2013 GEOTHERMAL POWER: INTERNATIONAL MARKET OVERVIEW

SEPTEMBER 2013

Kenya

Nicaragua

Photo provided by Geothermal Development Associates of Eburru, Kenya & Ram Power of San Jancinto Tizate, Nicaragua

GEOTHERMAL ENERGY ASSOCIATION

The Geothermal Energy Association has prepared this document to provide the interested public with a sample of the range and complexity of the international geothermal power market as of September 2013. The report was not able to include information on all countries where there is geothermal production, development, and exploration taking place. We appreciate and recognize people and companies in those countries whose efforts to expand geothermal energy production was not recognized or missed by this report.

The 2013 Geothermal Power: International Market Overview is a follow-up on the reports by the Geothermal Energy Association released in 2012 & 2010. This report is largely based upon observations made in the press and other public media, along with personal communications with GEA staff. Given this, it is intended to give a view of the world geothermal market in 2013, and is not meant to replace more thorough analysis. Although geothermal energy production includes heat as well as power, this report primarily describes recent development in the power market.

GEA sincerely thanks its member companies, as well as other organizations and individuals, for their cooperation and assistance in gathering the information used in this report.

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SEPTEMBER 2013

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A complete list of countries and territories GEA counted developing geothermal projects includes but is not limited to: Algeria, American Samoa, Argentina, Armenia, Australia, Belgium, Bolivia, Canada, Chile, China, Columbia, Costa Rica, Comoros Island, Croatia, Czech Republic, Djibouti, Dominica, Ecuador, El Salvador, Eritrea, Ethiopia, Fiji, France, Germany, Greece, Guadeloupe, Guatemala, Honduras, Hungary, Iceland, India, Indonesia, Ireland, Italy, Japan, Kenya, Kyrgyzstan, Latvia, Malaysia, Martinique, Mexico, Montserrat, Netherlands, Nevis, New Zealand, Nicaragua, Northern Mariana, Norway, Panama, Peru, Philippines, Republic of Vanuatu, Reunion, Russia, Rwanda, Saba, Serbia, Slovakia, Solomon Islands, South Korea, Spain, St. Lucia, Switzerland, Tanzania, Turkey, Uganda, United Kingdom, United States, Vietnam, Zambia.

A complete list of countries and territories GEA counted operating geothermal projects includes: Australia, Austria, China, Costa Rica, El Salvador, Ethiopia, Germany, Guadeloupe, Guatemala, Iceland, Indonesia, Italy, Japan, Kenya, Mexico, New Zealand, Nicaragua, Papua New Guinea, Philippines, Portugal, Romania, Russia, Thailand, Turkey, United States.

KEY HIGHLIGHTS

- As of August 2013, 11,765 Megawatts of (gross) geothermal power are operating globally in addition to several hundred MW in the final stages of construction. By the end of 2013 the global geothermal market is expected to reach 12,000 MW of geothermal capacity.
- Currently there is 11,766 MW planned capacity additions of geothermal power in the early stages of development or under construction in 70 countries and territories around the world. Additionally, developers are actively engaged with 27 Gigawatts of geothermal resource globally.
- Looking closer at projects in the pipeline the global capacity could approach 14,000 MW, adding several thousand megawatts, by the end of the decade with several hundred MW of new geothermal power becoming operational per year.
- This year some of the first demonstration Enhanced Geothermal System (EGS) projects provided electricity to grids in Australia and the United States.
- There are over 1,741 MW of geothermal power under construction. These potential capacity additions are located in 12 countries across the globe. GEA counted over 674 developing geothermal power projects globally, ranging from prospects to projects in the late stages of development.
- Counties such as Uganda, France, Tanzania, Chile, and Rwanda have geothermal projects under construction or in the latter stages of development and will have their first operational geothermal power plants within the next few years.

TERMS AND DEFINITIONS

While projects in the GEA's Annual U.S. Geothermal Power Production and Development Report are defined by several phases of development (Prospect and Phase 1-4) as defined by *GEA's 2010 New Geothermal Terms and Definitions,* this report uses much broader terms to define where a project tracks in its development because of the vastly different development models to construct geothermal power plants. These terms include Prospect, Early Stage, Under Construction, On Hold, Canceled, and Operational. The breadth and diversity of geothermal project tracking throughout the world makes labeling projects with specific phases incredibly difficult. Therefore, for the purposes of this report, projects are defined by much broader categories in order to maintain the integrity of the information regarding a project's forward progress.

Geothermal 'Prospects' are defined to be areas in which little exploration has taken place, and the country's government has tendered the property to a private company, government agency or contractor to conduct further exploration. Although geophysical features or prior exploration might indicate the presence of a geothermal resource at the site, past exploration may not have determined the economic feasibility of a geothermal power plant at the property tendered.

'Early Stage' projects are defined to be projects where some aspects of a resource are present and the initial stages of explorations and construction are underway. This could mean but is not limited to, the first exploration wells drilled, project funding, and/or significant knowledge of the geothermal resource attained.

Projects *'Under Construction'* are projects where physical work to build the actual power plant has begun. For the purpose of this report, this does not include production drilling. However, many definitions of 'Under Construction' do include production drilling. 'Under Construction' is roughly equivalent to GEA's Phase 4 of a project's development.

'Operational' plants are contributing electricity to a customer who agreed to purchase the power prior to the plant's construction. 'Under Construction' and 'Operational' of power plant are determined by information reported publically on company websites, press releases, government or academic reports, or media articles, or other public sources of information.

Projects *'On Hold'* are when forward progress on the projects has halted for any number of reasons not limited to land or religious disputes, loss of project funding, or an agreement that fell apart.

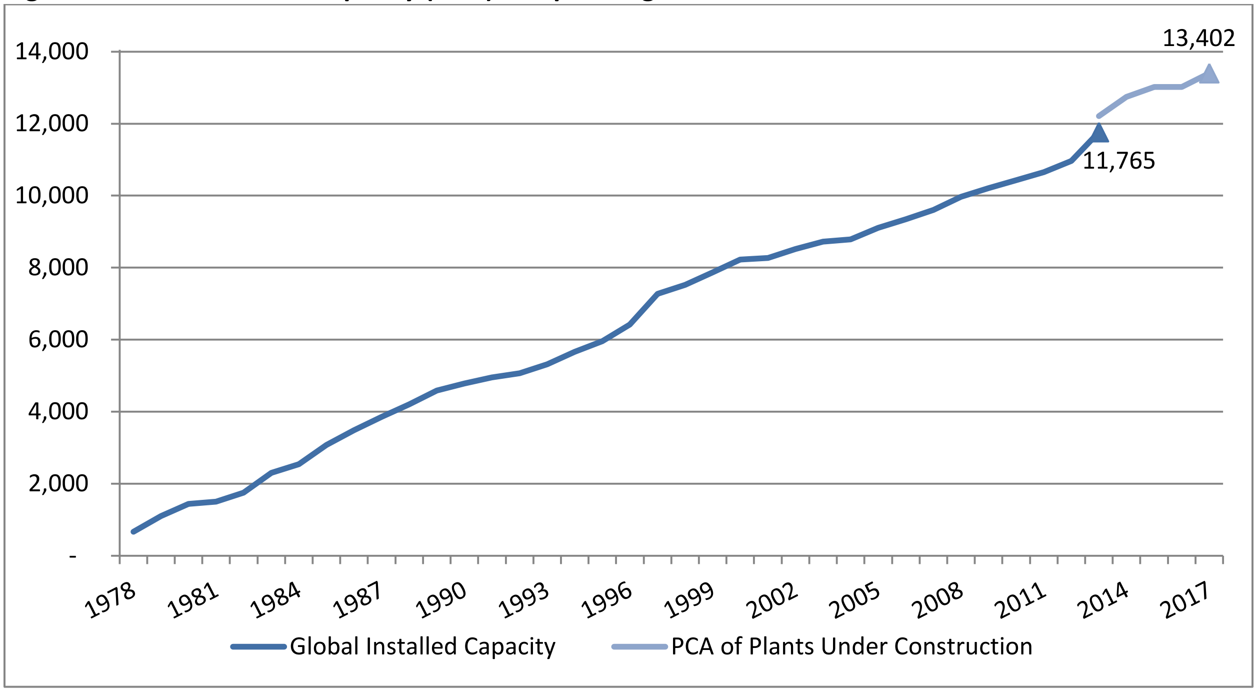
Projects *'Canceled'* are projects where the government, project developer, or contractor decided to make no more forward progress on a geothermal project in the immediate future and withdrew from developing that geothermal prospect into a power plant.

For this report, GEA collected two numbers for each project in cases where both were available. A "Resource Capacity Estimate" and a "Planned Capacity Addition" (PCA) estimate. At each project phase the geothermal resource capacity estimate may be thought of as the megawatt (MW) value of the total recoverable energy of the subsurface geothermal resource. It should not be confused with the PCA estimate, which is the portion of a geothermal resource that if the developer were to utilize the geothermal resource under its control to produce electricity, would be the power plants resulting estimated installed capacity. In other words, the PCA estimate is usually the expected power plant's installed capacity. In the case of an expansion to a conventional hydrothermal geothermal plant, the PCA estimate would be the estimated capacity to be added to the plant's current installed capacity.

INTERNATIONAL MARKET OVERVIEW

The global geothermal power market continues to grow substantially, with exciting new opportunities arising around the globe. As of August 2013, the global geothermal industry reached 11,765 MW of installed geothermal capacity. Currently there are 11,766 MW of planned capacity additions of geothermal power in the early stages of development or under construction in 70 countries and territories around the world. Additionally, developers are actively engaged with 27 gigawatts of geothermal resource globally (Resource Capacity Estimate). In Figure 1, the "Global Installed Capacity" is a cumulative representation of the geothermal power plants still operating today.

Figure 1: Global Installed Capacity (MW) of Operating Geothermal Power Plants

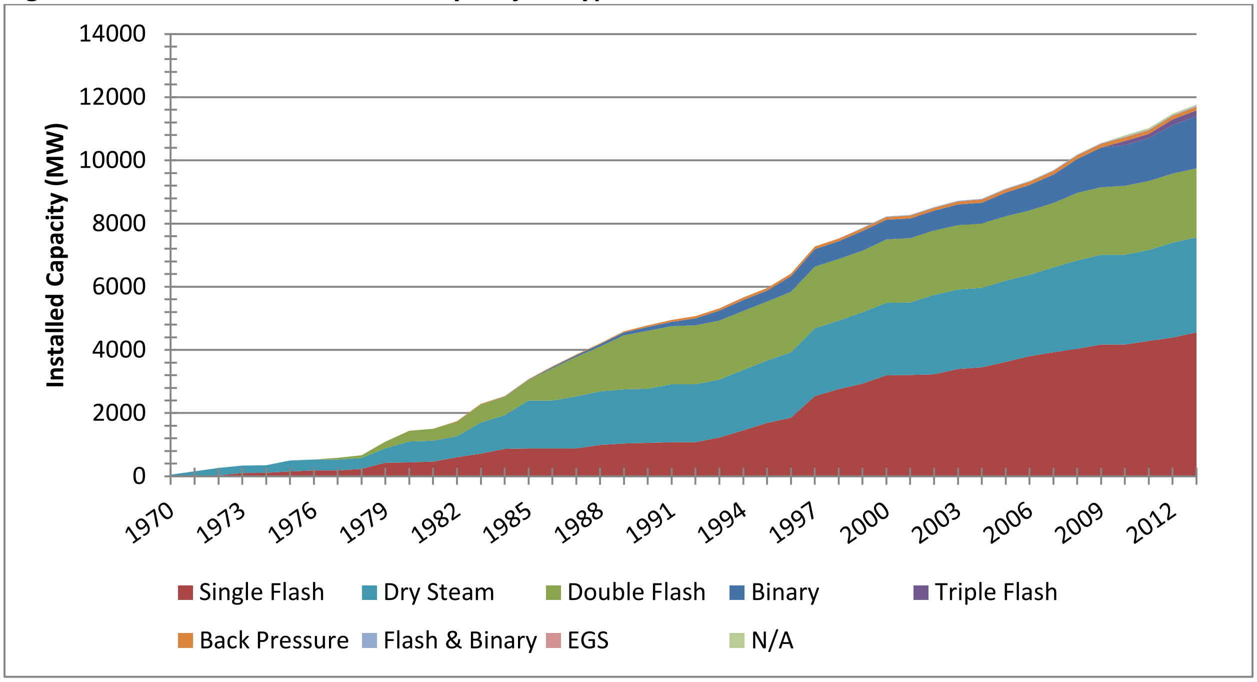


Note: PCA (Planned Capacity Additions), Pilot plants and geothermal plants built in the first half of the 20th century and then decommissioned are not included. Source: Author

"PCA of Plants Under Construction" is representative of the power projects under construction. If all power projects become operational by their publicly reported completion dates, the potential global capacity could reach 13,402 MW by 2017.

Looking closer at projects in the pipeline, the global capacity could approach 14,000 MW by the end of the decade with several hundred MW of new geothermal power becoming operational per year. The leader in terms of megawatts under construction is Indonesia with roughly 425 MW, followed by Kenya with over 296 MW of geothermal power currently under construction. Some other countries to note are the Philippines with 110 MW, Iceland with 260 MW, New Zealand 166 MW, and the U.S. with 178 MW of geothermal power currently under construction. Germany is second following the U.S. with the most new power plants under construction with 8 new power plants and 47MW. However, they are smaller projects ranging from 1-6 MW each.

Figure 2: Geothermal Power Plants by Project Type



Note: EGS plants are not double counted. EGS projects are counted separately despite the fact they use binary, flash, or dry steam turbines. Figure 2 depicts the cumulative representation of the geothermal power plants still operating today. It does not represent the installed geothermal capacity during a given year. Pilot plants and geothermal plants built in the first half of the 20th century and later decommissioned are not included.
Source: Author

Figure 2 shows that single flash power plants are the most used technology for geothermal power, composing 39% (~4,557 MW) of Installed Capacity globally. Dry Steam follows at 25% (~3,005 MW) and double flash ranks third at 19% (~2,184 MW) of global installed capacity. Lastly, binary is 14% (~1,654 MW) of global installed capacity. The last 3% of power plants are triple flash, back pressure, flash/binary hybrid, EGS, or some other geothermal technology.

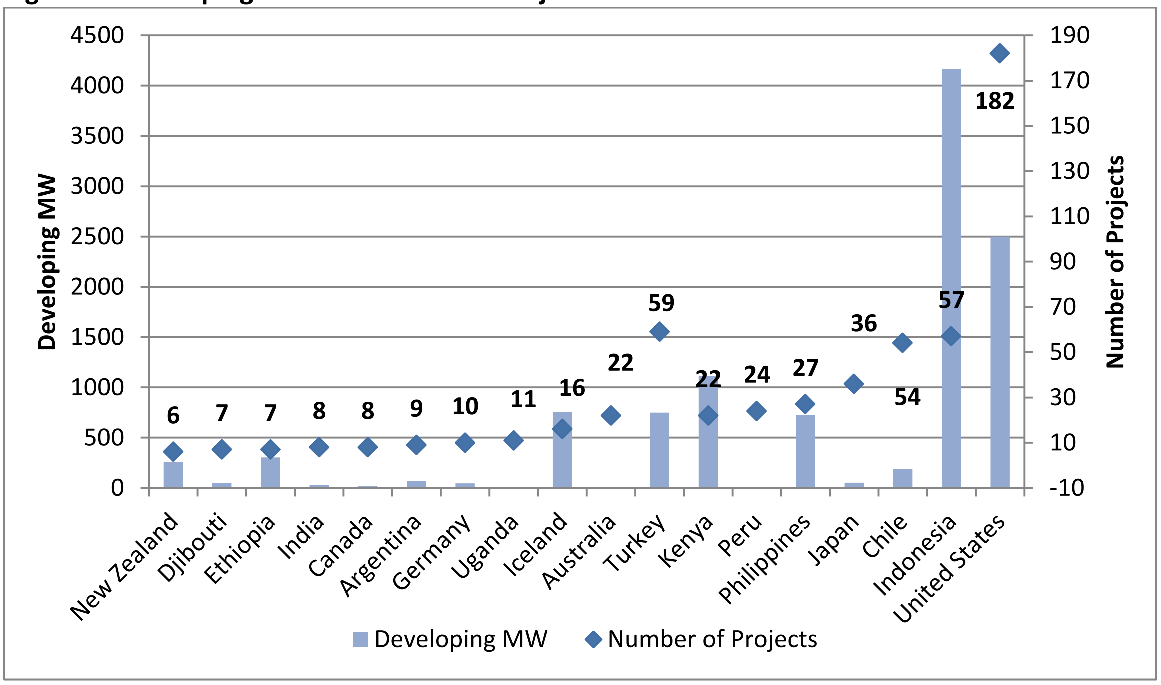
Figure 3 shows "Developing Geothermal Power Projects." The United States is the world leader with 182 projects. However, many of these projects are progressing slower than their counterparts in countries with less developed geothermal power markets. Many projects in the United States have been trapped in the same phase of development for several years.

The U.S. has nearly three times more developing projects than the closest counterparts – Indonesia and the Philippines – due in part to the U.S. being a geographically larger country and having built its first geothermal power plant over 50 years ago. The U.S. has also explored for geothermal resources much more extensively than other nations. Countries such as Chile and Indonesia are just beginning to explore their geothermal resources. In the future, GEA expects to see many more pieces of land tendered for exploration and development as the geothermal markets in countries like Japan, Chile, the Philippines, Indonesia, and others evolve.

Despite setbacks stemming from regulatory issues, religious or spiritual conflicts with geothermal resources on heritage sites, and/or a lack of knowledge about geothermal resources within their borders, countries in the developing world demonstrate noticeable forward progress on their projects. Specific examples will be discussed further in the "Country Narrative & Supplemental Information" section of this report. Developers in these countries continue to secure financing, PPAs, exploration permits and leases, and many are entering the construction phase of development.

While the U.S. leads in developing projects, Indonesia leads with a substantial number of MWs planned or under development. Many U.S. projects have progressed rather slowly due to an uncertain policy environment and problems attaining PPAs or financing. There could be a time in the foreseeable future when Indonesia leads in global installed geothermal capacity.

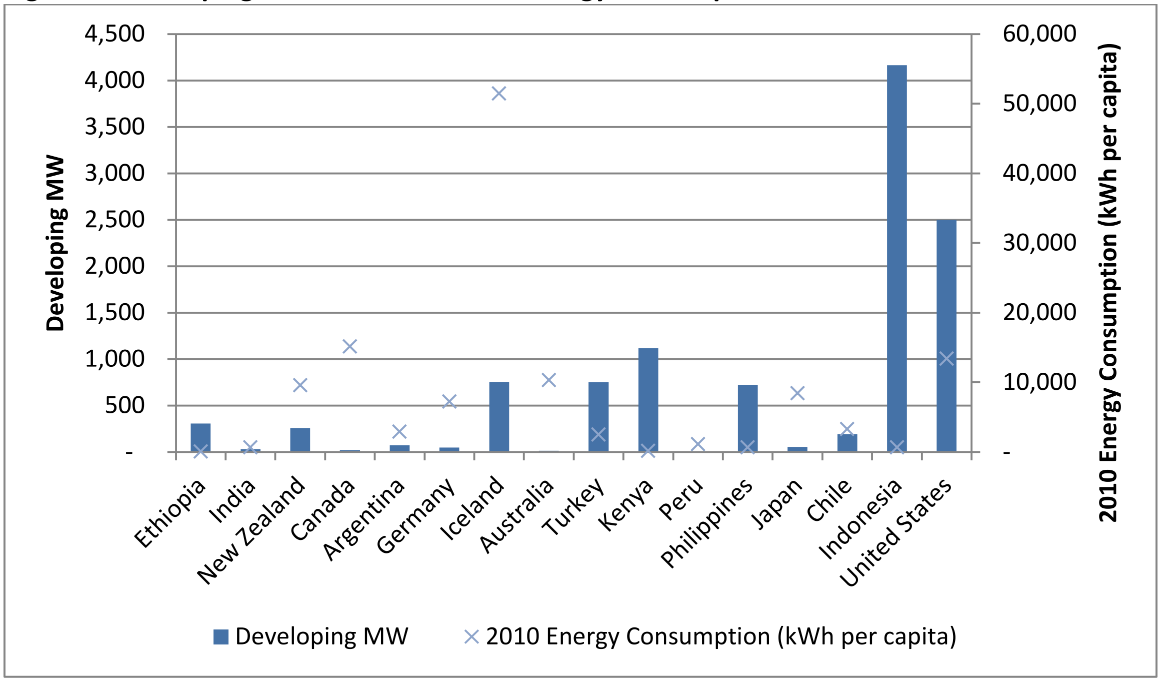
Figure 3: Developing Geothermal Power Projects



Source: Author

In Figure 3, countries with six or more developing projects are listed along with the respective number of geothermal MW planned in the country. Indonesia is the leader with almost 4,500 MW of developing resource, while the U.S. leads "Number of Projects" with 182 prospects and projects that are in some stage of completion. Figure 4 compares select countries' 2010 energy consumption, as reported by the World Bank, to their Developing PCA. This graph reflects countries' demand for electricity compared to how much geothermal capacity the respective country has in the pipeline.

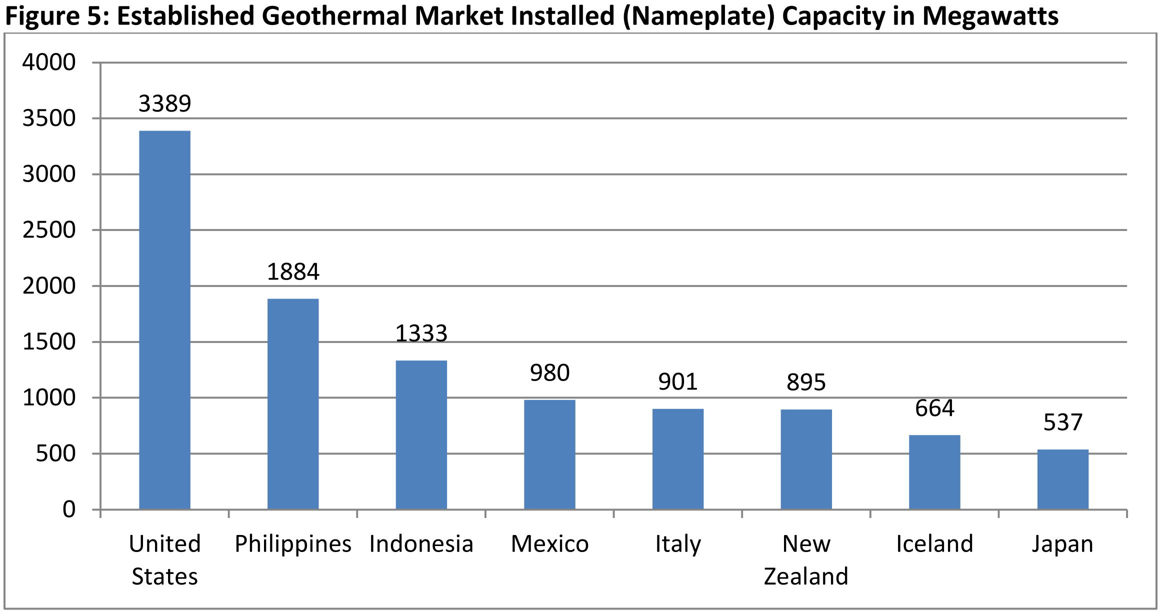
Figure 4: Developing Geothermal Power & Energy Consumption



Source: Author & the World Bank 2013b

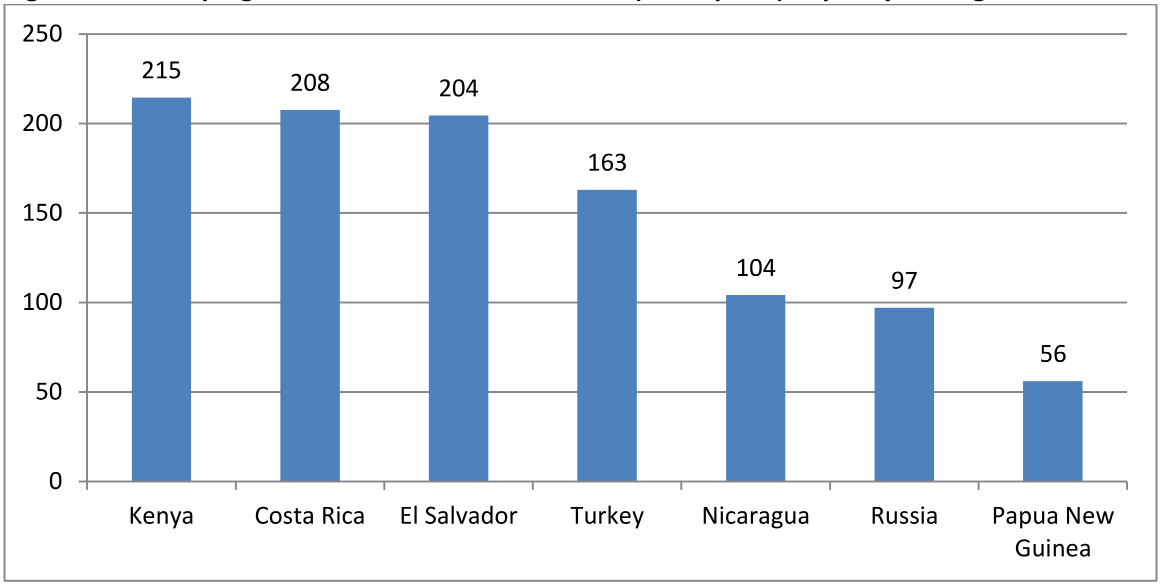
Figures 5-7 show the current installed capacity for every country in the world with an operating geothermal power plant and a total installed capacity of at least 1 MW. They are divided into three categories: Established Markets, with more than 500 MW, Developing Markets, which range from 50-500 MW, and New Markets, with less than 50 MW of installed capacity.

Figure 5: Established Geothermal Market Installed (Nameplate) Capacity in Megawatts



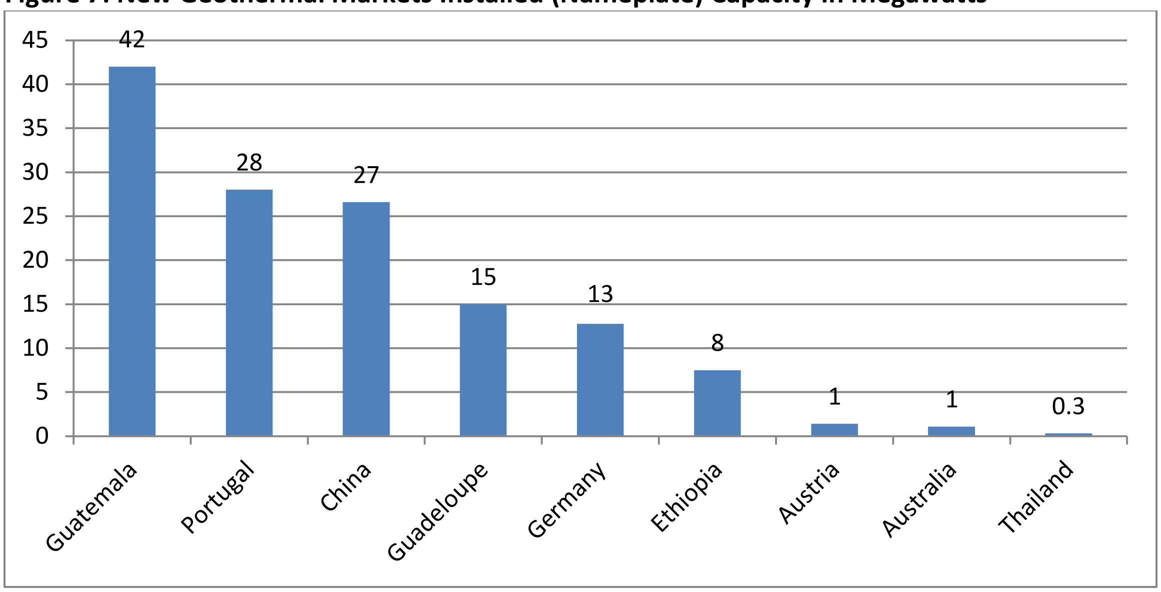
Source: Author

Figure 6: Developing Geothermal Markets Installed (Nameplate) Capacity in Megawatts



Source: Author

Figure 7: New Geothermal Markets Installed (Nameplate) Capacity in Megawatts



Source: Author

Not shown in the Figures 3-7 above are counties such as Uganda, France, Tanzania, and Rwanda that have several geothermal projects under construction or in the latter stages of development and will have their first operational geothermal power plants within the next few years.

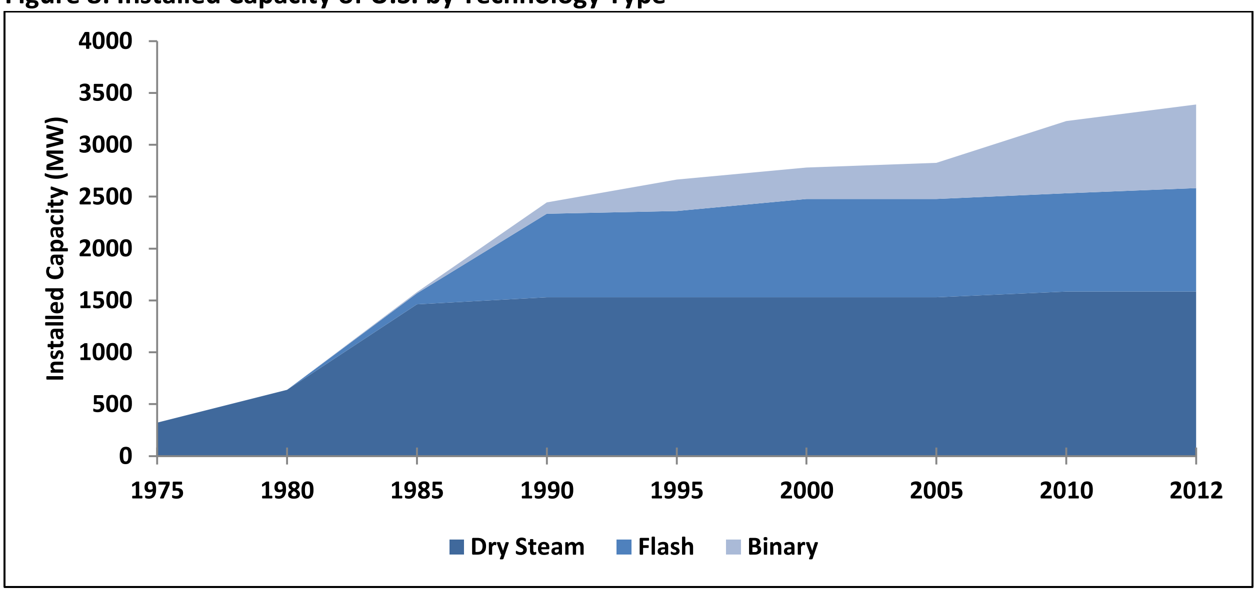
EMERGING INDUSTRY TRENDS & HIGHLIGHTS

GEOTHERMAL POWER TECHNOLOGIES

There are three main types of geothermal turbines: binary, flash, and dry steam. In dry steam, the oldest power technology, steam is withdrawn directly from an underground geothermal reservoir and used to run the turbines that power the generator. In flash plants, high-pressure and high- temperature geothermal water begins to separate into steam and water as it rises to the surface. The two phase mixture of steam and liquid is separated ("flashed") in a surface separator. The steam is delivered to a turbine that powers a generator and the resulting liquid is re-injected to the reservoir. In binary plants, geothermal water is used to heat a secondary liquid called a working fluid, which boils at a lower temperature than water. Heat exchangers are used to transfer the heat energy from the geothermal water to vaporize the working fluid. The vaporized working fluid, like steam in flash plants, turns the turbines that power the generators. The geothermal water is injected back into the reservoir in a closed loop that is separated from groundwater sources.

Interestingly, the distribution of power plant technology in the United States is not reflective of the rest of the world. Figure 8 separates U.S. installed capacity of geothermal power by technology type. The United States has mostly developed its high-temperature resource in flash and dry steam plants and very few new power plants with this technology are in the pipeline, favoring instead binary power plants. In fact, since 2007 all but one of the new power plants that came online in the United States was binary. This trend has not been replicated in the rest of the world, where many countries are beginning to develop their higher-temperature resources. Flash and dry steam plants are in the pipeline in many countries across South East Asia, South America, and Africa.

Figure 8: Installed Capacity of U.S. by Technology Type



Source: Author

ENHANCED GEOTHERMAL SYSTEMS POWER PROJECTS

Enhanced Geothermal System (EGS) projects can be divided into three categories: Infield, Nearfield, and Greenfield projects. Infield projects are located within an unproductive portion of an operational hydrothermal field. Nearfield are EGS projects on the margins of an existing hydrothermal field and

Greenfield projects are geothermal resources engineered where no geothermal development has occurred previously.

This year some of the first demonstration EGS projects added electricity to grids in Australia and the United States. Ormat Technologies, the U.S. Department of Energy, and GeothermEx successfully produced 1.7 additional megawatts from an EGS Infield project inside an existing well field in the U.S. Using innovative subsurface technologies, development teams stimulated an existing sub-commercial injection well, resulting in a 38 percent increase in power output from brine at Ormat's Desert Peak 2 geothermal power plant in the Brady Complex in Churchill County, Nevada. Support for the project included $5.4 million in direct U.S. DOE funding, $2.6 in million investment from Ormat, and more than four years of collaborative work with partners including Lawrence Berkeley National Laboratory, U.S. Geological Survey, Sandia National Laboratory, University of Utah EGI, Temple University, and TerraTek.[1]

At the Geysers geothermal field, Calpine Corporation successfully completed a Nearfield EGS project engineering 1.75 MW of geothermal power with the potential for 3.25 MW of more geothermal power. A pair of wells were completed as a production-injection well pair (respectively) into low-permeability rock with temperatures as high as ~400^{o}C. As a result of the successful demonstration, Calpine expects that additional EGS targets are available in the Geysers geothermal fields.[2]

In Australia, the commissioning of the Greenfield 1 MW Habanero Pilot Plant is a long anticipated and major milestone for Geodynamics. It marks a significant achievement for Australia and global geothermal exploration. The project is the first Enhanced Geothermal System (EGS) to derive power in Australia and the southern hemisphere.[3]

The long term goal with EGS technology is to create geothermal resources from Greenfield projects. Conventional geothermal resources tend to cost $3-12M to drill, carry significant exploration risk with low success rates, and incur high costs for drilling equipment. However, using EGS technologies could build wells for $0.5-1.5M by eliminating the risks associated with permits, PPA, financing, financial risk, drilling, mechanical equipment, etc.[4]

For example, AltaRock Energy, a U.S. EGS project developer, uses a thermo-degrading zonal isolation technology to block a stimulated fracture, diverting water deeper underground into hotter zones. No drill rig is needed and no chemicals are added to water, thus reducing engineering costs. Next, additional stimulation zones are built by pumping water from the surface at relatively low pressures to open new fractures. Lastly, a blocking agent is then easily removed through thermal degradation and multiple stimulated fractures allows for much higher flow rates to create more power production. Recently, with the help of the U.S. DOE and private funding, AltaRock created multiple stimulated zones from a single wellbore at the Newberry Enhanced Geothermal System (EGS) Demonstration site using this process.[5]

[1] Ormat Technologies Inc. 2013
[2] Rogers 2013
[3] Geodynamics Limited 2013
[4] Mandell 2013, AltaRock Energy 2013
[5] *Ibid.*

GLOBAL FUNDS & INITIATIVES FOR GEOTHERMAL DEVELOPMENT

Bloomberg New Energy Finance released a white paper in May 2013 proposing the possibility of a $500 million rotating debt facility that could provide affordable financing to a global portfolio of geothermal projects for the first few deep exploration wells. Bloomberg estimated that a commercial financing approach using a 7% cost of capital would result in a 17% interest rate to developers. With public sector support and a 3.5% rate of return public sector contributors could offer loans at a 14% interest rate. While these rates are high, they could be attractive, considering the notable lack of access to financing at this time for early-stage drilling. Additionally, Bloomberg believes a $500m fund would result in approximately $9.6bn of new investment in geothermal projects. This fund could directly finance drilling of 473MW across a portfolio of 24 projects. As a result, those confirmed resources would catalyze an additional 1,927MW, bringing the total impact of the fund to 2,400 MW.[6]

Around the same time as Bloomberg's paper was released, the World Bank announced a $500 million Global Geothermal Development Plan (GGDP) to better manage and reduce risks of exploratory drilling and help expand geothermal power generation in developing countries. The Global Geothermal Development Plan's (GGDP) initial target is to mobilize U.S.$500 million dollars for geothermal projects. The GGDP is to be managed by the World Bank's longstanding Energy Sector Management Assistance Program (ESMAP). The Bank Group's financing for geothermal development has increased from $73 million in 2007 to $336 million in 2012, and now represents almost 10 percent of the Bank's total renewable energy lending.[7]

The U.S. Department of State and the U.S. Department of Energy will lead participation on a "U.S.-Asia-Pacific Comprehensive Energy Partnership." The Partnership will work closely with the World Bank and the Asian Development Bank to ensure a coordinated approach to maximize investment opportunities for geothermal and other renewable energy projects. The Partnership will provide up to $6 billion in funding from Overseas Private Investment Corporation (OPIC) and the Export Import Bank (Ex-Im Bank). The Ex-Im Bank will launch a program to make available up to $5 billion in export credit financing to eligible countries in the Asian Pacific over the next four years to increase access to American technology, services and equipment for the implementation of energy infrastructure projects. OPIC will provide up to $1 billion in financing for sustainable power and energy infrastructure projects.

On June 30th, 2013 President Obama announced Power Africa, a new initiative to double access to electricity in sub-Saharan Africa. More than two-thirds of the population of sub-Saharan Africa is without electricity, and more than 85 percent of those living in rural areas lack access. Power Africa will build on Africa's enormous power potential, including new discoveries of vast reserves of oil and gas, and the potential to develop clean geothermal, hydro, wind, and solar energy. Power Africa will help countries develop newly-discovered resources responsibly, build out power generation and transmission, and expand the reach of mini-grid and off-grid solutions. The United States will work with an initial set of Power Africa partner countries, including Ethiopia, Ghana, Kenya, Liberia, Nigeria, and Tanzania, many of which have substantial geothermal resources. The United States will commit more than $7 billion in financial support to these countries over the next five years for this initiative.[8]

[6] Taylor et al 2013
[7] The World Bank 2013a
[8] Office of the Press Secretary 2013

CO-PRODUCTION, DISTRIBUTED GENERATION, & NEW TECHNOLOGIES

According to U.S. DOE estimates, 823,000 old wells in the U.S. produce hot water concurrent with oil and gas production. The water produced annually by oil and gas fields could generate up to 3 GW of clean, base-load power using binary geothermal units.[9] In 2012/13 several projects successfully progressed to establish emission free, distributed generation, or co-production projects with low temperature geothermal resources.

ElectraTherm is a leader in geothermal small-scale, distributed power produced from waste heat. The company recently celebrated the successful commissioning of its 4100C Green Machine at the Florida Canyon Mine in Imlay, Nevada. This marks their second geothermal project utilizing low-temperature (77-116°C) geothermal brine to generate electricity, following the startup of a Series 4000 Green Machine in Romania. This unit is nearing its 500th hour of run time as of July 2013. The Romanian installation provides 50kW of electricity from the geothermal hot water (102°C) without any fuel or emissions, and has reached more than 3,862 hours of run time as of July 2013. To further increase the generator's efficiency, once geothermal water has passed through the heat exchangers to pressurize the Green Machine working fluid, it continues on to heat nearby residential buildings in the winter.[10]

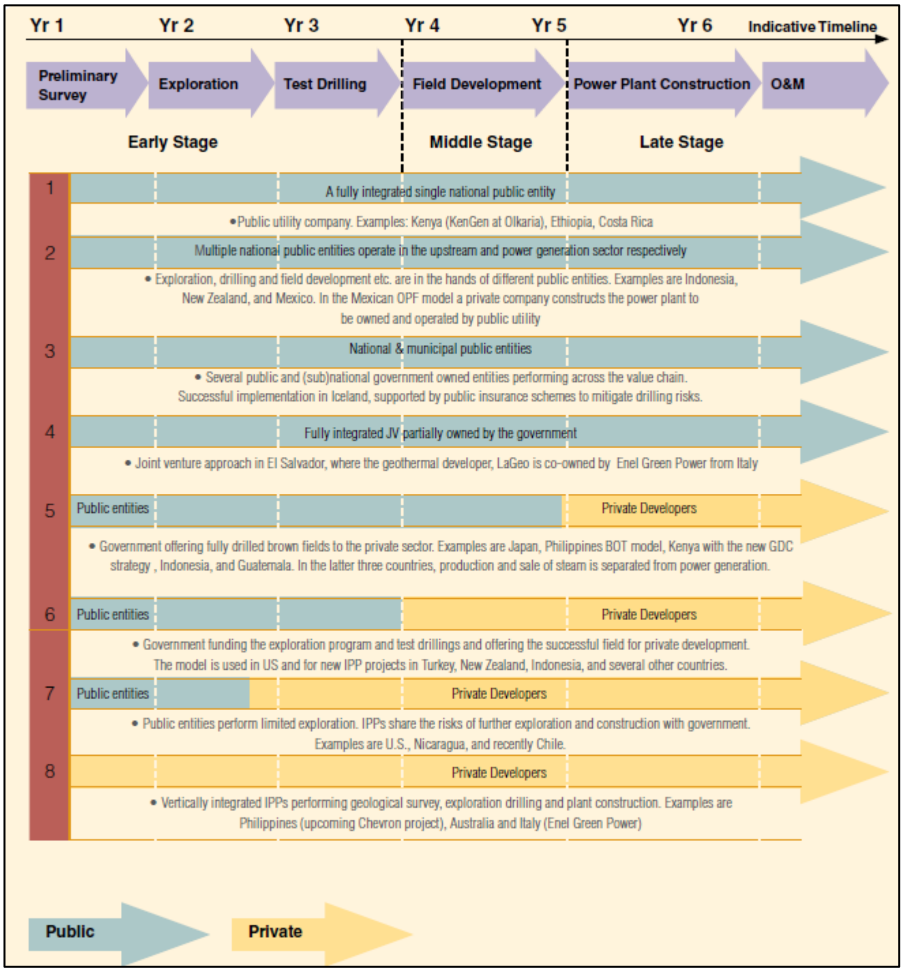
In Surprise Valley near Cedarville, California, Cornerstone Sustainable Energy is using new technology that will recycle water flowing naturally from artisan formations at 850gpm and 93°C to generate about 1.5 MW of electricity. The technology behind CSE's project, titled PwrCor, operates at notably lower temperatures (81°C) than Organic Rankine Cycle plants, providing fuel-free, 250 kW of electrical power using 150 gpm of water. This new type of technology uses liquefied CO_2 as the working fluid and operates relatively silently as a compact modular system with off the shelf components. Additionally, the technology is a completely closed loop system, which means that the PwrCor emits zero emissions.

GLOBAL GEOTHERMAL DEVELOPMENT

Globally, there is a spectrum of development models used to build geothermal power plants to avoid the risks associated with drilling and the initial exploration of geothermal development. In some countries, the government funds the initial geothermal exploration and then leases already discovered resources to private developers or government entities to build geothermal power plants. In other countries, companies share the risks of the initial exploration by undertaking joint ventures and business agreements to search for the geothermal resource. Another approach is for a country to issue a long-term concession based on private companies completing all exploration, development, and operation in exchange for a fixed sales and agreement and other financial incentives. Below this spectrum is illustrated by Magnus Gehringer and Victor Loksha of the Energy Sector Management Assistance Program (ESMAP) in their "Geothermal Handbook: Planning and Financing Power Generation."

[9] US DOE 2013
[10] ElectraTherm 2013

Figure 10: Models of Geothermal Power Development in International Practice



Source: Gehringer et al 2012

PLANTS UNDER CONSTRUCTION

The following list is of geothermal power projects under construction. This information is gathered from publically available information. For the purposes of this report, a plant is deemed "under construction" when actual work on the geothermal power plants has begun. For further information, please see the terms and definition section.

There are 1,741 MW of geothermal power under construction, or about one in ten projects globally. These potential capacity additions are located in 12 countries across the globe. These countries are located mostly in the western world and developed Asia as well as Kenya, Turkey, and Indonesia, which are likely to bring a substantial amount of geothermal power online in the next few years.

Table 1: Global Geothermal Power Plants Under Construction

Country	Developer	Field	Plant	Year of Operation	PCA (MW)
Ethiopia	Ethiopian Electric Power Corporation	Aluto-Langano			N/A
France	Soultz Geothermal Project	Soultz-sous-Forêts			2
Germany	Enex	Geretsried/Wolfratshausen		2015	5
Germany	Daldrup & Söhne AG	Taufkirchen/Oberhaching		2015	4
Germany	N/A	Kirchstockach		2013	6
Germany	N/A	Traunreut		2013	4
Germany	N/A	Brühl		2015	6
Germany	N/A	Kirchweidach		2015	7
Germany	N/A	Durrnhaar			6
Germany	N/A	Maurstetten			5
Germany	N/A	Saurlach			5
Iceland	Reykjavik Energy/ Orkuveita Reykjavikur	Hverahlid		2013	90
Iceland	Landsvirkjun	Bjarnarflag	Early Stage & 2		90
Iceland	Alterra Power (HS ORKA)	Reykjanes Expansion	Reykjanes 3	2016	50
Iceland	Alterra Power (HS ORKA)	Reykjanes Expansion	Reykjanes 4	2016	30
Indonesia	PT Pertamina Geothermal Energy	Lumat Balai 1 & 2		2015	110
Indonesia	PT Pertamina Geothermal Energy	Lumat Balai 3 & 4		2017	110
Indonesia	PT. Geo Dipa Energy	Patuha	Unit 2	2017	110
Indonesia	PT. Geo Dipa Energy	Patuha	Unit 1		55
Indonesia	PT Pertamina Geothermal Energy	Sulawesi - Lahendong	Lahendong Unit 6		20
Indonesia	PT Pertamina Geothermal Energy	Sulawesi - Lahendong	Lahendong Unit 5		20
Italy	Enel Green Power	Bagnore	Bagnore 4	2014	40
Japan	Oita Energy Industry Research Institute	Beppu City		2013	0.003
Japan	Kyusyu Electric Co, and Kawasaki Heavy Industry	Yamakawa power plant			0.25
Japan	GERD, Hirosaki Univ and AIST	Matsunoyu onsen		2012	1
Japan	Edit Co, Nagasaki Gov and Kyusyu Univ	Obama onsen			2
Kenya	Ormat Technologies	Olkaria III	Plant 3	2014	16
Kenya	KenGen	Olkaria IV	Olkaria IV	2014	140
Kenya	KenGen	Olkaria I Unit 4 & 5	Olkaria I Unit 4 & 5	2014	140
Mexico	Mexican Federal Electricty Commission (CFE)	Los Azufres	Los Azufres III	2014	50
Mexico	Mexican Federal Electricty Commission (CFE)	Los Humeros	Los Humeros III	2014	25
Philippines	Maibarara Geothermal (JV PetroEnergy, Trans-Asia Oil, and PNOC Renewables)	Maibarara	Maibarara	2013	20
Philippines	Energy Development Corp.	Bacon-Manito/Sorsogon/Alb	Bacman 3		40
Philippines	Energy Development Corp.	Cotabato	Mindanao 3	2017	50
Turkey	BM Enerji	Aydin-Gumuskoy	Gumuskoy	2013	15
Turkey	Maren Group	Aydin-Hidirbeyli	Hidirbeyli		24
Turkey	Maren Group	Aydin-Hidirbeyli	Hidirbeyli		44
Turkey	Alres A.S.	Aydin-Nazilli	Nazilli		10
Turkey	Celikler A.S.	Aydin-Pamukoren	Pamukoren	2013	45
Turkey	Menderes A.S.	Aydin-Salavatil	Dora III U2	2013	20
Turkey	Menderes A.S.	Aydin-Sultanhisar	Sultanhisar		10

Turkey	Menderes A.S.	Aydin-Sultanhisar	Sultanhisar		34
Turkey	Menderes A.S.	Aydin-Sultanhisar	Sultanhisar		12
Turkey	Karley A.S.	Aydin-Umurlu	Umurlu		5
Turkey	Zorlu Enerjii	Denizili-Saraykoy	Kizildere-2	2013	75
Turkey	Menderes A.S.	Aydin-Salavatil	Dora III U1		17
United States	Surprise Valley Electric Corp.	Paisley Geothermal		2013	2
United States	Ormat Technologies	Carson Lake			20
United States	Ormat Technologies	CD4 (Mammoth Complex)			30
United States	Ormat Technologies	Mammoth Complex repowering		2013	4
United States	Ormat Technologies	Wild Rose		2013	16
United States	Oregon Institute of Technology	GeoHeat Center 2		2013	2
United States	Gradient Resources	Patua		2013	60
United States	Enel North America	Cove Fort		2013	25
United States	Cyrq Energy	Lightning Dock 1		2013	15
United States	Chena Hot Springs	Chena Hot Springs 2		2013	0.4
				TOTAL	**1,741**

Source: Author

COUNTRY NARATIVES AND SUPPLEMENTAL INFORMATION

This section of the report contains brief summaries of select countries and regions where substantial news or progress to develop geothermal power capacity has taken place over the last year. Not every country with projects is mentioned in these summaries. In total, GEA counted 25 countries where geothermal power plants are currently operating and there are 70 countries developing new power plants. In total, counting countries developing power plants and countries with operating power plants there are 73 countries around the world with an active geothermal sector. Three countries – Austria, Romania, and Thailand – already have existing power plants but are not building any new ones at this time.

For more information on a select country, please refer to the International Geothermal Associations' *Geothermal Conference Paper Database*, ThinkGeo's *News Article Database*, or GEA's weekly newsletter *Geothermal Energy Weekly*.

For the complete list of developing projects, see GEA's website or contact GEA for an up-to-date list of developing projects.

MIDDLE EAST & AFRICA

Parts of the Middle East, such as Turkey and East Africa, have very promising geothermal resources. However, many countries across the region have just begun to develop their first projects and are struggling to find the right balance of rules, legislation, and business incentives to attract investors to fund their projects through development. Although this isn't anything unexpected for new geothermal markets, it is decelerating development in many African countries. As these countries fix their regulatory frameworks and learn more about their geothermal resources, a significant amount of geothermal development is expected in East Africa and Turkey over the next decade. In addition, the U.S. Agency for International Development (USAID) and the African Union Commission (AUC) have joined in a Memorandum of Understanding on the development of geothermal energy in East Africa.

DJIBOUTI

Media and industry experts report Djibouti made forward progress on their first geothermal power plants this year. In the medium term, Djibouti hopes to accomplish two goals: first, to develop a geothermal site to provide for their present energy needs (estimated at 50 MW); and second, to explore the country's overall geothermal resource potential. In the long term Djibouti would like to develop its geothermal resources to export electricity to other consumption centers. From general geodynamic and geologic considerations, it appears that Djibouti can potentially meet large geothermal power demands; and eventually, as in Iceland, attract foreign energy consuming industries willing to benefit from renewable, cheap, and reliable energy sources located in proximity to sea ports.[11]

There are six geothermal prospects areas in Djibouti and one early stage project at Fiale area. The World Bank approved funding of $6 million as part of a larger package of $31 million for the assessment of the commercial viability of the Fiale geothermal resource in the Lake Assal region of Djibouti. Studies by the Djibouti government and the World Bank determined that this project had the best economic potential for a power plant.

[11] Khaireh 2012

ETHIOPIA

Ethiopia has an estimated geothermal potential of 5,000 MW with plans to bring 450 MW online by 2019. With 6 early-stage geothermal fields under development and one geothermal plant expansion at Aluto-Langano, Ethiopia is actively pursuing development of its geothermal energy resources. Earlier this year, several containers of materials were delivered to Aluto-Langano for the 7.3 MW plant's expansion. More containers are currently processing at the dry port, according to the Ethiopian Electric Power Corporation (EEPCO).[12] The Aluto Langano expansion is expected to add between 35-70 MW to the existing plant's capacity by 2016. Ethiopia has received support for such projects from large public international donors such as the World Bank, the United States, and the Japanese Government.

Other recent announcements show promise for Ethiopian geothermal development. The Development Bank of Ethiopia said in July 2013 that an initial $20 million, funded by World Bank, will be ready to kick start geothermal energy projects within the coming months. An additional $20 million is expected to be added to the fund at a later date. The African Development Bank (AfDB) is working to define a geothermal development roadmap for Ethiopia.

KENYA

Geothermal exploration began in Kenya in 1957 and is presently generating approximately 212 MW, compared to a potential estimated at 7,000 MW to 10,000 MW. As forecasted in Vision 2030, Kenya aspires to generate a total of 15,000 MW, 5,000 MW of which will come from geothermal. In pursuant of this goal, Kenya's Geothermal Development Corporation (GDC), a 100% state-owned corporation incorporated in 2008 as a special purpose vehicle to accelerate the development of geothermal energy resources in Kenya, plans to drill 1,400 steam wells to provide steam for the generation of 5,000 MW of geothermal power by 2030. This will require a reported $18 billion in capital investments in the geothermal sector in the coming years.

Consumption of electricity in Kenya is extremely low at 121 kilowatt hours (KWh) per capita. Only about 29% of Kenyans are connected to electricity while the connection rate in the rural areas is estimated at 15%. Fortunately, this situation is rapidly changing as the country invests more resources in power generation, transmission, and distribution.[13]

Kenya is quickly developing its geothermal resources with 22 developing projects, three of which are under construction and expected to be operational in late 2014. The country is one of the fastest growing geothermal markets in the world. Kenya's government is moving a substantial amount of resources into building up its geothermal infrastructure. In his keynote address at GEA's 2013Finance Forum, Kenyan Ambassador to the U.S. Elkanah Odembo stressed that Africa is rapidly changing, growing, and evolving. He said, "There is business to be done on the continent; there is money to be made. If you make an investment in geothermal, you will get significant returns."

GDC is developing the steam resource at three primary resource areas (Menengai, Bogoria-Silali and Suswa). Through GDC, the Kenya government is planning on contracting with Independent Power Producers (IPP's) to sell geothermal steam/brine at the plant fence for use by the IPP's to convert the resource to energy through a power conversion contract. GDC is also evaluating potential joint

[12] Richter 2013a, Biggs 2013
[13] Omenda 2012

development agreements with private developers to assist in the development of the new steamfields. In addition, the Kenya government is encouraging private development of additional resource areas through concession agreements with private IPP's.

Right now 296 MW of the over ~1,000 MW of geothermal under development in Kenya are physically under construction. If all projects are completed on time Kenya will lead the world with substantial additions to their geothermal infrastructure over the next decade and become a center of geothermal technology on the African continent.

RWANDA

Rwanda is currently exploring four geothermal prospects with the help of Kenya's KenGen and GDC, and Chinese company Great Wall Drilling. KenGen has already estimated that over 700MW of untapped geothermal resources exist in the Western and Southern regions of Rwanda. Early exploratory drilling on the Karisimbi geothermal field began in July 2013. Exploration efforts are underway at Karisimbi, Gisenyi, and Kinigi, located in the Southern region, and Bugarama, located in the Western region. Rwanda hopes to site 300MW of geothermal power to bring online by 2017. The government of Rwanda is investing $27 million dollars to ensure this target is met.

Despite optimism and enthusiasm for geothermal power in Rwanda, the country has many challenges to overcome before it can fully realize its geothermal potential. Inadequate and unpredictable funding for geothermal exploration and development and the need for further exploration of geothermal resources hinders growth in Rwanda. Experts say Rwanda still needs to confirm the depth, temperature and fluid chemistry of their geothermal resources. This can only be confirmed by deep drilling of at least three exploration wells in each of the four geothermal areas. The country also struggles with inadequate data to conclusively determine its geothermal potential, in addition tothe lack of developed infrastructure to support drilling and exploration, and a shortage of properly trained personnel and equipment to carry out geothermal exploration.

TANZANIA

Geothermal Power Tanzania Ltd. plans to invest as much as $350 million to drill steam fields in the Southern region of Tanzania and build its first geothermal plants with the capacity to generate up to 140 megawatts by 2018. After some preliminary exploration, Geothermal Power Tanzania Ltd. identified three potential geothermal fields. Two are found in the Mbeya region and one is South East of Dar es Salaam. Furthermore, Tanzania introduced new policies creating a highly attractive climate for foreign investment – trade liberalization, financial sector reform, privatization, and special tax incentives.[14] This has spurred major interest in Tanzania's energy sector from companies around the world. The government strongly encourages foreign investment, and latest reports say Japanese and Icelandic companies are interested in developing geothermal prospects in Tanzania. Additionally, the African Development Bank is planning a major geothermal development support program for the region.[15]

[14] Mnjokava 2012
[15] Richter 2013b

TURKEY

A majority of the geothermal resources in Turkey are located in West Anatolian provinces. Since the 1960's, Turkey has drilled about 1,200 geothermal wells for geothermal electricity and direct use applications in to the fields and about one-third of these wellbores were drilled in the last four years.[16]

Experts in Turkey expect that four more power plants to be operating by the end of 2013, installing 150 more MW of geothermal power and bringing the installed capacity to over 300 MW. Currently, the total installed capacity for electricity is 163 MW and growing at a steady rate. Turkey has 59 projects under development and 310 MW of geothermal power under construction.

UGANDA

Most of Uganda's 11 projects under development are in the early stages. Several agreements to develop about 650MW of geothermal resource were recently completed. In addition, initial exploration estimates Uganda could contain over 30 geothermal sites.[17] There seems to be substantial support for geothermal development in Uganda as a result of Uganda's overall policy of increasing the use of modern renewable energy, from the current 4% to 61% of the total energy consumption by the year 2017, in addition to substantial momentum from the government to move geothermal projects forward.[18]

Despite these optimistic goals, experts claim that geothermal development in Uganda struggles with a number of barriers and regulatory issues. A recent report provided to GEA by USAID on geothermal development in Uganda outlined a number of issues faced by Independent Power Producers (IPPs) building plants in Uganda. For example, IPPs are struggling to acquire funding for their projects, facing problem with transmission connections, facing setbacks due to the lack of knowledge of appropriate technologies needed to develop geothermal fields, and are overwhelmed by the inadequate regulatory framework.[19] More specifically, the inadequate regulatory framework forces developers to follow mining regulations and some sections of the current Petroleum Act when developing projects. This frustrates geothermal developers as they search for Power Purchase Agreements (PPA) needed to build plants.[20]

EUROPE

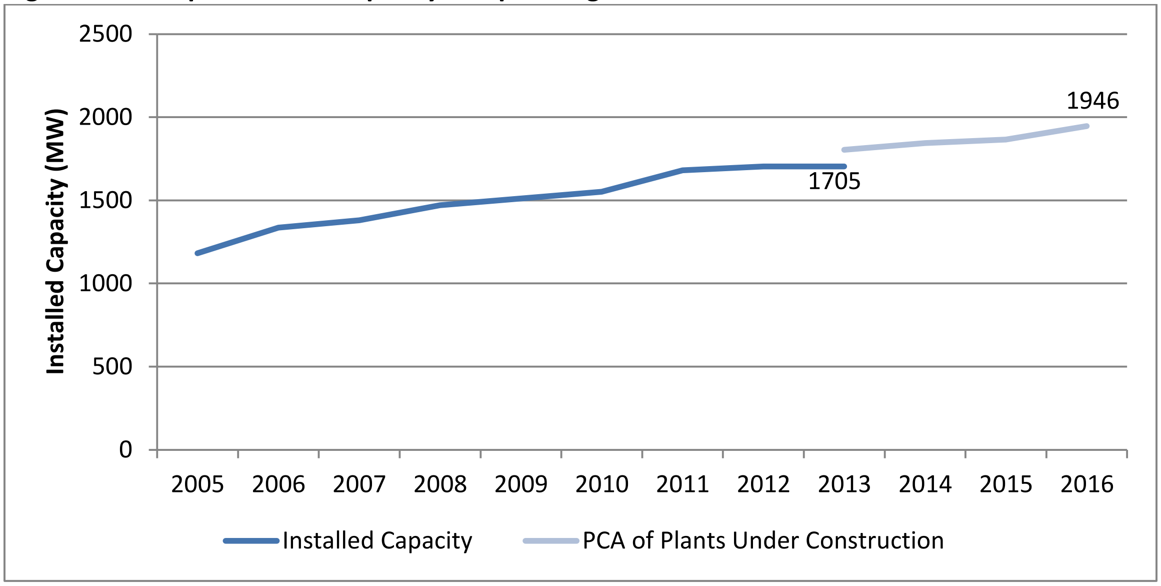
Europe has a substantial amount of geothermal projects under development and 15 projects actually under construction. With the exception of Iceland and Italy, these projects are traditionally smaller projects of less than 10 MW. For example, Germany has 8 geothermal power projects actually under construction, but they only sum to 47 MW.

Additionally, some Eastern European countries have begun to explore their geothermal resources. As mentioned earlier in this report, Romania has one of the first of Electratherm's Green Machines to use geothermal resources. China International Investment Stock Ltd signed an investment contract for a $415 million dollar paper mill in Slatina, Croatia that will include the construction of a geothermal power

[16] Parlaktuna 2013
[17] Simmons 2013
[18] Nyakabwa-Atwoki 2013
[19] Simmons 2013
[20] Nyakabwa-Atwoki 2013, Simmons 2013

plant to provide electricity to the mill.[21] A new report that came out this year estimated there could be 6,200 MW of geothermal resource between the Danube and the Tatra Mountains near Czech Republic and Slovakia.[22] Both of these countries have geothermal prospects in the early stages of development and are looking to build geothermal power plants in the longer term. Greece recently opened up four geothermal areas for exploration and work in Western Europe continues on several EGS projects in the Netherlands, Germany, the United Kingdom, Switzerland, and Ireland.

Figure 11: Europe Installed Capacity of Operating Geothermal Power Plants



Note: Figure 10 is a cumulative representation of the geothermal power plants still operating today and not the installed geothermal capacity at a given year. Pilot plants and geothermal plants built in the first half of the 20th century and then decommissioned are not included.
Source: Author

GERMANY

The German Geothermal Association reported that Germany continues to develop its geothermal resources. Now 22 power plants provide a combination of heat and power to German cities, 16 are under construction, and 43 more are planned.[23] Seven of those planned power plants or those already under construction will rely on hydraulic stimulation of EGS technology.[24]

For more information on German Geothermal projects please visit the German Geothermal Association's (Bundesverband Geothermie) website.

ITALY

Although Italy was the first country to install a geothermal power facility in the beginning of the 20th century, not much new development is currently underway. The Bagnore 4 power plant is under construction and reported to be operational by 2014. In addition, Italy has made accomplishments in

[21] Richter 2013h
[22] Schulze 2013
[23] GEA listed only those power plants currently under construction or those in Early stages of development.
[24] Bundesverbandes Geothermie (GtV) 2013

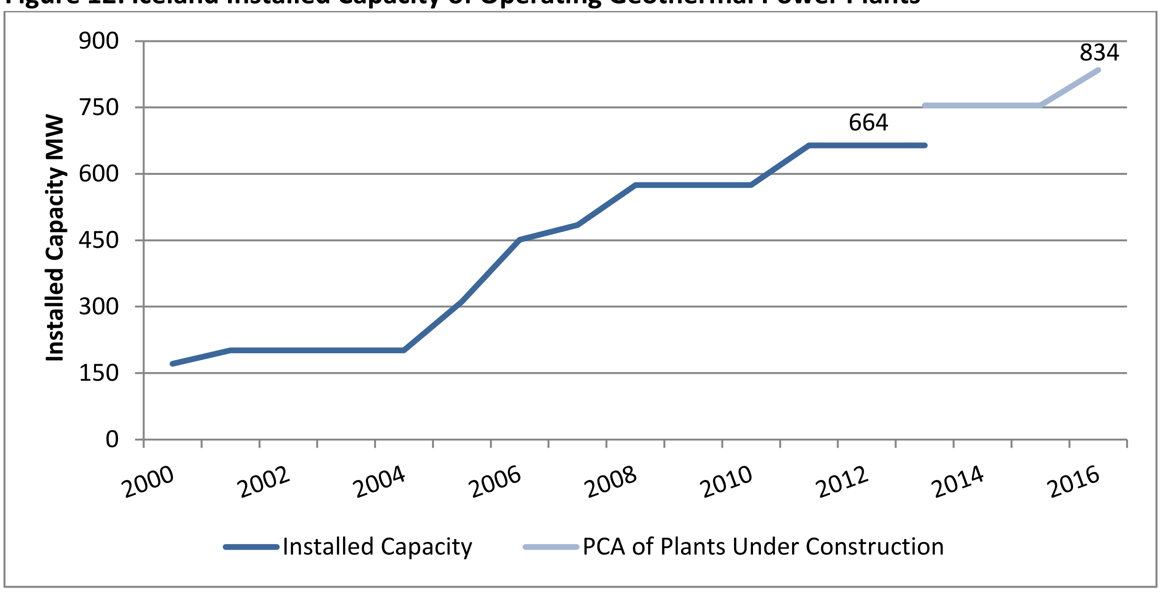
other areas such as technological breakthroughs. For example, the first radial centrifugal turbine has been installed in a binary geothermal power plant at the Bagnore facility operated by Enel Green Power. The Exergy radial turbine allows access to the geothermal sources previously thought to be unusable due to their low temperature of the primary fluid (100 °C-180°C) to be capable of generating power through a series of heat exchangers.[25]

For more information on geothermal power in Italy please visit the Italian Geothermal Union's website.

ICELAND

As a global leader in percentage of power and heating derived from geothermal and renewables, Iceland has four geothermal projects currently under construction. Iceland is a small country of only ~320,000 people in which a large portion of generated electricity supports the aluminum smelting industry. As a result, Iceland has begun to search for new markets for its electricity. Although the geothermal power supply in Iceland is plentiful, local demand is fairly stagnant. Eager to reach new customers, the power company Landsvirkjun has conducted extensive research into the possibility of a massive submarine transmission to connect to Europe's electricity grid. The cable would likely first connect to the northern tip of Scotland, which is about 700 miles away and then all the way to continental Europe, nearly 1,200 miles away.

Figure 12: Iceland Installed Capacity of Operating Geothermal Power Plants



Source: Author

CENTRAL & SOUTH AMERICA

Most of the geothermal work in Central and South America is in the early exploration stages. Governments such as Chile, Peru, and Argentina have rapidly made geothermal land available for exploration. However, some projects such as those in Guatemala and Nicaragua have reached the middle/late stages and drilled their first production or injection wells.[26] Many of the countries in this

[25] Richter 2013d

[26] Ram Power 2013, U.S. Geothermal 2013

region have lofty climate change goals and are placing a substantial amount of energy and resources into geothermal development. The threat of climate change combined with possibility of energy independence from fossil fuels is proving to be a powerful incentive to jumpstart geothermal and renewable energy development in this region.

CHILE

Media report claim that the Mariposa geothermal power project south of Santiago in Chile, a joint venture of Canadian Alterra Power and Philippine's EDC, could start producing power as early as 2017, if all goes according to plan. Additionally, local media reports Chile is considering a feed-in-tariff scheme for geothermal of $0.20 to $0.30 per kWh that would benefit geothermal developers and speed up development.[27]

Currently Chile has 54 projects under development and 190 PCA that could come online by 2016. Many of these projects are in the early stages of development. Before these projects can be completed more needs to be known about the potential and characteristics of Chilean geothermal resources.

COSTA RICA

Costa Rica has a substantial amount of geothermal resource. However, a lot of its resource is within the boundaries of national parks, leaving substantial regulatory barriers to its development. For example, the national geothermal potential is about 900 MW, with the areas of greatest potential located in the volcanic area of Guanacaste and the Central Volcanic Range. Furthermore, according to a recent interview with the head of the Ministry of Environment and Energy in Costa Rica, geothermal could be increased to provide 40% of the Costa Rican electricity generation, up from 12%, according to the latest EIA statistics.[28]

Despite the location of Costa Rica's geothermal resource, the government plans to introduce legislation that would open the Rincon de la Vieja National Park in Guanacaste for geothermal project development. However, media reports indicate that there is a substantial amount of opposition to those plans. While the current draft of legislation only refers to the Rincon de la Vieja National Park, environmentalists fear that it could be a precedent for development in other protected areas.[29] The two sides of the debate are working toward a solution and in late April 2013 it was reported Costa Rica Electricity Institute (ICE) Executive President President Teofilo de la Torre said ICE resubmitted a proposal to segregate 1,000 hectares of Rincón de la Vieja National Park, in the northwestern province of Guanacaste, to reduce the area of exploration and to implement an "eco-design" to minimize impact.[30]

Additionally, the Costa Rican government is aware the threat of Climate Change has on its country's energy infrastructure. Environment Minister René Castro said that global warming is "killing us over a slow fire" and creating water shortages that will make it more difficult to run the country's hydroelectric plants. Hydroelectric energy accounts for most of Costa Rica's total energy production.[31] Therefore, the

[27] Richter 2013f
[28] Richter 2012, Richter 2013e, EIA 2013
[29] Richter 2013g
[30] McPhaul 2013
[31] *Ibid.*

country is quickly trying to find alternatives to hydropower generation because of the fears that Climate Change will alter water levels and diminish the capabilities of their hydroelectric power plants.

NICARAGUA

GEA counted four projects under development in Nicaragua and a current installed capacity of 104 MW. Nicaragua wishes to expand its use of geothermal power. Recently, the Nicaraguan Government sought $15-20 million in funding from the World Bank and other international donors to undertake a massive feasibility study program on 10 potential areas for geothermal power development. The Nicaraguan government has performed independent geophysical surface studies to indicate the geothermal potential of these sites for generation; however, more feasibility studies are required to confirm their viability. These studies include drilling test wells on site and involve "quite high" costs with no clear guarantee for success. With financing available through the World Bank or similar financial institutions, Nicaragua could remove the high risk element of early resource confirmation and attract investment from private sources.[32]

PERU

More advanced geothermal exploration has just begun in Peru. The Japan International Cooperation Agency (JICA) and INGEMMET (the geological survey of Peru) identified 61 geothermal fields in Peru, 34 of which have one or more hot spring with discharge temperatures greater than 60° C. When prioritizing the 61 geothermal fields, JICA assessed the geothermal resource potential, ease of access, and – if those projects occur outside the protected area – what the required Environmental Impact Statement would contain.[33]

At the moment, GEA counted 660 MW of geothermal properties under tender and 24 geothermal projects leased to companies for exploration. Additionally, Peru has passed legislation to incentivize renewable energy projects, including free access of connection to transmission lines, purchase of power under technology specific auctions, and a target of 5% of the total electricity demand to be supplied by renewable energy, excluding large hydroelectric plants (>20 MW capacity). However, according to local media, this target is expected to be soon increased to at least 10%.

NORTH AMERICA

The United States is the world leader in geothermal energy. California alone has more installed capacity than the countries of Indonesia or the Philippines. Despite the US leading the world in installed geothermal energy, development has somewhat slowed in the first part of 2013 compared to a period of rapid growth in 2011 and 2012. The United States and Canada are working through a number of regulatory and structural barriers slowing down geothermal development. In Canada, project cancelations and what seems to be a struggle to gain attention for their resource are routine problems. Opposite of their neighbors to the north, Mexico's geothermal projects have made steady forward progress as the Mexican Federal Electricity Commission (CFE) moves closer to bringing several new power plants online. Despite obstacles in Canada and the United States, forward progress continues on projects throughout North America.

[32] La Prensa 2013
[33] Hot Rock Limited 2013

CANADA

CanGEA & the Geological Society of Canada claim that at least 5,000 MW are commercially available in Canada from approximately 3 km depth resources that can be harnessed with current technology. Despite the evidence indicating that Canada has a significant amount of potentially attractive geothermal areas and examples of successful and productive geothermal power plants built abroad by Canadian companies, there are no geothermal power plants operating in Canada today. Canada does have 8 projects and one recently canceled projects where geothermal power development is taking place. Furthermore, the use of geothermal energy for heating and cooling is only found sporadically across the country.

CanGEA reports a number of barriers must be overcome in order to approach the geothermal potential in Canada. Some of these barriers include, increasing the public awareness of the availability and merits of geothermal energy, better geoscience and resource mapping, creation of favorable geothermal legislation, and introducing incentives to the geothermal industry.[34]

For more information please visit the Canadian Geothermal Energy Association Website.

MEXICO

At 980 MW, Mexico is ranked fourth in terms of global installed geothermal capacity. The country has three new projects in the pipeline and 150 MW of geothermal power under development. The Los Humeros project and the Los Azufres III have both made strides toward completion. Currently one of the two 25-MW power units in Los Humeros has been commissioned; the other is expected to be commissioned by 2014. In addition, all of the eight 5-MW back-pressure units are still in operation at Los Humeros, with a current installed capacity of 65 MW.

The 50-MW power plant in Los Azufres (Los Azufres III) is under construction and scheduled to commission by December 2014. International bidding for Los Azufres III was won by Mitsubishi Heavy Industries, who awarded the Engineering, Procurement and Construction Contract (EPC) to Power Engineers.

Additionally, four older units of 37.5 MW, each in the Cerro Prieto geothermal field, will be soon be defunct. The Mexican state power company, Comisión Federal de Electricidad (CFE), will use the available steam in the more modern and efficient power units. Although the installed capacity remains the same in Cerro Prieto and Los Azufres, the running (operating) capacity has decreased. In the Los Azufres field, two small binary cycle power units (1.5 MW each) were recently decommissioned.[35]

UNITED STATES

In 2012, seven geothermal projects became operational, including the first U.S. co-production plant. Additionally, the first hybrid solar-geothermal plant went online in 2012, although no new geothermal capacity was added at this plant. There are currently ~182 geothermal projects under development in the U.S and about ~2,500 MW of PCA in the pipeline. However, many of these projects are facing significant delays due to an uncertain policy environment and structural setbacks. Currently, 3,388 MW of geothermal power are installed in the United States.[36]

[34] Thompson et al. 2013
[35] Gutiérrez-Negrín 2013
[36] Author

Despite these issues, projects throughout the U.S continue to move forward. For example, a geothermal project in Aspen, Colorado recently finished drilling test wells and will move forward on their project. Also, the first awards announced under the U.S. Army's new $7 billion dollar Multiple Award Task Order Contracts (MATOC) were to support geothermal energy on Defense Department installations. The five companies awarded contracts for use in competing and awarding PPA task orders using geothermal technology are Constellation NewEnergy, ECC Renewables, Enel Green Power North America, LTC Federal, and Siemens Government Technologies. In April 2012, the White House announced that the Defense Department was making one of the largest commitments to clean energy in history, by setting a goal to deploy 3 GW of renewable energy – including solar, wind, biomass or geothermal – on Army, Navy, and Air Force installations by 2025.

In the United States, discussions about the opportunities for geothermal to play a role not only as a baseload generation source but also as a flexible power source entered the forefront of discussion this year with a report sponsored by Ormat Technologies.[37] Binary power plants can be used as a flexible intermittent power sources in addition to their traditional role as baseloads. This is because binary turbines can be ramped up and down multiple times per day to a minimum of 10% of nominal power and up to 100% of nominal output power. The normal ramp rate for dispatch (by heat source valve) is 15% of nominal power per minute.[38]

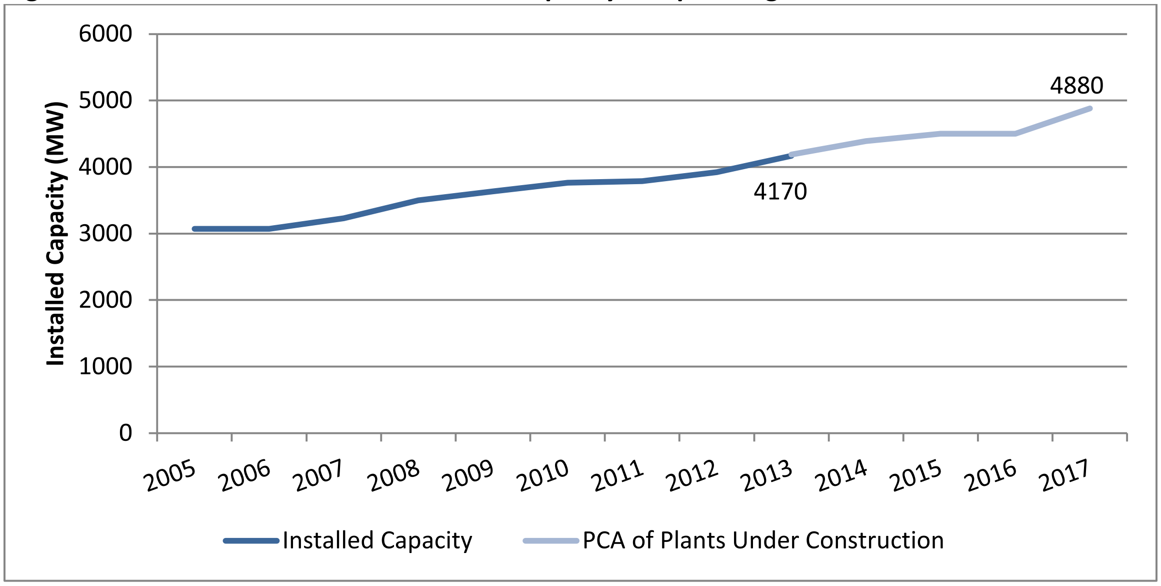
Lastly, a renewed optimism for geothermal development arose after President Obama's recent climate address. President Obama promised to direct the U.S. Environmental Protection Agency to establish a carbon pollution standard for both new and existing power plants and instructed the U.S. Department of the Interior to permit enough renewable projects on public lands by 2020 to power more than 6 million homes. Both of these promises could open new opportunities for geothermal development in the United States. Additionally, Nevada's legislature recently passed two bills in early June 2013 that could accelerate geothermal development in the state. The first, AB 239, defined geothermal as a renewable for purposes of tax abatements – a win for some developers who have been asking for the distinction for at least six years. The "NVision" coal removal bill, SB 123, requires the state utility to decommission its two coal-fired generating plants by 2019 and replace them with 350 MW of renewable energy and up to 550 MW of other generation, opening new doors for geothermal, which is expected to replace some of this coal generation.

ASIA SOUTH-EAST PACIFIC

The South East Pacific is an exciting place for new power plants and new geothermal installed capacity. This region has a substantial amount of geothermal resources under development. 5,209 MW are in the pipeline and 7,206 MW of resources have been identified for development. Countries like Indonesia and the Philippines are ranked second and third for installed geothermal capacity and already outpace the U.S. for new growth. There are 8 projects under construction in the region and another 1,136 MW that could become operational by the end of the decade.

[37] Linvill et al. 2013
[38] *Ibid.*

Figure 13: Asia Southeast Pacific Installed Capacity of Operating Geothermal Power Plants



Source: Authors

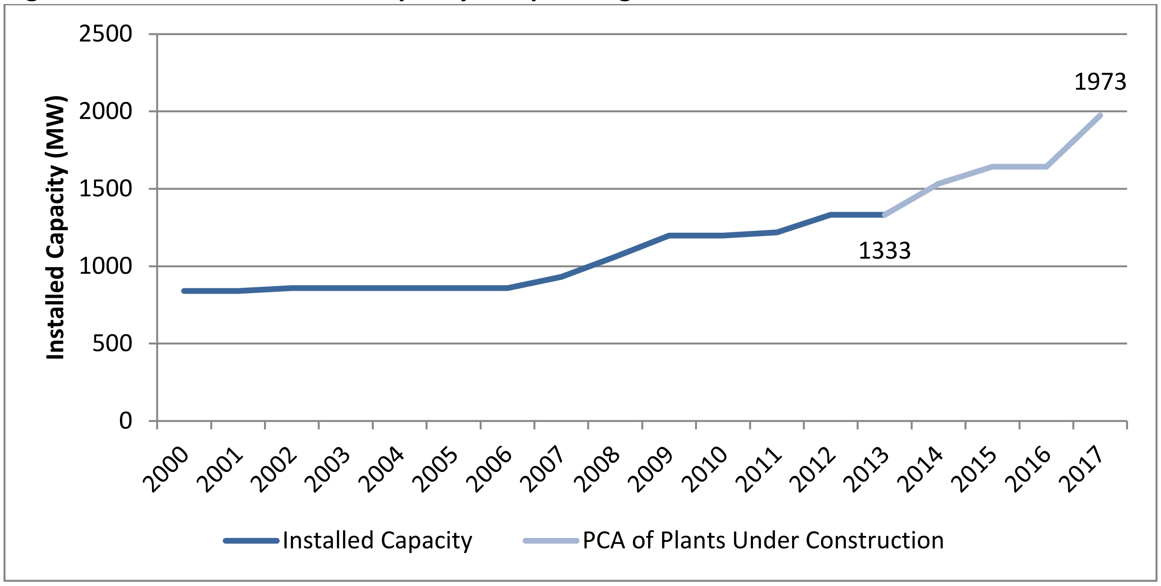
INDONESIA

Despite the massive potential for geothermal power in Indonesia, local experts and the media report that the country still struggles with regulatory issues and ineffective government obstructing geothermal development. Land acquisition and permit issues currently stall 30 geothermal projects that were launched before and after the introduction of Indonesia's 2003 Geothermal Laws. Geothermal Law 27/2003 significantly changed the framework for geothermal development. The law mandated that all future geothermal development was to be completed by competitive tendering for specific areas. The tendering was to be transparent and result in the issuance of a business license that permitted geothermal field development. However, 11 out of 20 geothermal projects launched before the 2003 law and 19 projects launched after the law are still in exploration stages.[39]

Despite these issues, Indonesia has almost 4,100 MW in the pipeline for development and 860 MW physically under construction. Indonesia ranks second for developing projects with 57 projects in some phase of development. While no more plants are expected to come online this year in Indonesia, if all the plants are finished by their publicly announced completion dates, Indonesia could reach almost 2 GW of installed capacity by 2018.

[39] Azwar 2013, Brophy 2011

Figure 14: Indonesia Installed Capacity of Operating Geothermal Power Plants



Source: Authors

JAPAN

Ever since the Fukushima Daiichi nuclear disaster in 2012, the Japanese people and the Ministry of Economy, Trade, and Industry (METI) are looking for clean and disaster-free alternatives to nuclear energy. As a result, interest in geothermal energy has been revived after several years of stagnant development. On March 2012, The Japanese Energy and Environment Council decided to deregulate many previous burdensome regulations that hindered geothermal development. For example, the Natural Park Act practically outlawed geothermal development except in 6 areas of Japan. METI told GEA that the deregulation of this legislation is considered a symbolic movement toward further geothermal development in Japan. Additionally, Japan now offers a new Feed-in Tariff Scheme that started on July 1st, 2012. The Feed-in Tariffs is 27.30 yen/kWh (~US$.30/kWh) for projects greater than 15 MW or 42.00 yen/kWh (~US$.46/kWh) for projects less than 15 MW. METI reported to GEA that Japan is currently developing 36 geothermal power projects and 4 of those projects are actually under construction. At the moment, Japan plans to bring at least 50MW of geothermal power online by the end of the decade.[40]

Despite the good news, the country has a number of regulatory and structural barriers to overcome before any surge in geothermal development is expected. It takes ten or more years from the first geological surveys to build an operating plant, a significantly long and costly lead time. Constructing a power generation plant with output of 10 MW or larger requires Environmental Impact Assessment; and at 3-4 years, Japans' EIA process is especially long. Shortening this period would be a significant step towards accelerated geothermal development. METI has already taken the initial steps to investigate how to shorten this period. Additionally, there is a lack of information and investigation about Japan's geothermal resources. METI has been investing to learn more about the geothermal resources within its borders.[41]

[40] Watanabe 2013
[41] *Ibid.*

NEW ZEALAND

With 895 MW, New Zealand ranks 6th in the world for installed geothermal capacity. Additionally 6 new projects in the pipeline could add another 256 MW to New Zealand's energy infrastructure over the next decade. The first stages of commissioning the new Te Mihi power station recently commenced. The completion of Te Mihi will bring to an end a greater than $2 billion investment program, adding lower-cost geothermal, and flexible thermal generation capacity.[42]

The major New Zealand geothermal company, Might River Power is now a publically traded corporation. Mighty River Power Limited (NZX: MRP / ASX: MYT) is now trading on a normal basis following the allocation and transfer of 675,031,404 ordinary shares from a government owned enity to more than 113,000 shareholders, who purchased a direct stake in the Company through the Initial Public Offering. Also, Mighty River Power took direct control of geothermal investments in the United States (EnergySource) and Chile.[43]

PHILIPPINES

The Philippines has 27 projects under development, three of which are under construction, as well as 724 MW of PCA. Recently, the Philippine Department of Energy announced plans for a geothermal expansion of 1,445 MW by 2030, with an estimated total potential investment volume of P325.125 billion (US$7.5 billion). This announcement could translate into a 75% growth over the current installed capacity. Additionally, based off the distribution of geothermal projects, a majority of this development is expected to happen by 2020.

ACRONYMS

AfDB	African Development Bank
CanGEA	Canadian Geothermal Energy Association
EGS	Enhanced Geothermal Systems
EIS	Environmental Impact Statement
EPC	Engineering, Procurement and Construction Contract
ESMAP	Energy Sector Management Assistance Program
FIT	Feed-In-Tariff
Gpm	Gallons per Minute
GEA	Geothermal Energy Association
IGA	International Geothermal Association
IPPs	Independent Power Producers
JICA	Japan International Cooperation Agency
METI	Japan's Ministry of Economy Trade and Industry
MW_e	Mega Watt of electrical power
MW_{th}	Mega Watts of thermal power
N/A	Not Available
ORC	Organic Rankine Cycle
PCA	Potential Capacity Additions
PPA	Power Purchasing Agreement
U.S.	United States

[42] White 2013
[43] Mighty River Power Co 2013

USAID United States Agency for International Development
U.S. DOE United States Department of Energy

REFERENCES

AltaRock Energy. 2013. "AltaRock Energy Announces Successful Multiple-zone Stimulation of Well at the Newberry Enhanced Geothermal Systems Demonstration." Seattle: AltaRock Energy. http://altarockenergy.com/media/AltaRock_Stimulation_Release_Final_1_21_13.pdf

Azwar. Amahl S. 2013. "RI's geothermal dream may never be a reality." Jakarta: The Jakarta Post. Accessed July 24th, 2013. http://www.thejakartapost.com/news/2013/07/01/ri-s-geothermal-dream-may-never-be-a-reality.html

Biggs, Juliet. "Ethiopia: Geothermal Energy." University Of Bristol June 18 2013. Web, http://www.youtube.com/watch?v=mS3HcFAtbWc.

Brophy, Paul, Guy Nelson, Widiatmoko, and Rajita Majumdar. 2011. "The Emerging Geothermal Development Sector in Indonesia." GRC Transactions, Vol. 35, 2011. Accessed July 24th, 2013. http://pubs.geothermal-library.org/lib/grc/1029395.pdf

Bundesverbandes Geothermie (GtV) 2013. "Neue Projektliste: Tiefe Geothermie schreitet voran" Berlin: Bundesverbandes Geothermie. Accessed July 23rd, 2013. http://www.geothermie.de/fileadmin/useruploads/bundesverband/presse/PM_2013/PM_Projektliste_Tiefe_Geothermie_schreitet_voran.pdf

ElectraTherm. 2013. "ElectraTherm Generates Power from Low Temperature Geothermal Resources." Reno: ElectraTherm. Accessed July 22nd, 2013. http://electratherm.com/docs/FCRomaniacommissioning20130409JF1.pdf

Khaireh, Aboulkader and Fouad Aye. 2012. "Geothermal Development in Djibouti Republic: A Country Report." Nairobi: Proceedings of the 4th African Rift Geothermal Conference. Accessed July 23rd, 2013. http://www.geothermal-energy.org/pdf/IGAstandard/ARGeo/2012/Khaireh.pdf?

Geodynamics Limited. 2013. "1MWe Habanero Pilot Plant – Commencement of Commissioning Operations." Queensland: Geodyanmics. Accessed July 23rd, 2013. http://www.geodynamics.com.au/getattachment/6dc50730-dee0-4495-a990-7e0774d801f5/1-MWe-Habanero-Pilot-Plant-%E2%80%93-Commencement-of-Commi.aspx

Gehringer, Magnus and Victor Loksha. 2012. "Geothermal Handbook: Planning and Financing Power Generation." Washington DC: World Bank Group, Energy Sector Management Assistance Program. Accessed July 23rd, 2013. http://www.esmap.org/sites/esmap.org/files/FINAL_Geothermal%20Handbook_TR002-12.pdf

Gutiérrez-Negrín, 'Luis Carlos. Email/Personal Communication. May 23, 2013.

Hot Rock Limited. 2013. "Top Geothermal Projects in Peru Held by Hot Rock." Brisbane: Hot Rock Limited. Accessed July 23, 2013.

http://www.hotrockltd.com/IRM/Company/ShowPage.aspx/PDFs/1536-94477317/TopGeothermalProjectsinPeruHeldbyHotRock

La Prensa. 2013. “Piden más al BM.” Managua: laprensa.com.ni. Accessed July 23rd, 2013. http://www.laprensa.com.ni/2013/07/04/activos/153299

Linvill, Carl, John Candelaria and Catherine Elder. 2013. “The Value of Geothermal Energy Generation Attributes: Aspen Report to Ormat Technologies.” Agoura Hills, CA: Aspen Environmental Group.

Mandell, Aaron. 2013. "AltaRock Energy." Lecture. 2013 National Geothermal Summit. Geothermal Energy Association. Grand Sierra Resort & Casino, Reno.

McPhaul, John. 2013. “ICE chief promises compromise on geothermal energy in national parks.” Ticotimes.net Accessed July 23rd, 2013. http://www.ticotimes.net/More-news/News-Briefs/ICE-chief-promises-compromise-on-geothermal-energy-in-national-parks_Tuesday-April-23-2013

Mighty River Power Co. 2013. “Mighty River Power takes direct control of geothermal interests in Chile and U.S.-based EnergySource.” Mighty River Power Co. Accessed July 25th,2013. http://www.mightyriver.co.nz/Media-Centre/Latest-News/Mighty-River-Power-takes-direct-control-of-geother.aspx

Mnjokava, Taramaeli T. 2012. “Geothermal Development in Tanzania – A Country Update.” Geological Survey of Tanzania: Dodoma. Accessed July 23rd, 2013. http://www.geothermal-energy.org/pdf/IGAstandard/ARGeo/2012/Omenda.pdf

Nyakabwa-Atwoki, Ralph K.B. 2013. “Challenges in Developing Katwe Geothermal Power Project in Kikorongo-Bunyampaka, Kasese District, Western Uganda.” Stanford: PROCEEDINGS, Thirty-Eighth Workshop on Geothermal Reservoir Engineering. Accessed July 23rd, 2013. http://www.geothermal-energy.org/pdf/IGAstandard/SGW/2013/Nyakabwaatwoki.pdf?

Office of the Press Secretary. 2013. “FACT SHEET: Power Africa.” Washington DC: The White House. Accessed August 12th,2013. http://www.whitehouse.gov/the-press-office/2013/06/30/fact-sheet-power-africa

Omenda, Peter. 2012. “Geothermal Development in Kenya: A Country Update – 2012.” Nairobi: Geothermal Development Company. Accessed July 22nd, 2013. http://www.geothermal-energy.org/pdf/IGAstandard/ARGeo/2012/Omenda.pdf

Onacha, Stephen. 2011. “Rwanda Geothermal Resources Development Country Update.” Nairobi: PROCEEDINGS, Kenya Geothermal Conference 2011. Accessed July 23rd, 2013. http://www.gak.co.ke/nibs/web_resources/RWANDA%20GEOTHERMAL%20RESOURCES%20DEVELOPMENT%20COUNTRY%20UPDATE.pdf

Ormat Technologies Inc. 2013. “Success with Enhanced Geothermal Systems Changing the Future of Geothermal Power in the U.S. DOE, Ormat and GeothermEx Collaboration Produces Electricity Using In-field EGS.” Reno: Nevada. Accessed July, 23rd 2013. http://www.ormat.com/news/latest-items/success-enhanced-geothermal-systems-changing-future-geothermal-power-us

Ram Power Corp., 2013. "Ram Power Commences Drilling Operations at San Jacinto-Tizate." Reno: Ram Power Accessed August 1, 2013. http://ram-power.com/news-media/ram-power-commences-drilling-operations-san-jacinto-tizate

Richter, Alexander. 2012. "Costa Rica to open Guanacaste for development." ThinkGeoEnergy. Accessed July 23rd, 2013. http://thinkgeoenergy.com/archives/14353

_____. 2013a. "Extension work about to begin at Aluto-Langano plant in Ethiopia." ThinkGeoEnergy. Accessed July 23rd, 2013. http://thinkgeoenergy.com/archives/14691

_____. 2013b. "Tanzania receives support by AfDB for geothermal roadmap." ThinkGeoEnergy. Accessed July 23rd, 2013. http://thinkgeoenergy.com/archives/15008

_____. 2013c. "Drilling to start at Karisimbi in Rwanda in April 2013." ThinkGeoEnergy. Accessed July 23rd, 2013. http://thinkgeoenergy.com/archives/15017

_____. 2013d. "First radial turbine centrifuge installed in binary plant in Bagnore, Italy." ThinkGeoEnergy. Accessed July 23rd, 2013. http://thinkgeoenergy.com/archives/15780

_____. 2013e. "Costa Rica could derive up to 40 percent of its electricity from geothermal." ThinkGeoEnergy. Accessed July 22nd, 2013. http://thinkgeoenergy.com/archives/14677

_____. 2013f. "Chile considering feed-in-tariff for geothermal of up to $0.30 per kWh." ThinkGeoEnergy. Accessed July 23rd, 2013. http://thinkgeoenergy.com/archives/15743

_____. 2013g. "Costa Rica utility proposes compromise on development in national parks." ThinkGeoEnergy. Accessed July 23rd, 2013. http://thinkgeoenergy.com/archives/15317

_____. 2013h. "Chinese investors plan geothermal plant in Slatina, Croatia." ThinkGeoEnergy. Accessed July 22nd, 2013. http://thinkgeoenergy.com/archives/14020

_____. 2013i. "Philippines planned FIT program to help renewables development." ThinkGeoEnergy Accessed July, 25, 2013. http://thinkgeoenergy.com/archives/15445

Rogers, Mike. 2013. "Demonstration of an Enhanced Geothermal System at the Northwest Geysers Geothermal Field, CA." Lecture. Lecture. 2013 National Geothermal Summit. Geothermal Energy Association. Grand Sierra Resort & Casino, Reno

Parlaktuna, Mahmut , Orhan Mertoglu, Sakir Simsek, Halime Paksoy, and Nilgun Basarir. 2013. "Geothermal Country Update Report of Turkey (2010-2013)." Pisa: European Geothermal Congress 2013. Accessed August 19, 2013. http://www.geothermal-energy.org/pdf/IGAstandard/EGC/2013/EGC2013_CUR-32.pdf?

U.S. Department of Energy (U.S. DOE). 2013. "Factsheet: Low-Temperature and Co-Produced Resources." Washington DC: U.S. DOE. Accessed July 22nd, 2013. http://www1.eere.energy.gov/geothermal/pdfs/lowtemp_factsheet.pdf

U.S. Energy Information Administration (EIA). 2013. “International Energy Statistics.” Washington DC: EIA. Accessed August, 2, 2013. http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=2&pid=2&aid=12

Simmons, Keith. Email/Personal Communication. 12 July 2013.

Schulze, Gerit. 2013. “Technologie kommt überwiegend aus dem Ausland.” Tscheechienonline. Accessed July, 30th, 2013. http://www.tschechien-online.org/news/20031-tschechien-slowakei-starten-projekte-erdwarme/

Taylor, Mark. Jessica Thompson, and Kieron Stopforth. 2013. “A Global Fund to De-Risk Exploration Drilling: Possibility or Pipe Dream?” New York: Bloomberg New Energy Finance. Accessed July, 23rd 2013. http://about.bnef.com/white-papers/a-global-fund-to-de-risk-exploration-drilling-possibility-or-pipe-dream/

Thompson, Alison, Steve Davis, Alexander Richter, Miriel Ko, David Ryan. 2013. “Sector Profile: An Assessment of the Geothermal Energy Sector in Canada – Now and in the Future.” Calgary: Canadian Geothermal Energy Association. Accessed July 23rd, 2013. http://www.cangea.ca/wp-content/uploads/2013/06/CanmetENERGY-Sector-Profile_Update-2013.pdf

U.S. Geothermal Inc. 2013. “U.S. Geothermal Inc. Updates Drilling at El Ceibillo Project – High Temperature Encountered.” Boise: U.S. Geothermal Ince. Accessed August 1, 2013. http://www.usgeothermal.com/NewsReleases/NR%2006-25-2013.pdf

The World Bank. 2013a. “World Bank Calls for Global Initiative to Scale Up Geothermal Energy in Developing Countries.” Washington DC: The World Bank. Accessed July 23rd, 2013. http://www.worldbank.org/en/news/press-release/2013/03/06/world-bank-calls-global-initiative-scale-up-geothermal-energy-developing-countries

The World Bank. 2013b. “Electric power consumption (kWh per capita).” OECD/IEA. Accessed August 2, 2013. http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC

Watanabe, Nobuhiko. 2013. "Geothermal Development in Japan." Lecture, International Geothermal Finance Forum from Geothermal Energy Association, New York.

White, Brian. 2013. “New Zealand Geothermal Association (NZGA) News – March 2013.” Wellington: New Zealand Geothermal Association. Accessed July 23rd, 2013. http://www.nzgeothermal.org.nz/Publications/Newsletters/NZGA-newsletter-March2013.pdf

Valine, Debra. 2013. “Army MATOC - First awards under $7 billion renewable energy contract.” Washington DC: US Army. Accessed July 23rd, 2013. http://www.army.mil/article/102675/Army_MATOC___First_awards_under__7_billion_renewable_energy_contract/