# 2016 Annual U.S. & Global Geothermal Power Production Report

GEOTHERMAL ENERGY ASSOCIATION
GEO-ENERGY.ORG

## Contents

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Cover Page Top: Menengai, Kenya, courtesy of Sam Abraham
Cover Page Bottom Left: McGuinness Hills Geothermal Plant, courtesy of Ormat Nevada
Cover Page Bottom Right: Olkaria Geothermal Power Plant Kenya, courtesy of Karl Gawell
Appendix Maps courtesy of Anna Crowell, University of North Dakota

## Geothermal Power Industry Highlights

### International

- GEA data shows a total of 18 new geothermal power plants came online in 2015, adding about 313 MW of new capacity to electricity grids globally.
- The global market is at about 13.3 GW of operating capacity as of January 2016, spread across 24 countries.
- This year the global geothermal market was developing about 12.5 GW of planned capacity spread across 82 countries.
- Based on current data, the global geothermal industry is expected to reach about 18.4 GW by 2021.
- Overall, if all countries follow through on their geothermal power development goals and targets the global market could reach 32 GW by the early 2030s.
- Flash technologies, including double and triple flash, compose a little less than two-thirds of installed capacity globally, while dry steam is about a quarter and binary is a remaining sixth. The last remaining 1% includes back pressure and other developing and experimental types of geothermal technologies.
- The United Nations and IRENA pledged a five-fold growth in the installed capacity for geothermal power generation and at least two-fold growth for geothermal heating by 2030 compared to 2014 levels.
- Communities and governments around the world have only tapped 6 to 7 % of the total global potential for geothermal power based on current geologic knowledge and technology. There are vast untapped resources that could provide baseload renewable energy to grids across the globe. However, natural disasters, permitting delays, and trouble obtaining financing have slowed geothermal power's growth globally.

### United States

- The U.S. industry had about 3.7 GW of installed nameplate capacity and 2.7[1] GW of net capacity at the end of 2015 and brought online 70 MW at two plant expansions in Nevada.
- In total, the U.S. market had about 1,250 MW of geothermal power under development with about half a gigawatt stalled in Phase 3, waiting for power purchase agreements (PPAs). These are projects that could be brought online in 17-33 months or sooner with the appropriate power contracts. An independent study by the National Renewable Energy Laboratory reached a similar conclusion.[2]
- Despite legislative stops and starts, a few new laws passed in 2015 could create new opportunities for geothermal companies in the US like a 100% Renewable Portfolio Standard (RPS) in Hawaii, a 50% RPS in California, and EPA's new Clean Power Plan if states choose to use geothermal power as part of their compliance options.

[1] (Energy Information Administration, 2015)
[2] (Wall and Young, 2016)

## Methodology and Terms

To increase the accuracy and value of information presented in its annual U.S. Geothermal Power Production and Development Report, the Geothermal Energy Association (GEA) developed a reporting system known as the Geothermal Reporting Terms and Definitions in 2010. The Geothermal Reporting Terms and Definitions serve as a guideline to project developers in reporting geothermal project development information to the GEA. A basic understanding of the Geothermal Reporting Terms and Definitions will also aid the reader in fully understanding the information presented in this annual report.

The Geothermal Reporting Terms and Definitions serve to increase reporting clarity and accuracy by providing the industry and the public with a lexicon of definitions relating to the types of different geothermal projects and a guideline for determining which phase of development a geothermal resource is in. These two tools help to characterize resource development by type and technology. They also help to determine a geothermal project's position in the typical project development timeline.

### Geothermal Resource Types and Their Definitions for U.S. Projects

In reporting a project in development to the GEA, the developer of a geothermal resource is asked to indicate which of the following definitions the project falls under:

**Conventional Hydrothermal (Unproduced Resource):** the development of a geothermal resource where levels of geothermal reservoir temperature and reservoir flow capacity are naturally sufficient to produce electricity and where development of the geothermal reservoir has not previously occurred to the extent that it supported the operation of geothermal power plant(s). Such a project will be labeled as "CH Unproduced" in this report.

**Conventional Hydrothermal (Produced Resource):** the development of a geothermal resource where levels of geothermal reservoir temperature and reservoir flow capacity are naturally sufficient to produce electricity and where development of the geothermal reservoir has previously occurred to the extent that it currently supports or has supported the operation of geothermal power plant(s). Such a project will be labeled as "CH Produced" in this report.

**Conventional Hydrothermal Expansion:** the expansion of an existing geothermal power plant and its associated drilled area so as to increase the level of power that the power plant produces. Such a project will be labeled as "CH Expansion" in this report.

**Geothermal Energy and Hydrocarbon Co-production:** the utilization of produced fluids resulting from oil and/or gas-field development for the production of geothermal power. Such a project will be labeled as "Co-production" in this report.

**Geopressured Systems:** the utilization of kinetic energy, hydrothermal energy, and energy produced from the associated gas resulting from geopressured gas development to produce geothermal electricity. Such projects will be labeled as "Geopressure" in this report.

**Enhanced Geothermal Systems:** the development of a geothermal system, where the natural flow capacity of the system is not sufficient to support adequate power production but where hydraulic fracturing of the system can allow production at a commercial level. Such a project will be labeled as "EGS" in this report.

## Tracking Projects through the Development Timeline

In addition to defining their projects according to the above list of definitions, GEA also asks developers to indicate projects' current status in the project development timeline using a four-phase system. This system captures how much and what type of work has been performed on that particular geothermal resource up until the present time. These four phases of project development are:

Phase I: Resource Procurement and Identification
Phase II: Resource Exploration and Confirmation
Phase III: Permitting and Initial Development
Phase IV: Resource Production and Power Plant Construction

Each of the four phases of project development is comprised of three separate sections, each of which contain phase sub-criteria. The three separate sections of sub-criteria are resource development, transmission development, and external development (acquiring access to land, permitting, signing PPAs and EPC contracts, securing a portion of project financing, etc.). For a project to be considered as being in any particular phase of development, a combination of sub-criteria, specific to each individual project phase, must be met.

## Planned Capacity Addition (PCA) and Resource Capacity

Finally, at each phase of a project's development, a geothermal developer has the opportunity to report two project capacity estimates: 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 defined as the portion of a geothermal resource that "if the developer were to utilize the geothermal resource under its control to produce electricity via a geothermal power plant . . . would be the power plant's estimated installed capacity." In other words, the PCA estimate is usually the power plant's expected estimated 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. In each phase of development the resource and installed capacity estimates are given different titles that reflect the level of certainty of successful project completion. The different titles as they correspond to the separate phases are as follows:

Phase I: "Possible Resource Estimate" and "Possible PCA Estimate"
Phase II: "Possible Resource Estimate" and "Possible PCA Estimate"
Phase III: "Delineated Resource Estimate" and "Delineated PCA Estimate"
Phase IV: "Confirmed Resource Estimate" and "Confirmed PCA Estimate"

This section outlines how the Geothermal Reporting Terms and Definitions influence the reporting and presentation of project in development information in this report. For a detailed explanation of each phase of development and the outline of its sub-criteria, please consult GEA's Geothermal Reporting Terms and Definitions.

## Geothermal Resource Types and Their Definitions for Global Projects

While projects in the GEA's Annual U.S. Geothermal Power Production and Development Report are defined by several phases of development (Prospect and Phases 1-4) as defined by GEA's 2010 New Geothermal Terms and Definitions, this report uses much broader terminology to define where a project stands in its development because of the vastly different development models to construct geothermal power plants outside the U.S. 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 under a specific Phase 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 as 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 as projects where some aspects of a resource are identified and the initial stages of explorations and construction are underway. This term could mean, but is not limited to, the first exploration wells drilled, project funded 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. Many definitions of 'Under Construction' do include production drilling. However, GEA looks at the projects on a case by case basis to determine if production drilling is enough to determine 'Under Construction' status. Based on the available information, sometimes a project must begin physical work on the power plant to be considered in this stage of development. 'Under Construction' is roughly equivalent to GEA's Phase 4 of a project's development but may contain elements of Phase 3 depending on the geothermal market, location of the plant and relative certainty of the project's completion.

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

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

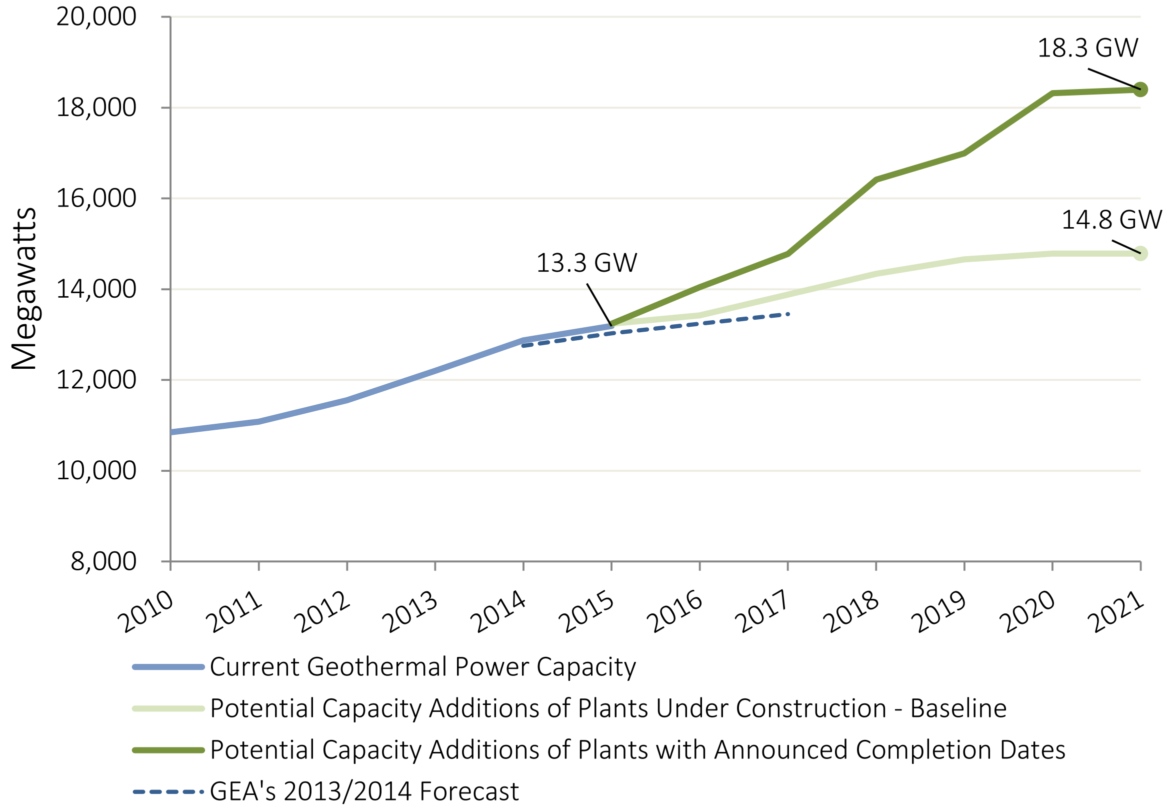
Projects **'Canceled'** are projects where the government, project developer or contractor decided to make no more forward progress on a geothermal project in the immediate future and withdrew from developing that geothermal prospect into a power plant.

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 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 would be the power plant's resulting estimated installed capacity if the developer were to utilize the geothermal resource under its control to produce electricity. In other words, the PCA estimate is usually the power plant's expected installed or nameplate 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 Geothermal Power Update

The past year was an exciting year for geothermal globally with many development milestones met. However, if countries plan on meeting international development goals, an increase in financial resources and strengthened government commitments are necessary components to meet 2030 goals.

*Figure 1: International Geothermal Power Nameplate Capacity (MW)*




Note: PCA (Planned Capacity Additions), pilot plants and utility scale geothermal plants built in the first half of the 20th century and then decommissioned are not included in the above time series.

### Global Statistics

In 2015, the global geothermal power industry brought online about 313 MW of capacity, which was less than previous years. However, relatively the same number of plants came online in 2015 as years past. Plants that became operational were mostly smaller binary/ORC facilities in the countries of Turkey, Kenya, Mexico, Japan, Germany and the United States. The slight drop in new capacity installed can be attributed to delays due to natural disasters[3], permitting/regulatory problems in several developing nations[4], and cheap fossil fuels that have made financing for some projects tougher to obtain as investors are wary about investing in renewable energy projects.[5]

In total, the world market reached upwards of 13.3 GW (gigawatts) of geothermal power operating in 24 countries. As of the end of 2015, there was 12.5 GW of potential capacity additions in 82 countries spread across 700 to 750 identifiable projects. Fourteen of those 82 countries are expected to bring 2 GW of

[3] (Think GeoEnergy, 2015a)
[4] (Ministry of Energy and Mineral Resource of Republic of Indonesia, 2015)
[5] (Cardwell, 2015; Horario, 2015)

power online over the next 3-4 years based on the current list of projects under construction with power purchase agreements, equipment ordered and/or wells drilled. Looking at these projects in the pipeline, it is expected that the geothermal industry will continue to grow at a steady pace globally since these 2 GW of projects have cleared most permitting and financing hurdles. This steady growth is the result of longer developmental time frames of geothermal projects which creates a less volatile industry compared to the booms and busts of other energy sectors.

This report forecasts that the global market will most likely reach 18.4 GW by 2021. The conservative forecast of 14.8 GW predicted is composed of announced completion dates of plants already under construction. Since projects normally take about 2-3 years to construct and the forecast goes out five years into the future, more projects will likely announce construction over the next year or two, increasing the tailend of the conservative baseline forecast. In the last decade, the global geothermal industry grew slowly but steadily, adding several hundred MWs online each year without pause. It seems unlikely this trend will discontinue if not accelerate as climate change becomes an increasingly important driver of energy choices in developing countries. The growth in new capacity will most likely come from European, East African, and South Pacific markets as these regions lead geothermal power's growth by substantial capacity additions in the next five years.

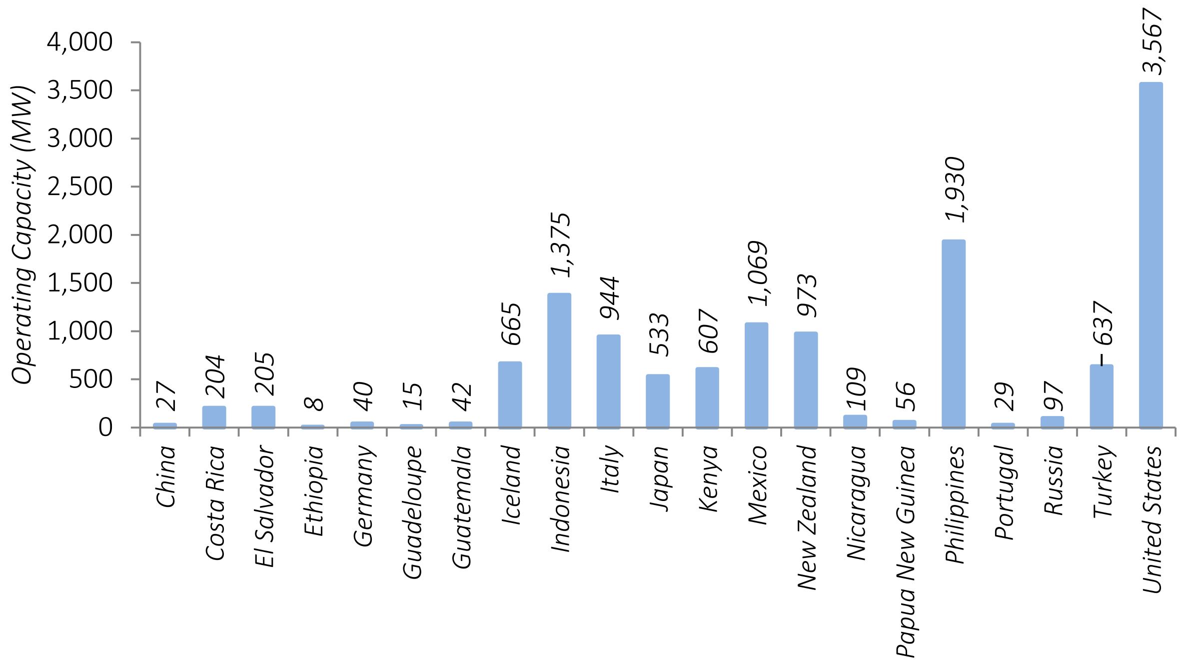
## Overview of the Global Market

According to GEA data collection (see Appendix 3), there is over 200 GWe of conventional hydrothermal potential globally available based on current knowledge and technology. The Intergovernmental Panel on Climate Change (IPCC) came to roughly the same conclusion.[6] Therefore, communities and governments around the world have only tapped 6-7% of the total global potential for geothermal power based on current geologic knowledge and technology.[7]

Figure 2 (below) depicts global operating capacity by country while Figure 3 lists developing planned capacity additions updated for 2015. Even with all of these planned capacity additions, only about a sixth of global potential has identifiable development plans. Based on the current market trajectory and projects in the pipeline, it is likely within the next decade or so that the Philippines, Indonesia or Europe could independently roughly equal the U.S. in installed capacity assuming development continues to stall in the United States.

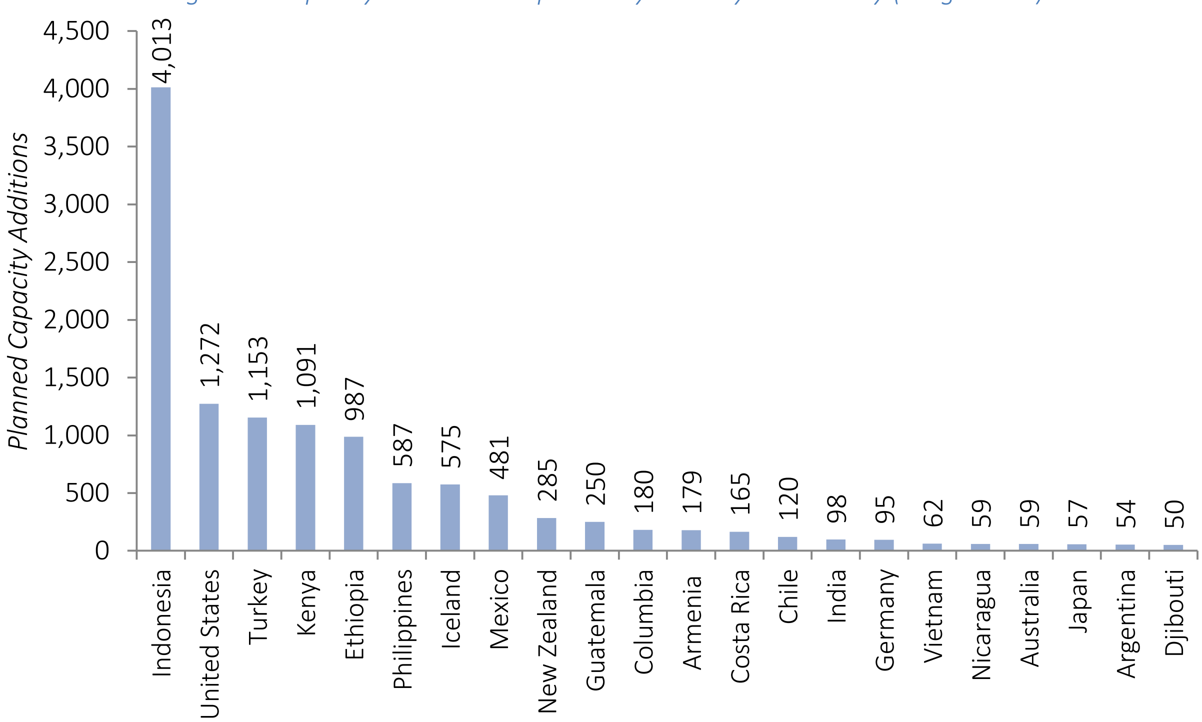
[6] (Goldstein et al., 2011)

*Figure 2: Geothermal Power Operating Capacity by Country*




*Note: 'Nameplate capacity' is often used to derive these estimates but also 'net capacity' is used when nameplate is not available*

*Figure 3: Capacity under Development by Country or Territory (Megawatts)*




*Note: A full international project list is published in conjunction with this report. The extraordinary amount of developing capacity for Indonesia could possibly be the result of the backlog of projects in the country stalled by prolonged PPA negotiations, delayed permits related to the usage of conservation or protected areas and resistance from local residents.*

Geothermal power projects around the globe continue to gain momentum and expand. Throughout Central and South America geothermal development is moving forward. El Salvador plans to incorporate a 40% share of geothermal power in its energy mix by the end of 2019 and is well on their way to meeting that target.[8] Chile began work on its first geothermal power plant at Cerro Pabellon and has laid out its 3 year drilling campaign.[9] Costa Rica secured a $500 million credit line from the Japanese International Cooperation Agency (JICA) to add up to 165 MW in geothermal power generation capacity at the Pailas and Borinquen projects[10] and Nicaragua extended incentives for renewables in 2015 to reach its 2020 goal of 90% powered by renewables.[11]

East Africa is another regional hotbed for geothermal activity as strong forward progress pushed several countries closer to building their first geothermal power plants. The Tanzania Geothermal Development Company pledged to bring 220 MW online by 2020.[12] Meanwhile, Kenya now exports some of its excess geothermal capacity to neighboring Rwanda and Uganda while generating half of its electricity from geothermal power.[13]

In North America, Mexico has increased its commitment to the geothermal market and is taking significant steps to build new projects and expand existing fields. In mid-2015, Mexico issued new rules on private geothermal leasing, legal, technical, administrative and financial requirements, as well as the procedures necessary to obtain a registration, permit or concession.[14] Then in the fall of 2015, Mexico released guidelines for their wholesale power market and took bids from independent power producers in November with contracts expected to be awarded in the second quarter of 2016.[15]

Lastly, the amount of countries constructing projects continues to grow. Some new entrants into the geothermal market include organizations in Middle Eastern countries like Saudi Arabia, Iran and Pakistan[16], which all have announced intentions to build projects or announced development goals in the short-term.

## Global Carbon Reduction Commitments with Geothermal Power

The urgency and ramifications of climate change became even more apparent this year as COP21 reached a historic global agreement between 161 countries on climate change mitigation. Geothermal technology was an important part of that discussion as a solution to the world's need for new and cleaner firm and flexible renewable energy source (see Table 1). Separately, the Global Geothermal Alliance (GGA), spearheaded by the International Renewable Energy Agency and supported by the United Nations Framework Convention on Climate Change (UNFCCC), pledged to quintuple the global geothermal capacity to around 65 GW by 2030.[17]

It's expected many other countries will use geothermal technology as a mitigation option to fulfill their obligations, but not all countries explicitly list geothermal power. Some specified renewables generally as

[8] (ACAN-EFE, 2016)
[9] (Think GeoEnergy, 2015b)
[10] (Think GeoEnergy, 2015c)
[11] (Think GeoEnergy, 2015d)
[12] (Lazaro, 2015)
[13] (Think GeoEnergy, 2014) (ThinkGeo Energy, 2015a, p. 50) (Christabel Ligami, 2015)
[14] (Jiménez et al., 2015)
[15] (Bierzwinsky, 2015)
[16] (Lashan et al., 2015; UNFCCC, 2015)
[17] (UNFCCC, 2015)

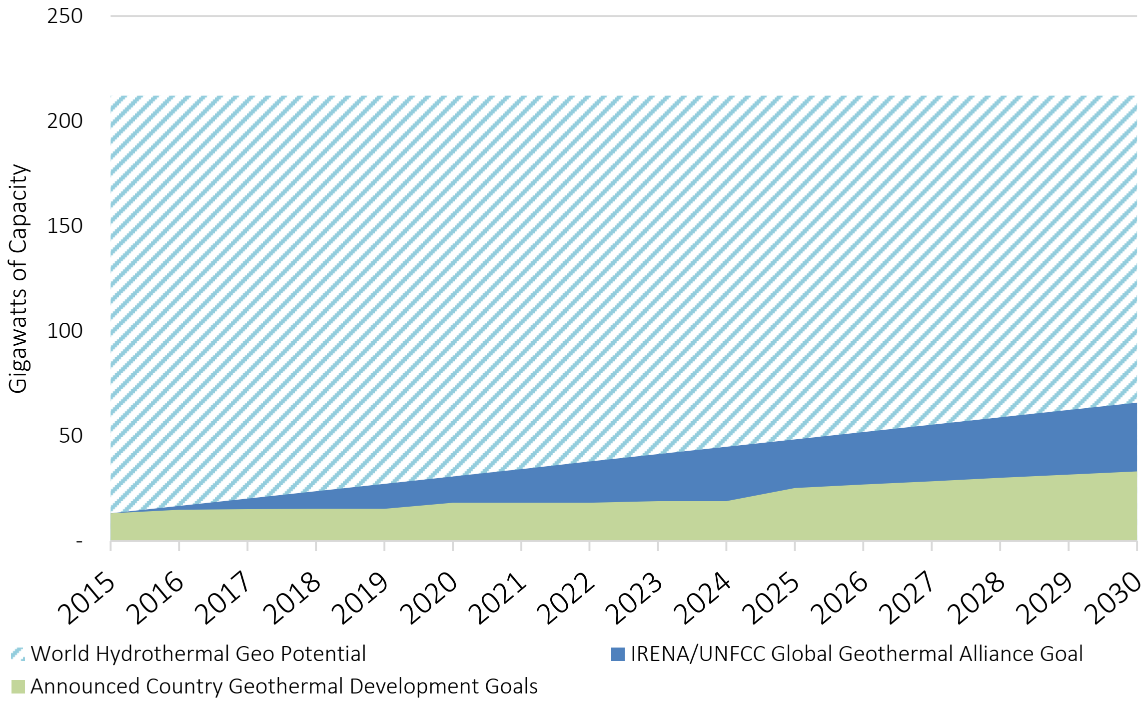
a tool. Each country listed below specifically mentioned geothermal power as a tool to mitigate their emissions in their pledge to the United Nations as part of COP21. The combined effect of country commitments to reduce their carbon pollution under their INDC pledges could double geothermal capacity by the 2030s.

*Table 1: Country INDC Commitments That Explicitly Mention Geothermal Power*

| *Country* | Geothermal Information in Pledge |
|---|---|
| *Bolivia* | Pledges to increase renewables including geothermal power. |
| *Costa Rica* | To achieve and maintain a 100% renewable energy matrix by 2030 with geothermal power as part of the portfolio. |
| *Canada* | Pledges investments to encourage the generation of electricity from renewable energy sources such as wind, low-impact hydro, biomass, photovoltaic and geothermal energy. |
| *China* | Plans to proactively develop geothermal energy |
| *Djibouti* | Pledges to develop renewable energy including geothermal power |
| *Dominica* | Made commitments to reduce emissions in energy sector using geothermal power |
| *Eritrea* | Pledges to develop geothermal as part of its commitment. |
| *Ethiopia* | Pledges to develop geothermal as part of its commitment. |
| *Fiji* | Pledges to develop geothermal as part of its commitment. |
| *Grenada* | Pledges to build 15 MW of geothermal power in the near-term. |
| *Kenya* | Expansion in geothermal and other renewables as part of its emissions mitigation strategy. |
| *Papua New Guinea* | Pledges to develop geothermal as part of its commitment. |
| *St Lucia* | 35% Renewable Energy Target by 2025 and 50% by 2030 based on a mix of geothermal, wind and solar energy sources. |
| *St Vincent and Grenadines* | The largest contributor to reducing emissions will be the installation of a geothermal electricity generation facility, which when operational will provide over 50% of the country's electricity needs. |
| *Solomon Islands* | Geothermal listed as mitigation opportunity. |
| *Uganda* | Geothermal listed as mitigation opportunity. |
| *Vanuatu* | Pledges to build 8 MWs of geothermal by 2030. |
| *St. Kitts and Nevis* | Commitment to geothermal as part of its INDCs. |

Figure 4 combined commitments of INDCs, other international goals, and GGA's development goals to compare them to the total global potential. The most important conclusion from Figure 4 is that countries will need to up their geothermal pledges and commitments to meet IRENA's goals of 65 GW by 2030. The geothermal potential is available throughout the world but significant assistance will be necessary to turn these resources into power plants, especially in developing countries where fossil fuels quickly become an easy alternative for an economy desperate for power. In North America, governments will need to realize the values of geothermal power, and its capability as a cost-effective approach to balance out intermittent renewables, and commit to developing these resources as a reliable power source.

*Figure 4: Global Geothermal Development Goals and Pledges*




A report published by Micale and Oliver in the summer of 2015 reached a similar conclusion particularly in the area of financing. Micale and Oliver found that public financing for geothermal power needs to increase seven to ten fold (from USD 7.4 billion currently to USD 56-73 billion) in order to drive enough private investment to meet developing countries' deployment targets.[18] Furthermore, the group noted "Governments and DFIs will need to provide 42-55% of the total additional financing of approximately USD 133 billion in the form of low-cost, long-term loans and equity for exploration, drilling, steamfield development and power plant construction. Most of this public finance is needed in countries with some experience with geothermal but challenging private investment markets, such as Indonesia and Kenya."[19]

International donor banks are working to reduce the risks of geothermal and provide financing but this money is still a fraction of what is needed. For example, financing of geothermal energy exploration by multinational banks has increased 11 percent, up from 6 percent in 2012 to 17 percent in 2015.[20] The World Bank's geothermal funds have focused on reducing risks associated with geothermal projects in developing countries in projects such as a $31.2 million drilling program at Lake Assal, Djibouti and a $115 million dollar risk mitigation program in Nicaragua that will leverage private risk capital for exploration drilling and resource confirmation at Casita-San Cristobal.[21] In total, the World Bank's Geothermal Development Plan's hopes to mobilize US$500 million to help with some of the problems laid out by Climate Policy Initiatives' findings.[22]

[18] (Micale and Oliver, 2015)
[19] (Micale and Oliver, 2015)
[20] (Delony, 2015)
[21] (Delony, 2015)
[22] (Energy Sector Management Assistance Program, 2013)

## U.S. Geothermal Power Update

The U.S. geothermal market has had a challenging year as growth nearly stalled in 2015. However, there are potential opportunities on the horizon that could help the sector grow and expand.

### Past Challenges

Overall the U.S. market continues to hover just over 3.7 GW of operating nameplate capacity and just over 2.7[23] GW of net capacity. There was little growth in geothermal capacity in 2015 because of cheap fossil fuel substitutes like natural gas and improperly designed tax incentives that favor other renewables over geothermal power (Figure 5). However, geothermal generation continues to grow steadily as developers bring the occasionally new plant online, expand existing facilities, or find ways to make current plants more efficient (Figure 6).

The tax package passed at the end of 2014 did little to help plants develop in 2015 since Congress only extended the PTC tax credit for several weeks. The tax package passed at the end of 2015 in the Omnibus bill extended the PTC and ITC for new geothermal plants that are under construction by the end of this year, but provided longer term incentives for only wind and solar. In the final agreement passed by Congress in December 2015, the Section 45 PTC for geothermal, hydropower and biomass was extended to the end of 2016, and there was no phase out specified. Meanwhile, the solar 30% tax investment credit will be available until the end of 2019, with a shrinking value in 2020 and 2021 in a phase-out. The wind PTC is extended at 100% through 2016, then has a shrinking value through 2019 in a phase-out. It is unclear whether geothermal power and a range of other technologies were accidentally neglected or intentionally left out. This uncertainty surrounding unbalanced incentives is likely to continue to cause frustrations and delay projects in the United States. For more information on tax incentives see Appendix 8.

Further hindering the US industry this year were very low natural gas prices. In fact one geothermal company to declare Chapter 7 bankruptcy this year explicitly cited cheap natural gas as the main obstacle to attaining financing and the reasons for the company's bankruptcy.[24]

Lastly, a comprehensive study of the U.S. geothermal market by the National Renewable Energy Laboratory outlined in detail some of the barriers in the U.S. market. The study found 25% of developing projects have the potential to come online if they overcome small hurdles. An additional, 51% of projects examined are currently stalled due to larger barriers, but could come online with support in overcoming these barriers. The barriers found to be hindering these projects included financing, permitting, transmission, and acquisition of power purchase agreements (PPA).[25] GEA's 2016 data agrees with this study's findings. Our list shows about 500 MW of power stuck in Phase 3, waiting for PPAs or financing to move forward. These projects could be brought online in 17-33 months or sooner with the appropriate power contracts.

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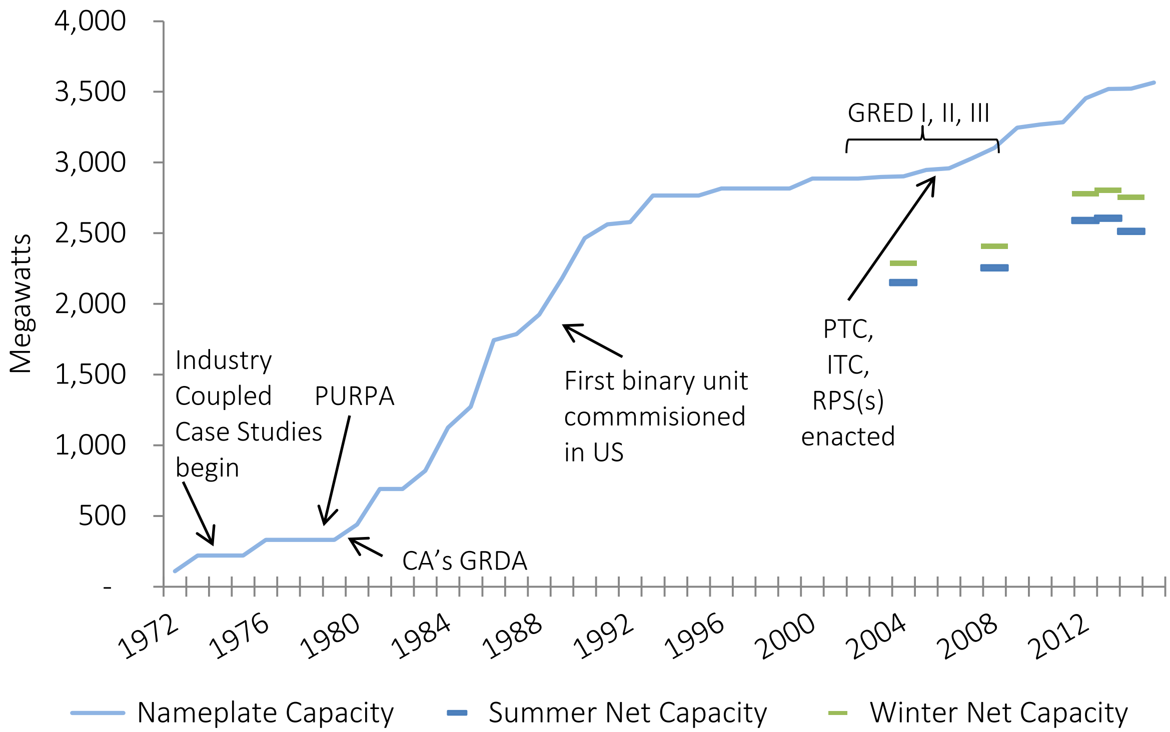
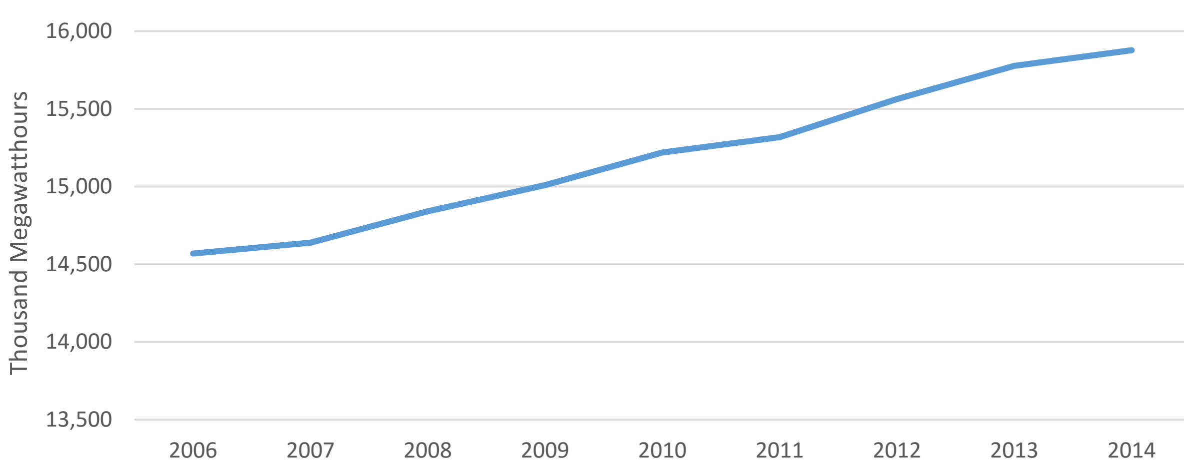
[23] (Energy Information Administration, 2015a, p. 860)
[24] (Floyd, 2015)
[25] (Wall and Young, 2016)

*Figure 5: U.S. Industry Geothermal Nameplate & Net Capacity*




*Note: PCA (Planned Capacity Additions), pilot plants and utility scale geothermal plants built in the first half of the 20th century and then decommissioned are not included in the above time series. Terms: Public Utility Regulatory Policy Act (PURPA), Geothermal Resource Exploration & Definition Program (GRED), Renewable Portfolio Standard (RPS), California's Geothermal Grant and Loan Program (CA's GRDA), Production Tax Credit (PTC), Investment Tax Credit (ITC). Source: GEA & EIA[26]*

*Figure 6: U.S. Utility Scale Geothermal Generation*




*Source:* (Energy Information Administration, 2015b)

[26] (Energy Information Administration, 2015a)

## Future Opportunities

Despite slow growth and challenging barriers, there are several new policies that could create opportunities for geothermal power in the western states. The governor of California, Jerry Brown, signed SB 350 into law in October 2015 which expanded the renewable portfolio standard (RPS). Also, Gov. Brown proposed an increase of $80 million Proposition 1 funding for the Department of Water Resources to design and implement projects that expand habitat and suppress dust at the Salton Sea which could include geothermal development. In other western states, Hawaii passed a 100% RPS by 2045, Oregon's legislature is debating a 50% RPS by 2045, New Mexico legislature sent a bill to the Governor's desk streamlining geothermal legislation in mid-February, and the Colorado Energy Office has entertained the idea of creating the first cost shared drilling program in a decades.[27]

At the federal level, EPA's Clean Power Plan rule became final and could create new opportunities for geothermal energy in states that need cleaner power sources to comply with the new rules if it survives court challenges. States which contain geothermal resources but have not developed them may consider adding new geothermal power plants to their portfolio to meet carbon dioxide reduction requirements.

As part of the Obama Administration's all-of-the-above energy strategy, the Dept. of Energy's Geothermal Technologies Office in early 2015 selected five projects for a total of $2 million for the first part of the multiphase Frontier Observatory for Research in Geothermal Energy effort. This research could unlock access to a domestic, geographically diverse, and carbon-free source of clean energy with the potential to supply power to up to 100 million homes in the United States. The first two phases of FORGE will provide a total of up to $31 million over two years for selected teams on EGS research.[28]

## Developing Projects

As shown in Figure 8, the inventory of developing geothermal projects fell in recent years from nearly 120 to about 80 projects. This fall can be attributed to projects reaching completion, industry consolidation, and developers cutting costs by freezing projects they wish to hold for development at this time.

The economics of a geothermal power project resemble that of mining or an oil and gas project more closely than other renewables such as wind and solar. Geothermal resources need to be discovered, drilled for, and extracted. Purchasing and returning leases is a normal exploration cycle that geothermal developers go through as they search for prime geothermal resources.

Lastly, some developers report low oil prices are helping lower the cost of exploration since it has become cheaper to run drill rigs and more crews are available. However, low oil prices have also shaken investor and made yieldcos more expensive due to rising interest rates. A yieldco is a company that is formed to own operating assets that produce a predictable cash flow and these company structures are commonly used by some larger geothermal power companies to buy and operate power plants.[29] Unfortunately, many regulatory regimes do not yet fully recognize the values of geothermal power. Despite the long-term investment nature of this energy resource, the levelized cost of energy of geothermal often can compete many other energy technologies because the renewable power generation is constant. EIA found the levelized cost of energy for geothermal power is lower than most other energy technologies. EIA writes,

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[27] (Senate Committee On Business and Transportation, 2016) (New Mexico Legislature, 2016)
[28] (Department of Energy Geothermal Technologies Office, 2015)
[29] (Cardwell, 2015; Think GeoEnergy, 2015e)

*"the average net differences are negative for all technologies except geothermal, reflecting the fact that on average, new capacity is not needed in 2020. . . Geothermal cost data is site-specific, and the relatively large positive value for that technology results because there may be individual sites that are very cost competitive."*[30]

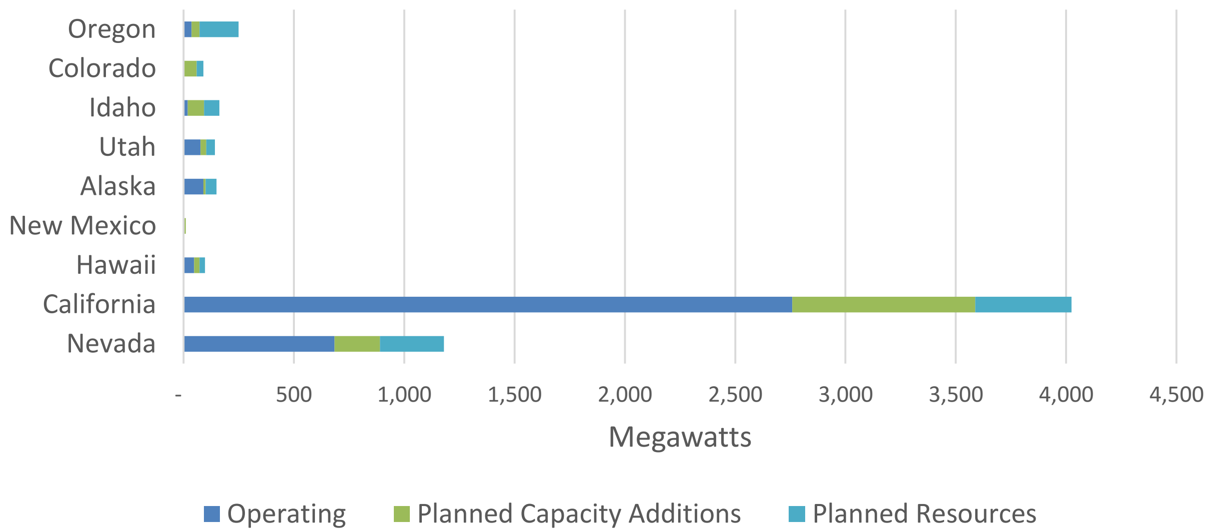



*Figure 7: Developing Planned Capacity Additions & Nameplate Capacity by State*

Note: Planned Capacity Additions (PCA) is the power plants estimated installed capacity.

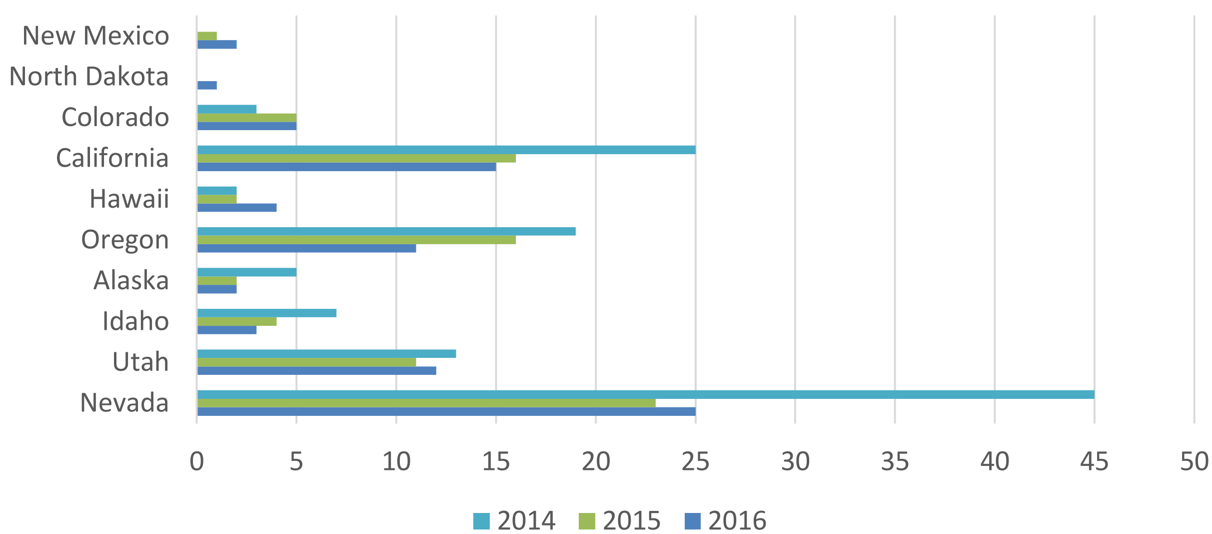



*Figure 8: Number of Developing Projects by State*

Note: In the past few years, demonstration and exploration projects have occurred in additional states such as Washington, Texas, Arizona, Louisiana, Montana, Mississippi, and Wyoming.

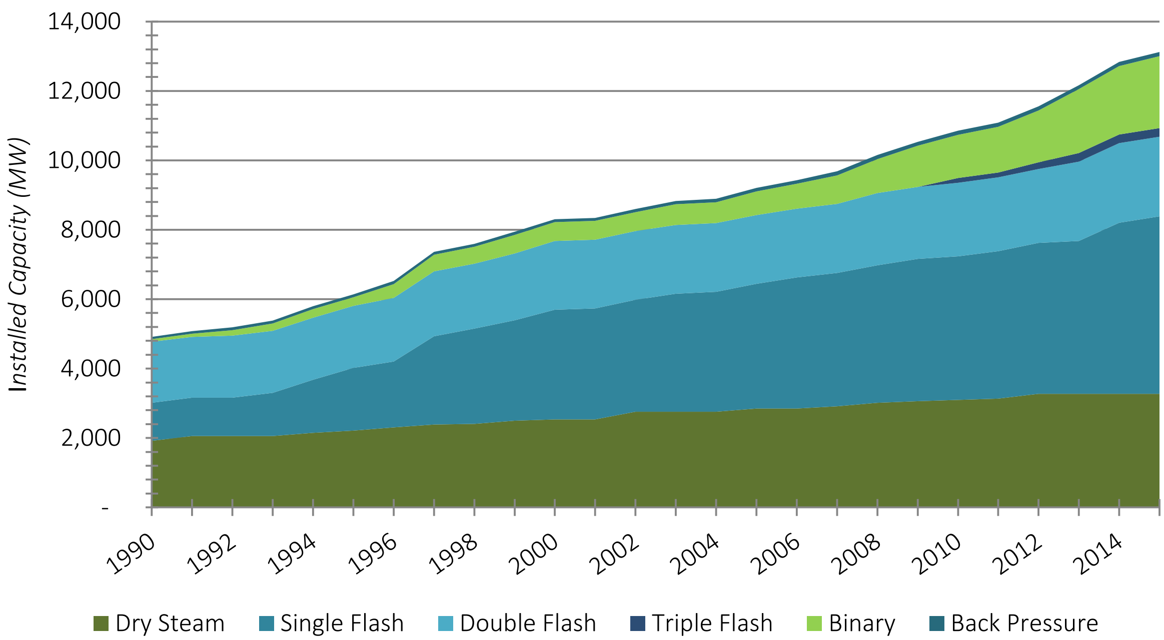
[30] (Energy Information Administration, 2015c)

## Global Technology and Manufacturing Update

The types of conventional geothermal power technologies are: dry steam, flash and binary. In dry steam plants, naturally occurring, high-pressure steam shoots up from the dry steam reservoir and is used to run the turbines that power the generator. In flash plants, steam is separated from high-pressure and high-temperature geothermal fluids (hot water and steam). The steam is delivered to a turbine that powers a generator. The liquid (condensed from the steam after passing through the turbine) and remaining geothermal water are injected back into the reservoir. In binary or ORC (i.e., Organic Rankine Cycle) plants, the heat is transferred from the hot water to an organic working fluid that has a boiling point lower than the boiling point of water. The working fluid is vaporized to run the turbine. The geothermal water is never allowed to reach the atmosphere - 100% is injected back into the reservoir. In all systems, the injected fluid is never allowed to mix with the shallow groundwater system.

The technology of choice for a geothermal power plant depends on the characteristics of the geothermal resources. Binary plants are used with lower temperature resources while flash and dry steam plants are used with higher temperature resources. Flash and dry steam technologies continue to be the more prevalent and the most developed. Flash technologies, including double and triple flash, make up a little less than two thirds of the global producing megawatts (58%), while dry steam is about a quarter (25%) and binary is a remaining 16%. The last remaining 1% of power includes back pressure and other non-traditional types of geothermal technologies. Figure 9 shows the change in the geothermal power market by turbine technology over time in megawatts. Furthermore, Figure 9 disagrees with the notion that geothermal power as a legacy or mature technology. The binary turbine market which can generate electricity from lower temperature fields is only about two decades old. Many lower temperature resources are just beginning to be identified, explored and developed.

*Figure 9: Operating Capacity by Technology Type*




In general, the geothermal turbine market has several companies who provide equipment and engineering for higher temperature projects; these companies include Toshiba, Mitsubishi, and Fuji. The lower temperature Organic Rankine Cycle (ORC) market is mostly accounted for by one manufacturer, Ormat Technologies Inc. (ORA). Several smaller manufacturers of ORC technologies just began to enter the geothermal market recently and capitalizing on specific niches. For example, Ormat has provided the turbines for about three quarters of the ORC market. Meanwhile, new suppliers like Electratherm, Exergy, Turboden and others recently just entered the geothermal ORC market.

Figure 10 displays some of the latest GEA data on the geothermal equipment suppliers market by projects. Ormat has provided equipment to substantially more projects than nearly any other company, but these are often smaller binary projects. Meanwhile flash and dry steam turbine providers have provided less equipment by project, but these are usually larger projects. In total, when looking at the global turbine market by number of projects, the leaders are Ormat (26%), Mitsubishi (18%), Fuji (13%) and Toshiba (10%). Additional geothermal equipment providers who fall in the "other" category include but are not limited to: Kaluga Turbine, Turboden, Atlas Copco/Mafi Trench, ElectraTherm, Elliot Turbomachinery, Exergy, Pratt & Whitney and Siemens.

In general, GEA expects that the binary market will continue to grow substantially in tandem with the flash and dry steam markets. In Europe and the U.S., binary projects are the main power plant type under construction while regions such as East Africa and the South Pacific have numerous flash and dry steam plants under development. Meanwhile, South and Central America have only started exploring and studying their geothermal resources, but it is expected these regions will develop a diverse mix of binary, flash and dry steam projects. In conclusion, there are significant geothermal resources under development across the temperature spectrum in many regions around the world, and the type of technology that will be used in future developments is difficult to predict.

*Figure 10: Geothermal Equipment Suppliers as Percent of Global Market by Number of Projects*

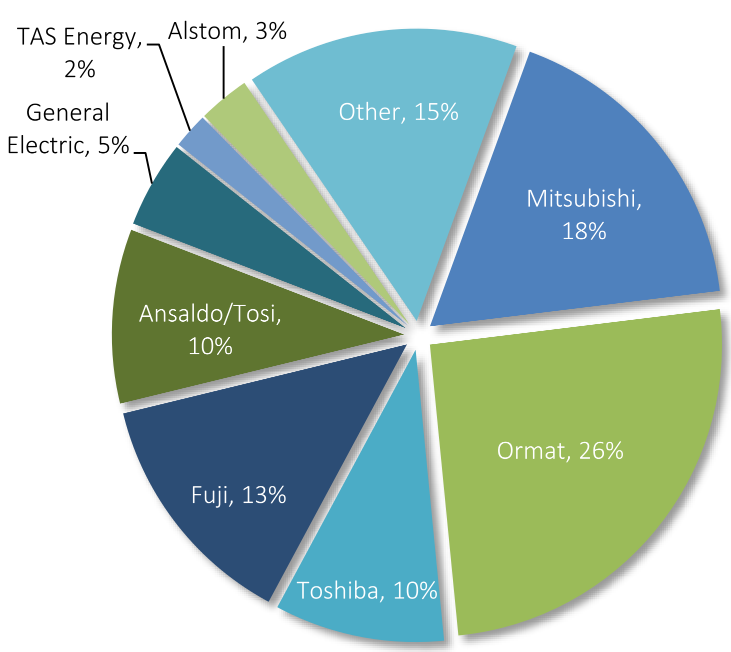


*Table 2: Announced Projects under Development by Major Turbine/Equipment Supplier by Country*

| Country | Field or Locality | Plant | Planned Capacity Addition (MW) | Primary Plant Type | Turbine |
|---|---|---|---|---|---|
| *Ethiopia* | Aluto Langano | Phase 1, Plant 1, Unit 1 | 75 | N/A | Toshiba |
| *Germany* | Maurstetten (EGS) | Maurstetten (EGS) | 5 | EGS | Atlas Copco/Mafi Trench |
| *Honduras* | Platanares | Phase 1 | 17 | Binary | Ormat |
| *Honduras* | Platanares | Phase 2 | 18 | Binary | Ormat |
| *Iceland* | Reykjanes | Reykjanes Expansion 3 | 50 | N/A | Fuji |
| *Iceland* | Theistareykir | Phase 1 & 2 | 45 | N/A | Fuji |
| *Indonesia* | North Sumatra | Sarulla Phase 2 | 110 | N/A | Toshiba |
| *Indonesia* | North Sumatra | Sarulla Phase 3 | 110 | N/A | Toshiba |
| *Indonesia* | Sulawesi - Lahendong | Lahendong Unit 5 | 20 | N/A | Fuji |
| *Indonesia* | Lampung | Ulbelu Unit 3 | 55 | Single Flash | Fuji |
| *Indonesia* | North Sumatra | Sarulla Phase 1 | 110 | Single Flash | Toshiba |
| *Indonesia* | West Java | Kamojang Unit 5/Karaha Bodas | 37 | N/A | Alstom |
| *Indonesia* | Lampung | Ulbelu Unit 4 | 55 | Single Flash | Fuji |
| *Indonesia* | West Java-Bandung | Patuha - Unit 2 | 55 | N/A | Toshiba |
| *Kenya* | Olkaria | Olkaria - Green Energy Group transfer | 20 | Binary | Green Energy Group |
| *Kenya* | Olkaria | Olkaria 3 Unit 4 | 24 | Binary | Ormat |
| *Mexico* | Los Humeros | Los Humeros III B | 27 | Single Flash | Alstom |
| *Mexico* | Los Azufres | Los Azufres III - 2 | 25 | Single Flash | Fuji |
| *Mexico* | Los Humeros | Los Humeros III A | 27 | Single Flash | Alstom |
| *Mexico* | San Pedro Lagunillas | Phase 1 | 25 | N/A | Mitsubishi |
| *Mexico* | San Pedro Lagunillas | Phase 2 | 25 | N/A | Mitsubishi |
| *Philippines* | Oriental Mindoro | Montelago | 44 | N/A | Turboden |
| *Portugal* | Terceira island | Pico Alto field | 12 | Binary | Ormat |
| *Turkey* | Denizli-Sarayköy | Jeoden | 3 | Binary | Turboden |
| *Turkey* | Aydin-Umurlu | Umurlu 2 | 12 | Binary | Exergy |
| *Turkey* | Denizli-Sarayköy | Saraykoy 1 | 13 | Binary | Exergy |
| *Turkey* | Denizli-Sarayköy | Saraykoy 2 | 13 | Binary | Exergy |
| *Turkey* | Aydin-Sultanhisar | Sultanhisar Unit 1 | 14 | Binary | Exergy |
| *Turkey* | Aydin-Salavatil | Dora IV | 17 | Binary | Ormat |
| *Turkey* | Aydin-Pamukoren | Pamukoren 3 | 23 | Binary | Exergy |
| *Turkey* | Aydin-Pamukoren | Pamukoren 4 | 23 | Binary | Exergy |
| *Turkey* | Manisa-Alesehir | Kemaliye Aleshir 1 & 2 | 25 | Binary | Exergy |

## Appendix 1: U.S. Project under Development (as of January 2016)

| Project Name | Developer | Estimated Nameplate Capacity (MW) | Project Type | Location (State, County) | Project Phase |
|---|---|---|---|---|---|
| Mount Spurr | Ormat Nevada Inc. | N/A | CH Unproduced | AK | Phase 1 |
| Akutan Geothermal Project | City of Akutan | 10 | CH Unproduced | AK, Aleutians East Borough (County) | Phase 3 |
| Glass Mountain | Calpine | N/A | CH Unproduced | CA, | Phase 2 |
| Heber Expansion | Ormat Nevada Inc. | 16 | CH Expansion | CA, Imperial | Phase 4 |
| Imperial Wells Power | EnergySource | 85 | CH Produced | CA, Imperial | Phase 1 |
| Black Rock 1-2 | CalEnergy | 159 | CH Produced | CA, Imperial | Phase 3 |
| Black Rock 5-6 | CalEnergy | 235 | CH Produced | CA, Imperial | Phase 3 |
| Brawley (North and East) | Ormat Nevada Inc. | N/A | CH Produced | CA, Imperial | Prospect |
| Truckhaven | Ormat Nevada Inc. | 30 | CH Unproduced | CA, Imperial | Phase 1 |
| Bottlerock | AltaRock Energy | 55 | CH Produced | CA, Lake | On hold |
| Buckeye North Geysers | Calpine | 56.9 | CH Produced | CA, Lake | N/A |
| CD4 (Mammoth Complex) | Ormat Nevada Inc. | N/A | CH Unproduced | CA, Mono | Phase 2 |
| Four Mile Hill | Calpine | 49.9 | CH Unproduced | CA, Siskiyou | N/A |
| Telephone Fiat | Calpine | 49.9 | CH Unproduced | CA, Siskiyou | N/A |
| Geysers Project (aka WGP Geysers) | U.S. Geothermal | 30 | CH Unproduced | CA, Sonoma | Phase 3 |
| Wildhorse | Calpine | 48 | CH Produced | CA, Sonoma | Phase 1 |
| Pagosa Waters | Pagosa Verde | 10 | CH Unproduced | CO, Archuleta | Phase 2 |
| Poncah Hot Springs | Mt Princeton Geothermal LLC | 10 | CH Unproduced | CO, Chaffee | Phase 2 |
| Mt Princeton | Mt Princeton Geothermal LLC | 10 | CH Unproduced | CO, Chaffee | Phase 2 |
| Waunita Waters Project | Pagosa Verde | 30 | CH Unproduced | CO, Gunnison | Phase 2 |
| City of Aspen Geothermal Project | City of Aspen | N/A | CH Unproduced | CO, Pitkin | Phase 2 |
| Puna Expansion | Ormat Nevada Inc | 25 | CH Expansion | HI, Big Island | N/A |
| Kula | Ormat Nevada Inc. | N/A | CH Unproduced | HI, Big Island | Prospect |
| Kona | Ormat Nevada Inc. | N/A | CH Unproduced | HI, Big Island | Prospect |

| | | | | | |
|---|---|---|---|---|---|
| *Ulupalakua (Maui)* | *Ormat Nevada Inc.* | *N/A* | *CH Unproduced* | *HI, Maui* | *Phase 1* |
| *Walker Ranch* | *Agua Caliente, LLC* | *30* | *CH Unproduced* | *ID, Cassia* | *Phase 2* |
| *Raft River Unit III* | *U.S. Geothermal* | *32* | *CH Produced* | *ID, Cassia* | *Phase 1* |
| *Raft River Unit II* | *U.S. Geothermal* | *13* | *CH Produced* | *ID, Cassia* | *Phase 2* |
| *Rhame* | *University of North Dakota* | *N/A* | *Co-production* | *ND* | *N/A* |
| *Rincon* | *Ormat Nevada Inc.* | *N/A* | *CH Unproduced* | *NM, Doña Ana* | *Prospect* |
| *Lightning Doc 2* | *Cyrq Energy* | *6* | *CH Produced* | *NM, Hidalgo* | *Phase 4* |
| *Beowawe* | *Ormat Nevada Inc.* | *N/A* | *CH Produced* | *NV,* | *Prospect* |
| *Hycroft* | *Ormat Nevada Inc.* | *N/A* | *CH Unproduced* | *NV,* | *Prospect* |
| *Baltazar* | *Ormat Nevada Inc.* | *N/A* | *CH Unproduced* | *NV,* | *Phase 1* |
| *South Jersey* | *Ormat Nevada Inc.* | *N/A* | *CH Unproduced* | *NV,* | *Prospect* |
| *Edwards Creek* | *Ormat Nevada Inc.* | *N/A* | *CH Unproduced* | *NV,* | *Prospect* |
| *Lee Hot Springs* | *U.S. Geothermal* | *20* | *CH Unproduced* | *NV, Churchill* | *Phase 1* |
| *Tungsten Mountain* | *Ormat Nevada Inc.* | *N/A* | *CH Unproduced* | *NV, Churchill* | *Phase 4* |
| *Upsal Hogback* | *Cyrq Energy* | *N/A* | *CH Expansion* | *NV, Churchill* | *Phase 1* |
| *Desert Queen* | *Cyrq Energy* | *N/A* | *CH Unproduced* | *NV, Churchill* | *Phase 1* |
| *Soda Lake East* | *Cyrq Energy* | *N/A* | *CH Unproduced* | *NV, Churchill* | *Prospect* |
| *Soda Lake South* | *Cyrq Energy* | *N/A* | *CH Unproduced* | *NV, Churchill* | *Phase 1* |
| *Agua Quieta* | *Ormat Nevada Inc.* | *N/A* | *CH Unproduced* | *NV, Churchill* | *Phase 1* |
| *Carson Lake* | *Ormat Nevada Inc.* | *N/A* | *CH Unproduced* | *NV, Churchill* | *Phase 2* |
| *Dixie Meadows* | *Ormat Nevada Inc.* | *N/A* | *CH Unproduced* | *NV, Churchill* | *Phase 2* |
| *McCoy* | *Cyrq Energy* | *N/A* | *CH Unproduced* | *NV, Churchill, Lander* | *Phase 1* |
| *Ruby Hot Springs* | *U.S. Geothermal* | *20* | *CH Unproduced* | *NV, Elko* | *Phase 1* |
| *Tuscarora - Phase 2* | *Ormat Nevada Inc.* | *N/A* | *CH Unproduced* | *NV, Elko* | *Phase 2* |
| *Crescent Valley* | *U.S. Geothermal* | *25* | *CH Unproduced* | *NV, Eureka* | *Phase 1* |
| *Blue Mountain* | *AltaRock Energy* | *50* | *EGS* | *NV, Humboldt* | *N/A* |
| *Argenta* | *Ormat Nevada Inc.* | *N/A* | *CH Unproduced* | *NV, Lander* | *Prospect* |
| *Granite Springs* | *Cyrq Energy* | *N/A* | *CH Unproduced* | *NV, Pershing* | *Phase 1* |
| *San Emidio Phase II* | *U.S. Geothermal* | *11* | *CH Produced* | *NV, Washoe* | *Phase 3* |
| *Gerlach* | *U.S. Geothermal* | *10* | *CH Unproduced* | *NV, Washoe* | *Phase 2* |

| | | | | | |
|---|---|---|---|---|---|
| *North Valley* | *Ormat Nevada Inc.* | *55* | *CH Unproduced* | *NV, Washoe, Churchill* | *Prospect* |
| *Warm Springs Tribe* | *Ormat Nevada Inc.* | *N/A* | *CH Unproduced* | *OR,* | *Prospect* |
| *Winema* | *Ormat Nevada Inc.* | *N/A* | *CH Unproduced* | *OR,* | *Prospect* |
| *Newberry* | *Davenport Newberry Holdings/AltaRock Energy* | *0* | *EGS* | *OR, Deschutes* | *Phase 2* |
| *Twilight - Newberry* | *Ormat Nevada Inc.* | *N/A* | *CH Unproduced* | *OR, Deschutes* | *Phase 2* |
| *Alvord* | *Cyrq Energy* | *N/A* | *CH Unproduced* | *OR, Harney* | *Phase 1* |
| *Klamath Plant* | *Cyrq Energy* | *N/A* | *CH Unproduced* | *OR, Klamath* | *Phase 2* |
| *Midnight Point - Glass Butes* | *Ormat Nevada Inc.* | *N/A* | *CH Unproduced* | *OR, Lake* | *Phase 2* |
| *Goose Lake - Lakeview* | *Ormat Nevada Inc.* | *N/A* | *CH Unproduced* | *OR, Lake* | *Prospect* |
| *Crump Geyser* | *Ormat Nevada Inc. (Crump Geothermal Company, LLC)* | *10* | *CH Unproduced* | *OR, Lake* | *Phase 2* |
| *Vale Butte* | *U.S. Geothermal* | *15* | *CH Unproduced* | *OR, Malheur* | *Prospect* |
| *Neal Hot Springs II* | *U.S. Geothermal* | *10* | *CH Produced* | *OR, Malheur* | *Phase 2* |
| *Whirlwind Valley* | *Ormat Nevada Inc.* | *N/A* | *CH Unproduced* | *UT,* | *Phase 1* |
| *Thermo 4* | *Cyrq Energy* | *N/A* | *CH Produced* | *UT, Beaver* | *Phase 1* |
| *Thermo 3* | *Cyrq Energy* | *N/A* | *CH Produced* | *UT, Beaver* | *Phase 1* |
| *Thermo 2* | *Cyrq Energy* | *N/A* | *CH Produced* | *UT, Beaver* | *Phase 1* |
| *Thermo Central* | *Cyrq Energy* | *N/A* | *CH Produced* | *UT, Beaver* | *Prospect* |
| *Thermo Greater* | *Cyrq Energy* | *N/A* | *CH Produced* | *UT, Beaver* | *Prospect* |
| *DeArmand* | *Cyrq Energy* | *N/A* | *CH Unproduced* | *UT, Iron* | *Prospect* |
| *Abraham* | *Cyrq Energy* | *N/A* | *CH Unproduced* | *UT, Millard* | *Prospect* |
| *Cricket* | *Cyrq Energy* | *N/A* | *CH Unproduced* | *UT, Millard* | *prospect* |
| *Drum Mountain* | *Cyrq Energy* | *N/A* | *CH Unproduced* | *UT, Millard* | *Prospect* |
| *Pavant* | *Cyrq Energy* | *N/A* | *CH Unproduced* | *UT, Millard* | *Prospect* |

*Note: This list is accurate as of January 2016. For more information please contact the Geothermal Energy Association*

## Appendix 2: New Power Plants to become Operational in 2015

*Table 3: Power Plants to Come Online in 2015 Globally*

| Country | Region | Field or Locality | Plant | Capacity Addition (MW) | Primary Plant Type | Plant Owner | Turbine |
|---|---|---|---|---|---|---|---|
| Germany | Europe | Traunereut | Traunereut | 5.5 | Binary | Geothermischen Kraftwerksgesellschaft Traunreut mbH (GKT) | Turboden |
| Japan | Asia | Fukushima | Tsuchiyu onsen | 0.4 | Binary | Tsuchiyu onsen energy Co. | Ormat |
| Japan | Asia | Oita | Sugawara Binary Cycle | 5.0 | Binary | Kyushu Electric Power | N/A |
| Kenya | Middle East/Africa | Olkaria | Olkaria GEG | 5.0 | Single Flash | GEG | Green Energy Group |
| Kenya | Middle East/Africa | Olkaria | Olkaria GEG (OW43) | 15.0 | Single Flash | Green Energy Group transfer to KenGen (Temporary) | Green Energy Group |
| Mexico | North America | Los Azufres | Los Azufres III - 1 | 53.0 | Single Flash | Comision Federal de Electricidad | Mitsubishi |
| Turkey | Europe | Aydin-Umurlu | Umurlu 1 | 2.3 | Binary | Karadeniz Holding | Exergy |
| Turkey | Europe | Denizli-Tosunlar | Tosunlar | 3.8 | Binary | AKCA Holding | Exergy |
| Turkey | Europe | Çanakkale-Ayvacik | Babadere Jeotermal | 8.0 | Binary | MTN Enerji | Ormat |
| Turkey | Europe | Aydin-Umurlu | Umurlu 1 Phase 2 | 9.7 | Binary | Karadeniz Holding | Exergy |
| Turkey | Europe | Manisa-Alesehir | Alasehir Expansion | 11.3 | Single Flash | Zorlu Enerji | N/A |
| Turkey | Europe | Aydin-Germencik | Germencik (Efeier, Efe 2) | 22.5 | Single Flash | Gürmat Elektrik Üretim A.Ş. | Mitsubishi |
| Turkey | Europe | Aydin-Germencik | Germencik (Efeier, Efe 3) | 22.5 | Single Flash | Gürmat Elektrik Üretim A.Ş. | N/A |
| Turkey | Europe | Aydin-Germencik | Germencik (Efeier, Efe 4) | 22.5 | Single Flash | Gürmat Elektrik Üretim A.Ş. | N/A |
| Turkey | Europe | Aydin-Kuyucak | Pamukoren 2 | 22.5 | Binary | Celikler A.S. | Exergy |
| Turkey | Europe | Manisa-Alesehir | Alasehir | 33.7 | Single Flash | Zorlu Enerji | Toshiba |
| United States | North America | NV - Deadhorse Wells (Wild Rose) | Don A. Campbell (Wild Rose) II | 22.5 | Binary | Ormat | Ormat |
| United States | North America | NV - McGinness Hills | McGinness Expansion | 48.0 | Binary | Ormat | Ormat |

## Appendix 3: Country Geothermal Potentials

The estimates listed below are country-wide potentials announced by respective country governments or published in peer reviewed work. The potential numbers are not meant to be official resource or reservoir estimates and are not verified by GEA. These estimates are simply published for the purpose of informing public policy. For some countries, like small island nations, their potential listed below is likely much larger than their economy would ever need. However, in some of these cases there could be opportunities to export this power to nearby islands or countries via undersea cables where economically appropriate and feasible in the future.

*Table 4: Conventional Hydrothermal Potential based on Current Knowledge of Country's Geothermal*

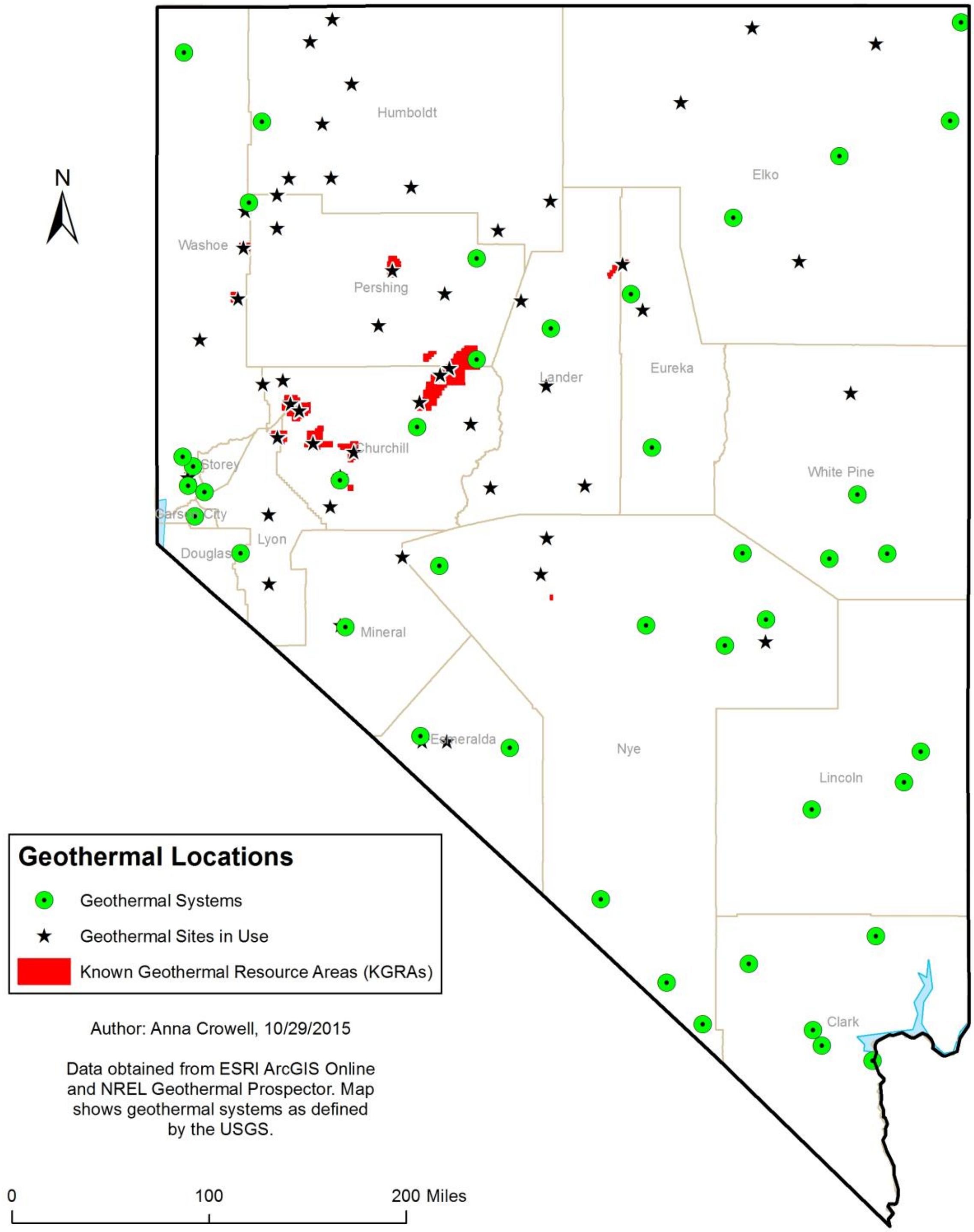
| *Country/Territory* | Potential ($MW_e$) | Citation |
|---|---|---|
| *Argentina* | likely resource base, no country-wide estimate | |
| *Austria* | 41 | (Enex and Geysir Green Energy, 2008) |
| *Azerbaijan* | 800 | (Orujova, 2014) |
| *Belgium* | 82 | (Enex and Geysir Green Energy, 2008) |
| *Bolivia* | likely resource base, no country-wide estimate | |
| *Bulgaria* | 164 | (Enex and Geysir Green Energy, 2008) |
| *Canada* | 5,000 | (CanGEA, 2015) |
| *Chile* | 16,000 | (Lahsen et al., 2005) |
| *China* | 6,744 | (Xiang et al., 1995) |
| *Colombia* | likely significant potential, no country-wide estimate | |
| *Comoros Island** | likely significant potential, no country-wide estimate | |
| *Costa Rica* | 1000 | (Lippmann, 2002) |
| *Croatia* | 100 | (Kolbah et al., 2015) |
| *Cyprus* | 8 | (Enex and Geysir Green Energy, 2008) |
| *Czech Republic* | 250 | (Think GeoEnergy, 2013) |
| *Djibouti* | 1,200 | (Republic of Djibouti, 2015) |
| *Dominica** | 1,400 | (Ministry of Public Works and Ports, 2013) |
| *Ecuador* | 3,000 | (Lahsen et al., 2015) |
| *El Salvador* | 2,210 | (Portillo, 2013) |
| *Eritrea* | likely significant potential, no country-wide estimate | |
| *Ethiopia* | 5,000 | (Geological Survey of Ethiopia, 2016) |
| *Fiji* | 70 | (Chen et al., 2015) |
| *France* | 82 | (Enex and Geysir Green Energy, 2008) |
| *Germany* | 164 | (Enex and Geysir Green Energy, 2008) |
| *Greece* | 1,500 | (ThinkGeoEnergy, 2014) |
| *Grenada** | 1,100 | (Maynard-Date, 2015) |
| *Guadeloupe (France)** | 3,500 | (Maynard-Date, 2015) |
| *Guatemala* | 800-4,000 | (Lippmann, 2002) |
| *Honduras* | 130-500 | (Lippmann, 2002) |
| *Hungary* | 312 | (Enex and Geysir Green Energy, 2008) |
| *Iceland* | 4,300-7,000 | (International Energy Agency (IEA), 2012) |

| | | |
|---|---|---|
| *India* | 10,000 | (Sharma, 2010) |
| *Indonesia* | 29,000 | (Hasan and Wahjosudibjo, 2014) |
| *Iran* | 800 | (ThinkGeo Energy, 2015b) |
| *Italy* | 2000 | (Cataldi et al., 2013) |
| *Jamaica* | 34 | (Wishart, 2013) |
| *Japan* | 23,000 | (Yanagisawa, 2013) |
| *Kenya* | 10,000 | (Omenda, 2012) |
| *Martinique (France)** | 3,500 | (Maynard-Date, 2015) |
| *Mexico* | 10,500 | (Sarmiento and Steingrimsson, 2007) |
| *Montserrat** | 940 | (Maynard-Date, 2015) |
| *Myanmar* | 200 | (DuByne and Koh, 2015) |
| *Netherlands (Antilles)* | likely significant potential, no country-wide estimate | |
| *New Zealand* | 3,600 | (New Zealand Geothermal Assn., 2009) |
| *Nicaragua* | 4,000 | (Lippmann, 2002) |
| *Northern Mariana** | 125 | (McCoy-West et al., 2011) |
| *Pakistan* | 12,000 | (Ahmed, 2015) |
| *Panama* | 50 | (Lippmann, 2002) |
| *Papua New Guinea* | 4,000 | (McCoy-West et al., 2011) |
| *Peru* | 3,000 | (Matsuda et al., 2015) |
| *Philippines* | 3,000-4,000 | (Pastor et al., 2010) |
| *Portugal* | 164 | (Enex and Geysir Green Energy, 2008) |
| *Romania* | 164 | (Enex and Geysir Green Energy, 2008) |
| *Russia* | 2000 | (Svalova and Povarov, 2015) |
| *Rwanda* | 700 | (African Development Bank Group, 2013) |
| *Slovakia* | 90 | (Enex and Geysir Green Energy, 2008) |
| *Solomon Islands* | 40 | (Solomon Islands Government, 2015) |
| *Spain* | 1,922 | (Iñigo et al., 2015) |
| *St. Kitts and Nevis** | 500 & 800 | (Maynard-Date, 2015) |
| *St. Lucia** | 170 | (Maynard-Date, 2015) |
| *St. Vincent and Grenadines** | 890 | (Maynard-Date, 2015) |
| *Saudi Arabia* | 3,000-5,000 | (Lashan et al., 2015) |
| *Taiwan* | 7,150 | (Yang and Geothermal Energy Research Teams of Taiwan, 2015) |
| *Tanzania* | 650 – 5,000 | (Mnjokava, 2012) & (Kisima, 2016) |
| *Turkey* | 1,500 | (Parlaktuna et al., 2013) |
| *Uganda* | 450 | (Bahati et al., 2010) |
| *United States* | 9,057 | (Williams et al., 2008) |
| *Vanuatu* | likely significant potential, no country-wide estimate | |
| *Vietnam* | 113 | (Linh Ngoc et al., 2010) |
| *Total* | 203,266 - 229,566 ($MW_e$) | |

*Note: These country's geothermal potential exceed their current demand for power. It is very unlikely geothermal resources in these countries will be fully utilized.

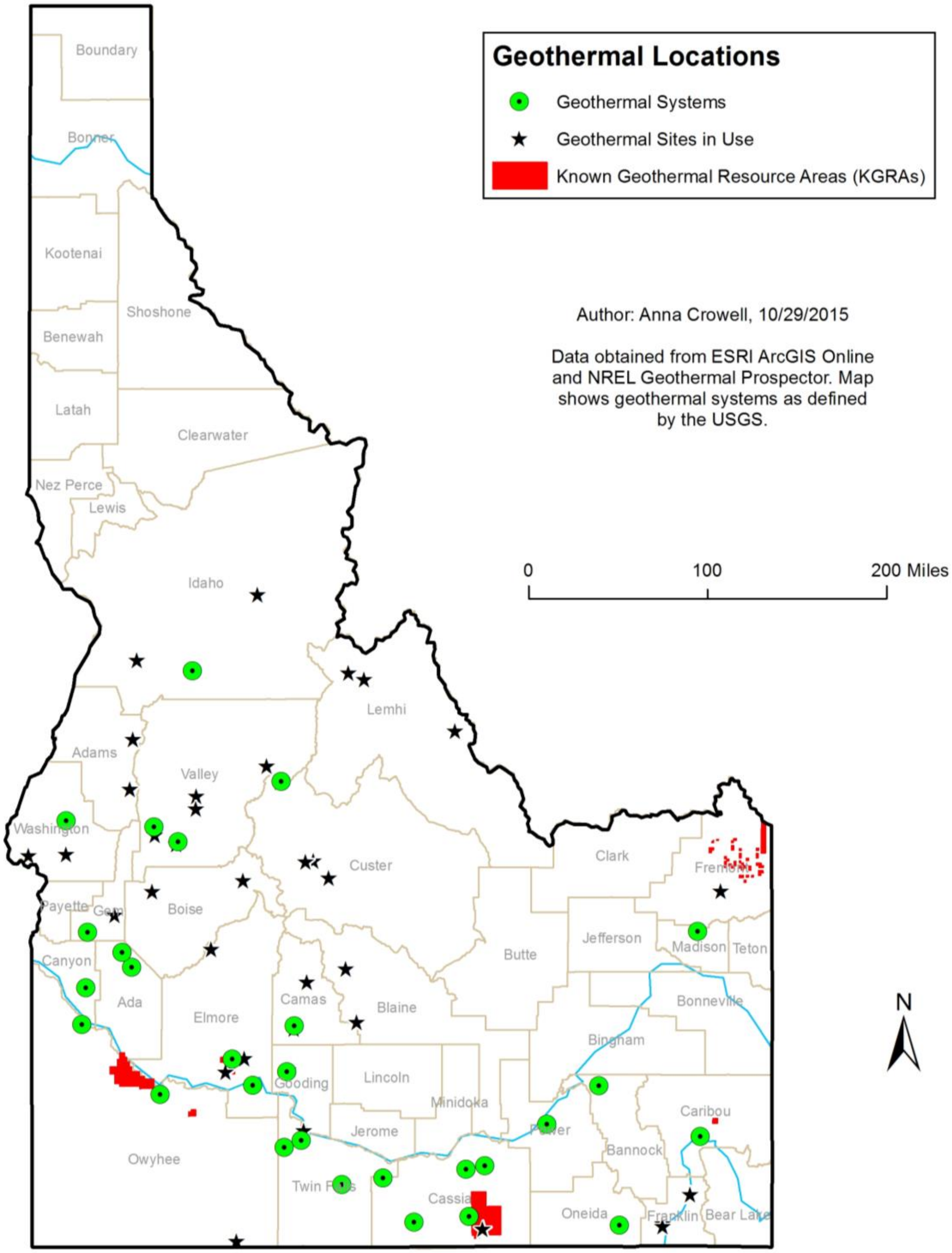
## Appendix 4: Map of Nevada's Geothermal Resource Locations

*Figure 11: Geothermal Sites in Nevada as of 2015*



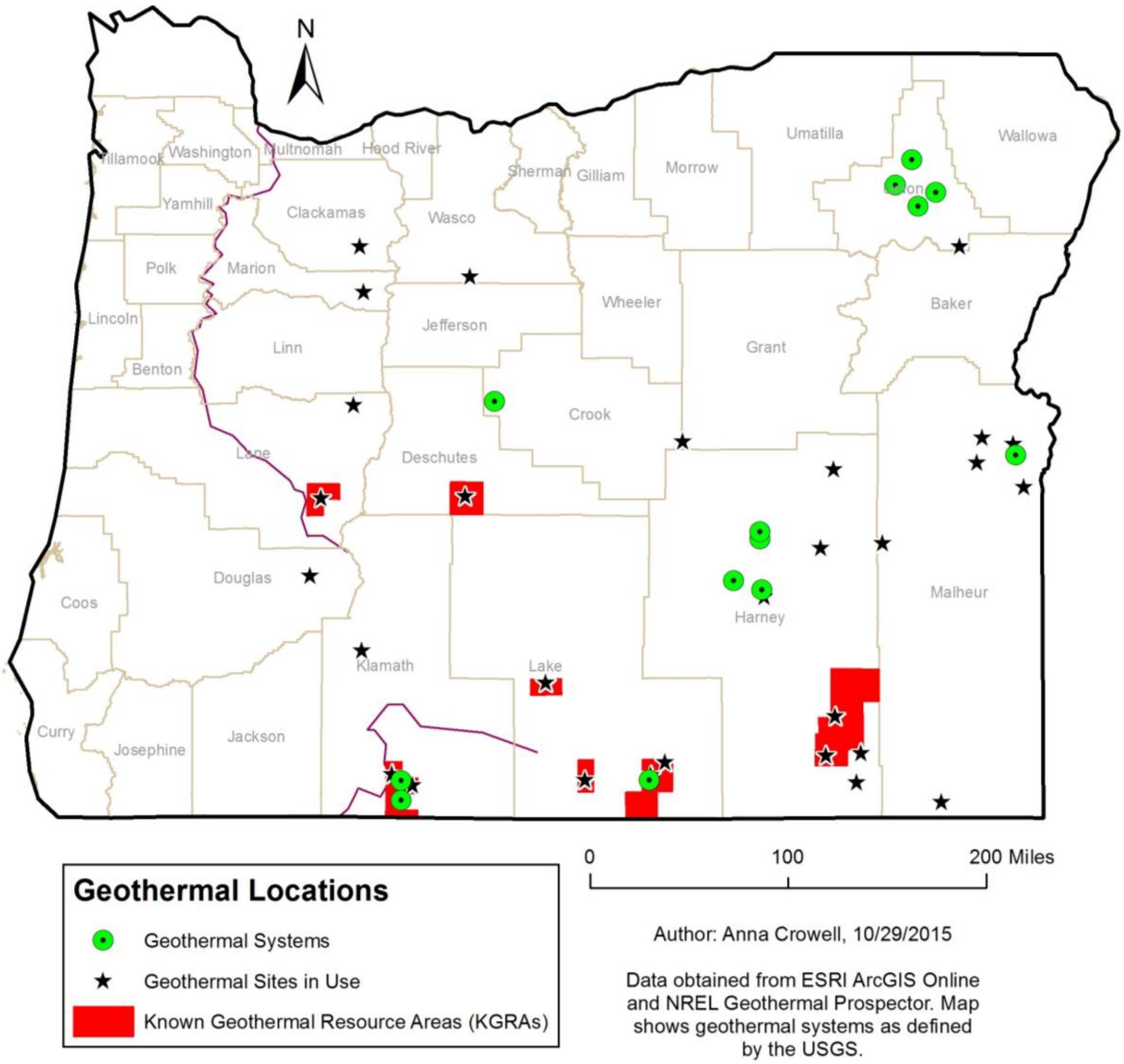
## Appendix 5: Map of Idaho's Geothermal Resource Locations

*Figure 12: Geothermal Sites in Idaho as of 2015*



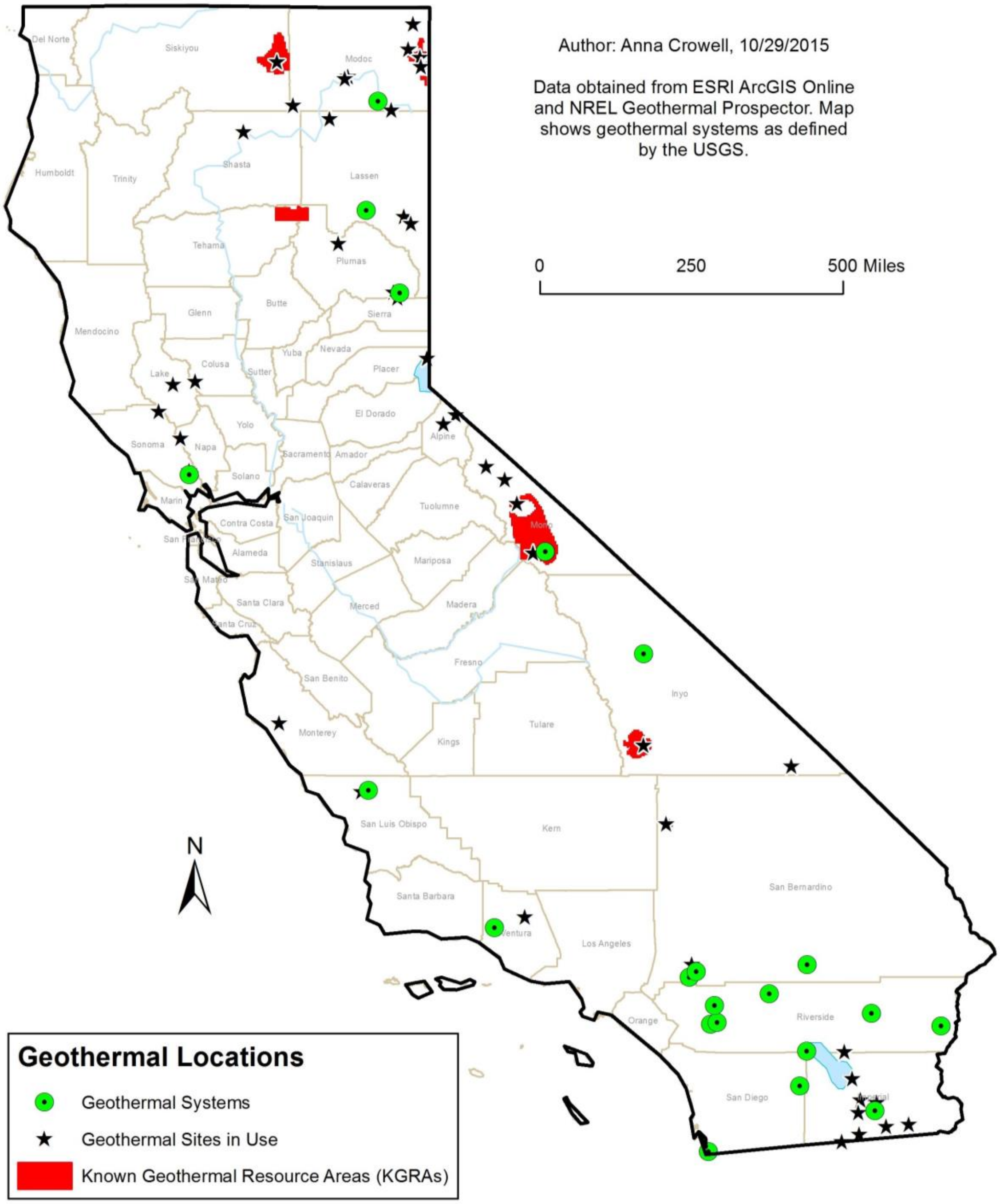
## Appendix 6: Map of Oregon's Geothermal Resource Locations

*Figure 13: Geothermal Sites in Oregon as of 2015*



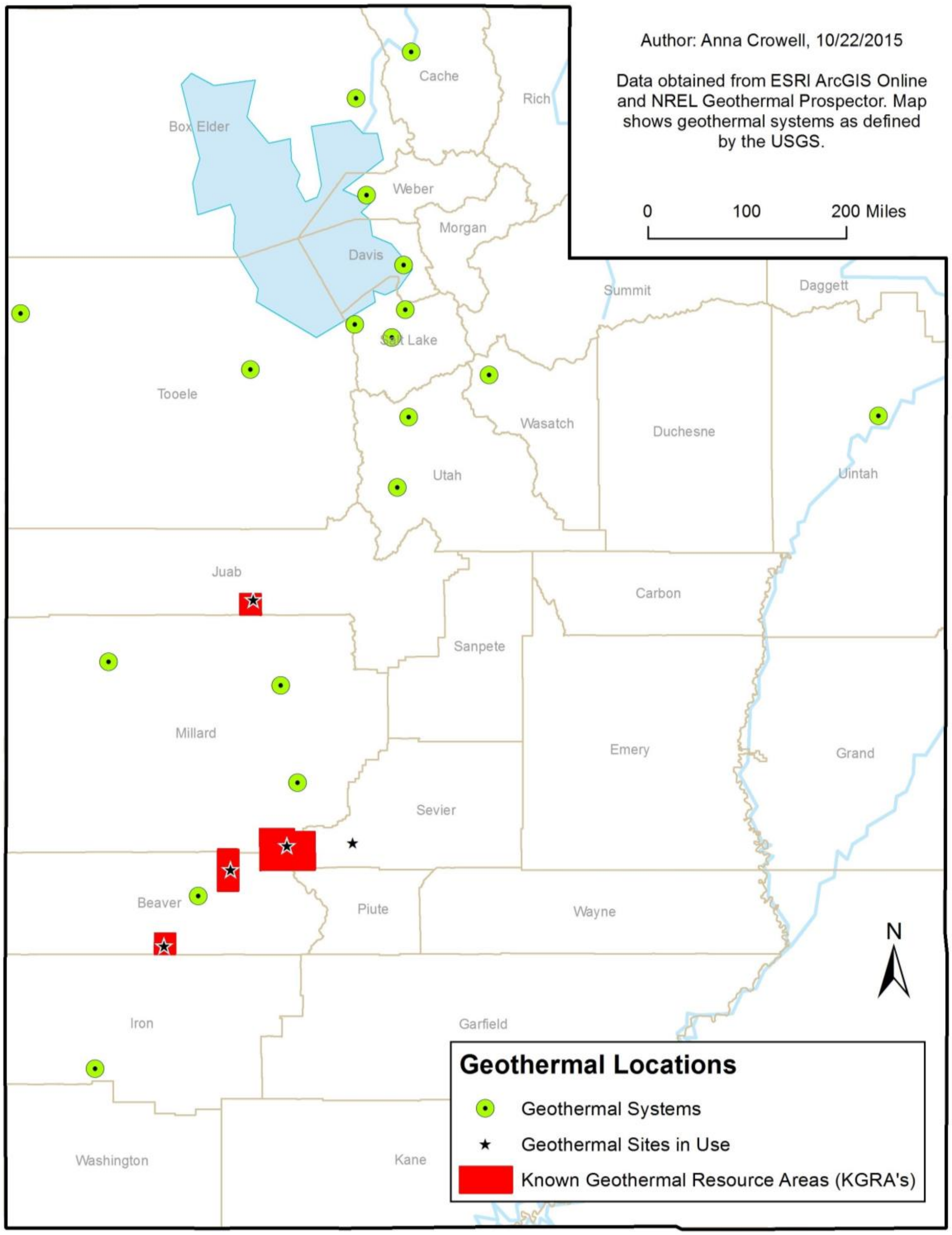
## Appendix 7: Map of California's Geothermal Resource Locations

*Figure 14: Geothermal Sites in California as of 2015*



## Appendix 8: Map of Utah's Geothermal Resource Locations

*Figure 15: Geothermal Sites in Utah as of 2015*



## Appendix 9: Energy Tax Incentives

### Production Tax Credit (PTC)[31]

The federal renewable electricity production tax credit (PTC) is an inflation-adjusted per-kilowatt-hour (kWh) tax credit for electricity generated by qualified energy resources and sold by the taxpayer to an unrelated person during the taxable year. The duration of the credit is 10 years after the date the facility is placed in service for all facilities placed in service after August 8, 2005.

1) In December 2015, the Consolidated Appropriations Act, 2016 extended the expiration date for the PTC to December 31, 2019, for wind facilities commencing construction, with a phase-down beginning for wind projects commencing construction after December 31, 2016.
2) The Act extended the tax credit for other eligible renewable energy technologies including geothermal power commencing construction through December 31, 2016.
3) The Act applies retroactively to projects that began construction January 1, 2015.
4) The rebate amounts to $0.023/kWh for wind, geothermal, closed-loop biomass and $0.012/kWh for other eligible technologies.
5) The tax credit is phased down for wind facilities and expires for other technologies commencing construction after December 31, 2016. The phase-down for wind facilities is described as a percentage reduction in the tax credit amount described above:
    a) For wind facilities commencing construction in 2017, the PTC amount is reduced by 20%
    b) For wind facilities commencing construction in 2018, the PTC amount is reduced by 40%
    c) For wind facilities commencing construction in 2019, the PTC amount is reduced by 60%

### Investment Tax Credit (ITC)[32]

Renewable energy facilities placed in service after 2008 and commencing construction prior to 2017 (or 2020 for wind facilities) may elect to make an irrevocable election to claim the ITC in lieu of the PTC. As of January 1, 2015, only wind energy systems are eligible to claim the ITC in lieu of the PTC. For electricity produced by geothermal power, equipment qualifies only up to, but not including, the electric transmission stage. For geothermal heat pumps, this credit applies to eligible property placed in service after October 3, 2008. Note that the credit for geothermal property, with the exception of geothermal heat pumps, has no stated expiration date.

| Technology | 12/31/16 | 12/31/17 | 12/31/18 | 12/31/19 | 12/31/20 | 12/31/21 | 12/31/22 | Future Years |
|---|---|---|---|---|---|---|---|---|
| PV, Solar Water Heating, Solar Space Heating/Cooling, Solar Process Heat | 30% | 30% | 30% | 30% | 26% | 22% | 10% | 10% |
| Hybrid Solar Lighting, Fuel Cells, Small Wind | 30% | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Geothermal Heat Pumps, Microtubines, Combine Heat and Power Systems | 10% | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Geothermal Electric | 10% | 10% | 10% | 10% | 10% | 10% | 10% | 10% |
| Large Wind | 30% | 24% | 18% | 12% | N/A | N/A | N/A | N/A |

31 (DSIRE database, 2015a)
32 (DSIRE database, 2015b)

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