MW_{th})	564.1(IEA, 2013)
New Installed Capacity (MW_{th})	NA
Total Heat Used (GWh/yr)	2,287 (IEA, 2013)
Total Installed Capacity Heat Pumps (MW_{th})	12,000 (IEA, 2013)
Total Net Heat Pump Use [GWh/yr]	17,143 (IEA, 2013)
Target (PJ/yr,)	NA
Estimated Country Potential(MW_{th} /PJ/yr/GWh/yr)	NA

NA = data not available
italics = data estimated based on projections

With an estimated direct-use capacity of 12.5 GW_{th} (IEA, 2013), the United States continues to have the most robust geothermal market in the world. Although resources used for power production are isolated to western states, such as California and Nevada, examples of low temperature direct-use facilities of significant scale across the country have also been brought into operation. Ball State University (Muncie, Indiana), which leveraged $5 million in stimulus funding under the American Recovery and Reinvestment Act (ARRA), uses more than 1,800 bore holes to create the largest ground source heat pump system currently in the use in the US (Ball State University, 2013). Geothermal (ground source) heat pump data has not been calculated since 2010, but at that point there was estimated to be 12,000 MW_{th} of capacity. An estimated count of direct-use (non-GSHP) facilities nationwide is more than 450, with an estimated capacity of 564 MW_{th} in 2011 (OpenEI, n.d.).

22.1 National Programme

The United States energy strategy is characterized by an "All-of-the-Above Approach" given the need to achieve energy independence and to strengthen the Nation's economy. In 2012, President Obama's administration remained committed to renewable energy, achieving its 2008 goal to double renewable energy generation (White House, 2012).

The United States Executive Branch is involved in numerous aspects of geothermal power production, and a brief outline of the key Federal players is outlined here. With respect to regulatory policy and permitting, the Bureau of Land Management and the United States Forest Service are most involved in managing the geothermal permitting process on Federal lands. Currently, almost 50% of all geothermal energy installed capacity in the United States is under this jurisdiction. The US Department of the Treasury offers incentives designed to reduce the cost of capital for geothermal projects by issuing cash grants and tax credits based on either capital expenditures or production rates. Advanced research, development, and deployment (RD&D) of geothermal technologies are supported by the US Department of Energy, and its programs in the Geothermal Technologies Office (GTO), Building Technologies Office (BTO), and the Loan Programs Office (LPO). Among other Federal agencies the United States Geological Survey (USGS) has been involved with estimating the location and geothermal resource potential ranging from conventional hydrothermal to EGS and low temperature resources. Lastly, geothermal technologies are also supported through a variety of state-level government initiatives such as renewable portfolio standards and agencies focused on mineral resources.

Given the absence of a national Renewable Portfolio Standard (RPS), many states have passed legislation to implement binding RPS energy targets. For example, Nevada and California, which host approximately 95% of total geothermal installed capacity, have binding targets and are presently reaching interim milestones. A number of other states with significant geothermal potential have implemented RPS targets, as summarized in Table 2 (DSIRE, 2013). Strong RPS targets in states like Colorado, Oregon, New Mexico, and Washington, are driving development efforts to expand or initiate geothermal markets with new capacity.

At the federal and state level, a number of policy tools are in place to encourage geothermal development. On the federal level are continuing power generation incentives such as the production tax credit (PTC), business energy investment tax credit (ITC), Section 1603 cash grants (in lieu of ITC), and Section 1705 loan guarantee program, which has supported qualified renewable energy projects in the United States. On a non-utility scale, residential tax credits are available for geothermal heat pumps (DSIRE, 2012), and state incentive programs exist beyond regulatory efforts that are aimed at offering geothermal providers (electric and non-electric) with property tax exemptions.

Table 22.2 Summary of Western states with RPS binding targets as of December 31, 2102.

State	RPS Target (Year)	Bill No. (Year)
California	33% (2020)	SB X1-2 (2011)
Nevada	25% (2020)	SB 358 (2009)
Hawaii	25% (2020)	HB 1464 (2009)
Oregon	25% (2025)	SB 838 (2007)
Colorado	30% (2020)	HB 1001 (2010)
Montana	15% (2015)	HB 681 (2007)
New Mexico	20% (2020)	SB 418 (2007)
Washington	15% (2020)	I 937 (2006)

22.2 Industry Status and Market Development

Power plant distribution in 2012 was spread among Ormat Technologies (39%, 56 MW), GE Energy LLC (34%, 49.9MW), and TAS Energy Inc (27%, 39.1MW) for a total capacity addition of 145 MW_e (Bloomberg New Energy Finance, 2013a), or 4% growth. These additions increased the existing market share for Ormat Technologies from 23% to 24%, while reducing shares of manufacturers Fuji and Toshiba each by 2%. This dynamic further supports an on-going shift in equipment scale from high-temperature resource design to that of smaller, low-temperature resources in the power generation space.

In 2012, geothermal power produced a cumulative net generation of 16.8 TWh (EIA, 2013) across six states and just one interconnect region (EIA, 2013). For those states with EIA reporting data there are market penetration rates ranging from 0.02% to 3.81% of total net generation, and from 0.59% to 47.04% of net renewable generation in megawatt-hours (Figure 22.5 below). The state of Nevada is a standout in market penetration as it represents both the greatest apportionment of geothermal net generation to total and renewable outputs. At 47.04% market penetration Nevada relied heavily on geothermal power in 2012 as part of the state renewable energy mix. California was also significant in market penetration with 3.31% and 23.4% of total and renewable generation, respectively. Utah and Hawaii reported strong geothermal results as part of their renewable mixes, while Oregon and Idaho only have markets in the initial stages of growth

Table 22.3 Market Share by Turbine Supplier.

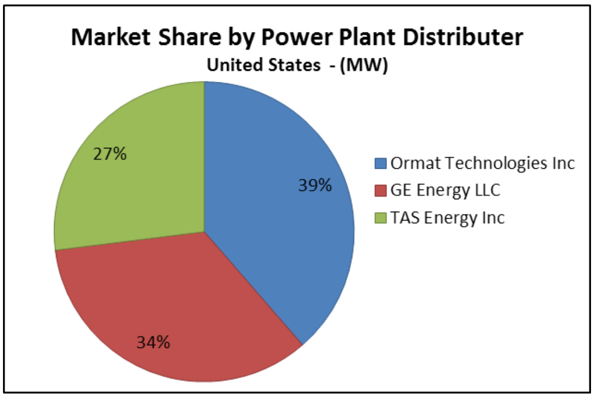
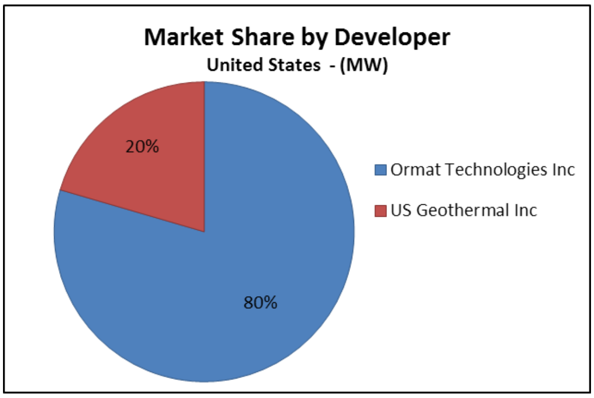


Table 22.4 Market Share by Project Developer.



Capital costs remain a challenge in the US geothermal market in 2012 (Figure 22.5). Precise data on installed costs is not readily available, but estimated costs per capacity installed is possible from US Treasury data on the distributions of Section 1603 cash grants in 2012. Four projects brought online in 2012 received these incentives and are valued from $12 million to $102 million per project (see table). Lawrence Berkeley National Laboratory (Barbose et al., 2012) first used this method of estimating cost per unit for solar PV, and in an equivalent calculation the cost per MW_e (Geothermal) in 2012 is estimated in a range of $2.52 to $6.82/ MW_e installed.

In addition to Section 1603 awards, projects were also eligible for either the PTC or ITC in 2012. Specific legislation for all three incentive programs prohibits projects from utilizing more than one. This resulted in a choice by project developers that, like prior years, resulted in only 1603 awards being utilized by comparing known projects with 1603 awards. The reasoning behind this highlights the nature of higher up-front costs and the challenges faced in monetizing tax credit benefits in the existing tax equity markets. Although useful, the PTC and ITC were insufficiently able to support the needs of projects coming online in 2012. In looking forward the Section 1603 cash grant program did reach its horizon point at the end of 2011, with awards continuing only under the safe harbour rule by qualifying the start of construction in 2009, 2010, or 2011.

The US Department of Energy's Loan Programs Office (LPO) also supported the geothermal industry through the Section 1705 loan guarantee program (Table 22.6). As a result, three geothermal developers were approved for more than $500 million in guarantees. In 2012, this program supported $125 million in project financing with the commissioning of McGinness Hills (NV), Neal Hot Springs (OR), and Tuscarora (NV). Each of these projects was also a 1603 awardee, and cumulatively awarded $104 million for a capacity of more than 80 MW.

22.3 Research, Development and Demonstration/Deployment

At the Department of Energy, the Geothermal Technologies Office is the primary funding mechanism to advance geothermal technologies in partnership with industry, academia, and national laboratories. With a portfolio of approximately 200 projects, the overarching goal is to research, develop, and demonstrate innovative technologies that will lower both risk and costs for the geothermal sector. Program priorities include the following:

- Identifying new hydrothermal resources while simultaneously lowering the cost and risk;
- Proving the benefits of low-temperature and co-produced systems through demonstration and deployment in the near to intermediate term;
- Advancing EGS systems through RD&D over the longer term; and
- Addressing non-technical and market barriers.

In 2012, GTO partnered in a number of successes, crossing focus areas in EGS, low temperature and co-produced, innovative exploration, and systems analysis. The following bullets highlight those efforts:

- Calpine's EGS demonstration at the Geysers completed a full year of stimulation in 2012, generating 5 MW of equivalent steam from an abandoned well. As one of six DOE-funded EGS projects, Calpine is the first to complete a successful EGS demonstration.

- The AltaRock demonstration project underwent a stimulation regime in 2012 using various innovative technologies such as diverters to create an EGS reservoir by injecting cold fluid into the subsurface at pressure. With a DOE commitment of $21.4 million towards the $44 million demonstration project, the goal is to demonstrate that an EGS reservoir can be developed outside of an existing geothermal well field.
- Analysis from the Caldwell Ranch Innovative Exploration Technologies (IET) project culminated in the confirmation of an initial 11.4 MW of equivalent steam, which was 50% more than what was expected from three previously abandoned wells at the Geysers. Calpine further estimated that, in combination with a portion of the presently undeveloped EGS project to the west, Caldwell Ranch could produce up to 45 MW of equivalent steam.
- Partnering with Simbol Materials, the DOE pursued the development of mineral extraction of Lithium from geothermal brines with the potential to power 300,000–600,000 electric vehicles per year (Geothermal Technologies Office, 2012). DOE support enabled the company to build the first demonstration facility and co-produce materials such as lithium, manganese, and zinc from geothermal brines.
- GTO launched a strategic initiative to engage the oil & gas sector in geothermal co-production following a successful demonstration project at the Rocky Mountain Oilfield Testing Center (RMOTC) in Wyoming. GTO aimed to further validate the technology by deploying binary power units into new oil & gas fields in states such as Texas.
- The Geothermal Regulatory Roadmap (GRR) was initiated to develop a working guide for agency, industry, and policy use to clarify the geothermal permitting process, and in its first year developed flowcharts on the federal level as well as for eight western states. The GRR is conducting an analysis to identify best practices to streamline geothermal permitting by collecting data on potential issues and concerns, and identifying overlaps in current processes.
- DOE's Induced Seismicity Protocol was released to address and estimate risk associated with EGS-induced seismic events. The strategy was to engage public officials, industry, regulators, and the public to ensure safety and facilitate progress on well-designed projects. A National Academy of Science report entitled "Induced Seismicity Potential in Energy Technologies" recommended that the protocol to be used as a standard (National Research Council, 2013) and is now enforced by all DOE-funded EGS demonstration projects.

Notable successes were achieved by the geothermal industry's trade association, the Geothermal Energy Association, which included participating in lobbying efforts for legislative victories and successful defences, perhaps the most notable being the revision of Internal Revenue Code (IRC) Sections 45 and 48, which define the terms of the PTC and ITC, respectively. This revision qualified all renewable technologies for the geothermal horizon date of December 31st, 2013 and added a clause for qualifying projects under construction (H.R. 8 112th Congress, 2013). The geothermal industry remained vibrant as evidenced by the Geothermal Resources Council (GRC) annual meeting in Reno, NV that was attended by over 2,000 attendees from over 33 countries.

22.4 Geothermal Education

A wide range of educational opportunities supporting geothermal technologies are available in the United States (Table 22.7). These offerings come from largely the academic sector, but are also supported through government and industry efforts. Due to the extensive nature of results on this subject, only an overview is provided. For more detailed information please review: http://geo-energy.org/reports/2011GEAGeothermalEducationandTrainingGuide.pdf

Beginning in 2011, and then following in 2012, the University of Nevada-Reno hosted the National Geothermal Academy, with support from the Geothermal Technologies Office at the U.S. Department of Energy, Oregon Institute of Technology, Stanford University, Cornell University, Southern Methodist University, West Virginia University, the University of Utah, and others. Leading instructors and professionals in the fields of geothermal engineering, geology, geo-physics, reservoir engineering, drilling, policy, and business development administered a 4-week course schedule during the month of July. In addition to the institutions involved in the Academy, Table 7 provides a fuller list of education providers focused on geothermal technologies.

22.5 Future Outlook

In looking to the future, the United States geothermal market has ample room to grow, both in the power sector and through direct-use applications. Expanding the feasibility of projects at lower temperature ranges and the demonstration of near-field EGS are vital areas of increased technology development that are at the forefront of the United States market. RD&D efforts in both EGS (e.g., Desert Peak, The Geysers) and low-temp/co-production (e.g. RMOTC) are proving the viability of expanded well-head temperature ranges and removing geographic constraints currently placed on resource development. With these types of projects reaching technical success, future deployment efforts will create new potential in areas of geothermal market growth.

The United States geothermal industry identified the need for open access to data, which resulted in the development of the National Geothermal Data System (NGDS). The NGDS is an on-going effort that addresses data accessibility, interoperability, and preservation, which is slated to expand the collective knowledge of the industry regarding sub-surface characteristics and other relevant data. In addition, this system will support the research community's ability for analysis and map suitable exploration points for future development across the geothermal resource spectrum.

A 2012 White House Executive Order intended to modernize the federal permitting process represents an opportunity to streamline geothermal development timeframes through avenues such as the National Environmental Policy Act (NEPA). In support of this initiative, the Geothermal Regulatory Roadmap is communicating the regulatory process across jurisdictions and will identify best practices to inspire reform such as eliminating redundancies. A desirable outcome would be a commensurate level of review for activities that have no significant or cumulative impact to the environment, thereby eliminating the discrepancies between oil & gas and renewable energy sources such as wind and solar.

As the range of application for geothermal projects expands there is/will be a need for also increasing the versatility of project revenues. Co-developed power and heat systems, combined to hybrid power systems (e.g. geothermal plus solar) are creating opportunities to fully maximize the resource potential and generate financial support. Diversified PPA contracts will begin to also recognize geothermal as a more adaptable energy source and start to introduce it as more than solely baseload power.

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- http://geo-energy.org/ - Geothermal Energy Association
- http://cgec.ucdavis.edu/ - California Geothermal Energy Collaborative
- http://www.gbcge.org/education-NGA.php - National Geothermal Academy
- http://www.gbcge.org/ - Great Basin Center for Geothermal Energy

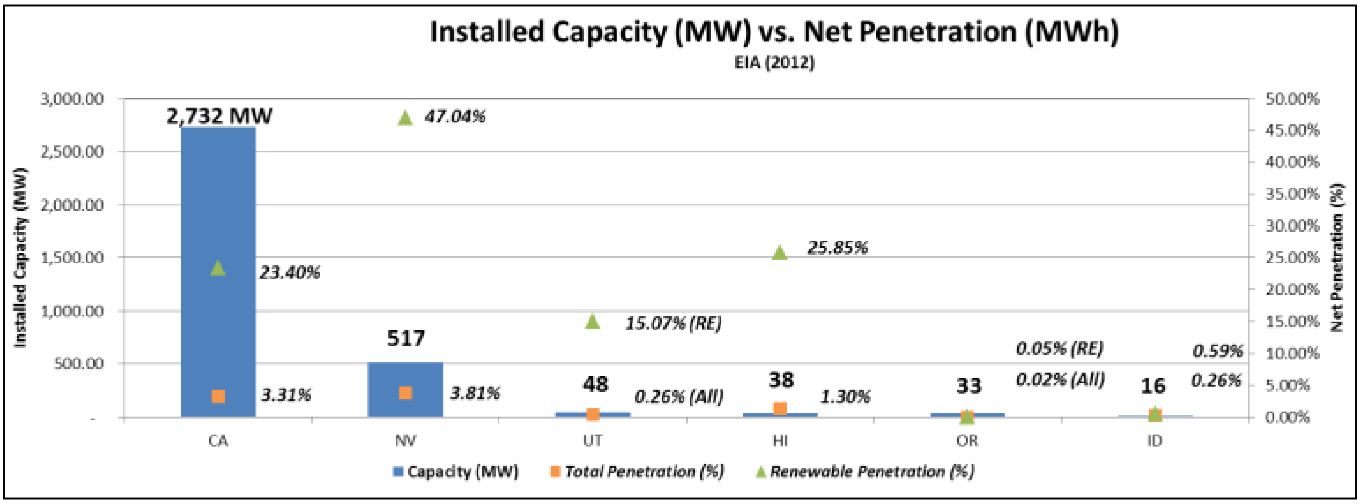

Figure 22.5 Geothermal market penetration by state.

Table 22.6 Estimations of Project Cost.

Project Name	State	Installed Capacity (MW)	Year	1603 Grant ($M)	Est. Cost Basis ($M)	$/MW ($M)
Florida Canyon Mine	NV	0.1	2012	$0.1	$0.4	$3.61
Dixie Valley	NV	6.2	2012	$4.7	$15.6	$2.52
San Emidio	NV	11.75	2012	$11.7	$39	$3.32
Tuscarora	NV	21	2012	$23.8	$79.4	$3.78
McGinness Hills	NV	30	2012	$46.9	$156.4	$5.22
Neal Hot Springs	OR	30.1	2012	$32.7	$109.1	$3.63
John L. Featherstone	CA	49.9	2012	$102	$340.2	$6.82

Table 22.7 Geothermal education in the United States

National Education: National Geothermal Academy		
Geological Sciences:	**Engineering:**	**Direct Use/Ground Source Heat Pumps:**
• Colorado School of Mines • *Southern Methodist University* • *Stanford University* • *University of Alaska, Fairbanks* • *University of California, Davis* • *University of Nevada, Reno* • *University of North Dakota* • *University of Utah*	• Cornell University • *Massachusetts Institute of Technology* • Oregon Institute of Technology • Truckee Meadows Community College • *West Virginia University*	• *Clarkson University* • *Greenville Technical College* • HeatSpring Learning Institute • *Oklahoma State University* • *Oregon Institute of Technology* • *Gateway Technical College of Wisconsin*

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